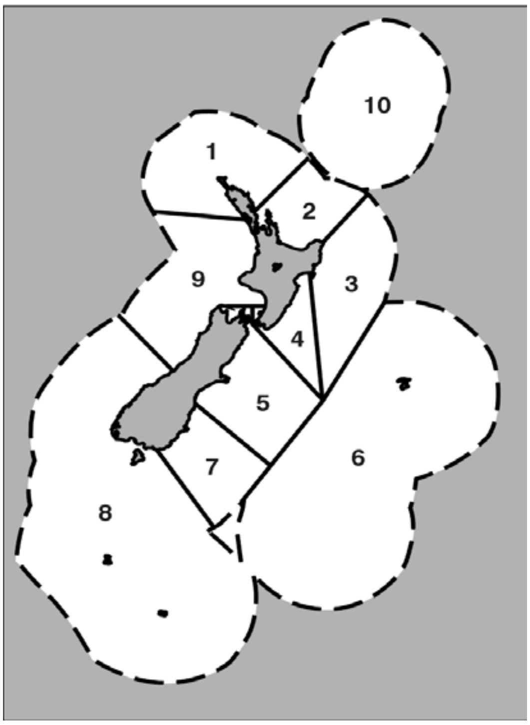
ROCK LOBSTER (CRA and PHC)

(*Jasus edwardsii*, *Sagmariasus verreauxi*)



1. FISHERY SUMMARY

The rock lobster fishery takes two species. The red rock lobster (*Jasus edwardsii*) supports nearly all the landings and is caught all around the North and South Islands, Stewart Island and the Chatham Islands. The packhorse rock lobster (*Sagmariasus verreauxi*) is taken mainly in the north of the North Island. Packhorse lobsters (PHC) grow to a much larger size than do red rock lobsters (CRA) and have different shell colouration and shape.

The rock lobster fishery was brought into the Quota Management System (QMS) on 1 April 1990, when Total Allowable Commercial Catches (TACCs) were set for each Quota Management Area (QMA) shown above. Before this, the fishery was managed by input controls, including minimum legal size (MLS) regulations, a prohibition on the taking of berried females and soft-shelled lobsters, and some local area closures. Most of the input controls have been retained in the fishery but the limited entry provisions were removed and allocation of individual transferable quota (ITQ) was made to the previous licence holders based on catch history.

Historically, three rock lobster stocks were recognised for stock assessment purposes:

- NSI – the North and South Island (including Stewart Island) red rock lobster stock
- CHI – the Chatham Islands red rock lobster stock
- PHC – the New Zealand packhorse rock lobster stock

In 1994, the Rock Lobster Fishery Assessment Working Group agreed to divide the NSI stock into three substocks:

- NSN – the northern stocks CRA 1 and 2
- NSC – the central stocks CRA 3, 4 and 5
- NSS – the southern stocks CRA 7 and 8

CRA 9 has not been assigned to a substock. Since 2001, assessments have been carried out at the

Fishstock level, i.e. for CRA 1, CRA 2 etc.

Time series of commercial landings and CPUE (catch per unit effort) data are provided for NSI, NSN, NSC, NSS and CHI for comparison with earlier years. The fishing year runs from 1 April to 31 March.

The NSI stock is composed of the CRA QMAs 1–5 and 7–9, each being a separate Fishstock with a separate TACC. The sum of the TACCs for the NSI stock was set at 3 275 t for the year commencing 1 April 1990. This total was reduced in each year until 1993–94 to reach 2 382 t (taking into account some increases in individual ITQs resulting from appeals over catch histories by fishers). The total TACC for the NSI stock then fluctuated at a level of 2 300 to 2 400 t/year up to the 2005–06 season, when the NSI TACC dropped to 2 229 t through a reduction to the CRA 3 TACC from 327 t to 190 t (Table 1). The CRA 3 TAC dropped at the same time from 453 t to 319 t. The total NSI TACC increased in 2006–07 to 2 407 t through increases to the CRA 7 and CRA 8 TACCs from the operation of the NSS Decision Rule in 2005.

The TACC for the CHI stock (CRA 6) was set at 518 t in 1990 but increased through appeals to 531 t at the beginning of the 1993–94 fishing year (Table 1). The CHI TACC was subsequently reduced to 400 t in 1997–98 and to 360 t in 1998–99. CRA 10 comprises the Kermadec Islands, and has a nominal TACC of 0.086 t. The TACC for PHC increased from 27 t in 1990 to its current value of 40.3 t at the beginning of the 1993–94 fishing year following appeals.

TACs (Total Allowable Catch including non-commercial catches) were set for the first time in 1997–98 for three CRA QMAs (Table 1). Setting TACs is a requirement under the Fisheries Act 1996 and consequently TACs have been set since 1997–98 whenever adjustments have been made to the TACCs.

The MLS in the commercial fishery for red rock lobster is based on tail width (TW), except in the Otago fishery. For Otago (CRA 7), the MLS is a tail length (TL) of 127 mm, which applies to both sexes during the period 21 June to 19 November, the primary commercial season. The female MLS in all other CRAs except Southern (CRA 8) has been 60 mm TW since mid-1992. For Southern (CRA 8), the female MLS has been 57 mm TW since 1990. The male MLS has been 54 mm TW since 1988, except in Otago (MLS described above) and Gisborne (CRA 3) where it is 52 mm for the June-August period.

Special conditions applied to the Gisborne (CRA 3) fishery after 1993–94. During June, July and August, commercial fishers were permitted to retain males at least 52 mm TW but females could not be taken. These measures changed the commercial CRA 3 fishery to a mainly winter fishery for male lobsters from 1993 to 2002. The fishery was closed beginning in 1993 to all users from September to the end of November, but in 2000, it closed from 1 October instead of 1 September. In 2002 the closed season was shortened further. It now remains officially closed to commercial fishers only in May, and from mid-December to mid-January by voluntary agreement.

For recreational fishers, the red rock lobster MLS has been 54 mm TW for males since 1990 and 60 mm TW for females since 1992 in all areas of NZ. The commercial and recreational MLS measure for packhorse rock lobster is 216 mm TL for both sexes.

Commercial fisheries

Table 1 provides a summary by fishing year of the reported commercial catches, TACCs and TACs by Fishstock (CRA). The Quota Management Reports (QMRs) and their replacement Monthly Harvest Reports (MHRs; since 1 October 2001) provide the most accurate information on landings. Other sources of annual catch estimates include the Licensed Fish Receiver Returns (LFRRs) and the Catch, Effort, and Landing Returns (CELRs). In recent years, landings reported by LFRRs have been close to the QMR totals.

Table 1. Reported commercial catch (t) from QMRs or MHRs (after 1 October 2001), commercial TACC (t) and total TAC (t) (where this quantity has been set) for *Jasus edwardsii* by rock lobster CRA for each fishing year since the species was included in the QMS on 1 April 1990. –, TAC not set for QMA. [[1]all totals exclude CRA 10 and CRA EEZ]

	CRA 1			CRA 2			CRA 3		
Fishing Year	Catch	TACC	TAC	Catch	TACC	TAC	Catch	TACC	TAC
1990–91	131.1	160.1	–	237.6	249.5	–	324.1	437.1	–
1991–92	128.3	146.8	–	229.7	229.4	–	268.8	397.7	–
1992–93	110.5	137.4	–	190.3	214.6	–	191.5	327.5	–
1993–94	127.4	130.5	–	214.9	214.6	–	179.5	163.7	–
1994–95	130.0	130.5	–	212.8	214.6	–	160.7	163.7	–
1995–96	126.7	130.5	–	212.5	214.6	–	156.9	163.7	–
1996–97	129.4	130.5	–	213.2	214.6	–	203.5	204.7	–
1997–98	129.3	130.5	–	234.4	236.1	452.6	223.4	224.9	379.4
1998–99	128.7	131.1	–	232.3	236.1	452.6	325.7	327.0	453.0
1999–00	125.7	131.1	–	235.1	236.1	452.6	326.1	327.0	453.0
2000–01	130.9	131.1	–	235.4	236.1	452.6	328.1	327.0	453.0
2001–02	130.6	131.1	–	225.0	236.1	452.6	289.9	327.0	453.0
2002–03	130.8	131.1	–	205.7	236.1	452.6	291.3	327.0	453.0
2003–04	128.7	131.1	–	196.0	236.1	452.6	215.9	327.0	453.0
2004–05	130.8	131.1	–	197.3	236.1	452.6	162.0	327.0	453.0
2005–06	130.5	131.1	–	225.2	236.1	452.6	170.0	190.0	319.0
2006–07	–	131.1	–	–	236.1	452.6	–	190.0	319.0

	CRA 4			CRA 5			CRA 6		
Fishing Year	Catch	TACC	TAC	Catch	TACC	TAC	Catch	TACC	TAC
1990–91	523.2	576.3	–	308.6	465.2	–	369.7	518.2	–
1991–92	530.5	529.8	–	287.4	426.8	–	388.3	503.0	–
1992–93	495.7	495.7	–	258.8	336.9	–	329.4	503.0	–
1993–94	492.0	495.7	–	311.0	303.2	–	341.8	530.6	–
1994–95	490.4	495.7	–	293.9	303.2	–	312.5	530.6	–
1995–96	487.2	495.7	–	297.6	303.2	–	315.3	530.6	–
1996–97	493.6	495.7	–	300.3	303.2	–	378.3	530.6	–
1997–98	490.4	495.7	–	299.6	303.2	–	338.7	400.0	480.0
1998–99	493.3	495.7	–	298.2	303.2	–	334.2	360.0	370.0
1999–00	576.5	577.0	771.0	349.5	350.0	467.0	322.4	360.0	370.0
2000–01	573.8	577.0	771.0	347.4	350.0	467.0	342.7	360.0	370.0
2001–02	574.1	577.0	771.0	349.1	350.0	467.0	328.7	360.0	370.0
2002–03	575.7	577.0	771.0	348.7	350.0	467.0	336.3	360.0	370.0
2003–04	575.7	577.0	771.0	349.9	350.0	467.0	290.4	360.0	370.0
2004–05	569.9	577.0	771.0	345.1	350.0	467.0	323.0	360.0	370.0
2005–06	504.1	577.0	771.0	345.6	350.0	467.0	351.2	360.0	370.0
2006–07	–	577.0	771.0	–	350.0	467.0	–	360.0	370.0

	CRA 7			CRA 8		
Fishing Year	Catch	TACC	TAC	Catch	TACC	TAC
1990–91	133.4	179.4	–	834.5	1152.4	–
1991–92	177.7	164.7	–	962.7	1054.6	–
1992–93	131.6	153.1	–	876.5	986.8	–
1993–94	138.1	138.7	–	896.1	888.1	–
1994–95	120.3	138.7	–	855.6	888.1	–
1995–96	81.3	138.7	–	825.6	888.1	–
1996–97	62.9	138.7	–	862.4	888.1	–
1997–98	36.0	138.7	–	785.6	888.1	–
1998–99	58.6	138.7	–	808.1	888.1	–
1999–00	56.5	111.0	131.0	709.8	711.0	798.0
2000–01	87.2	111.0	131.0	703.4	711.0	798.0
2001–02	76.9	89.0	109.0	572.1	568.0	655.0
2002–03	88.6	89.0	109.0	567.1	568.0	655.0
2003–04	81.4	89.0	109.0	567.6	568.0	655.0
2004–05	94.2	94.9	114.9	603.0	603.4	690.4
2005–06	95.0	94.9	114.9	603.2	603.4	690.4
2006–07	–	120.2	140.2	–	755.2	842.2

	CRA 9			Total		
Fishing Year	Catch	TACC	TAC	Catch[1]	TACC[1]	TAC
1990–91	45.3	54.7	–	2907.4	3793.0	–
1991–92	47.5	50.2	–	3020.9	3502.9	–
1992–93	45.7	47.0	–	2629.9	3201.9	–
1993–94	45.5	47.0	–	2746.2	2912.1	–
1994–95	45.2	47.0	–	2621.5	2912.1	–
1995–96	45.4	47.0	–	2548.6	2912.1	–
1996–97	46.9	47.0	–	2690.5	2953.1	–
1997–98	46.7	47.0	–	2584.2	2864.1	1312.0
1998–99	46.9	47.0	–	2726.0	2926.8	1275.6
1999–00	47.0	47.0	–	2748.5	2850.2	3442.6
2000–01	47.0	47.0	–	2795.9	2850.2	3442.6
2001–02	46.8	47.0	–	2593.0	2685.2	3277.6
2002–03	47.0	47.0	–	2591.1	2685.2	3277.6
2003–04	45.9	47.0	–	2451.5	2685.2	3277.6
2004–05	47.0	47.0	–	2472.3	2726.4	3318.8
2005–06	46.6	47.0	–	2471.2	2589.4	3184.8
2006–07	–	47.0	–	–	2766.6	3362.0

Problems with rock lobster catch and effort data

There are two types of data on the CELR form: the top part of each form contains the fishing effort and an estimated catch associated with that effort. The bottom part of the form contains the actual landed catch, which may span several records of effort. Estimated catches from the top part of the CELR form may show differences from the catch totals on the bottom part of the form, particularly in some CRAs such as CRA 5 and CRA 8 (Vignaux & Kendrick 1998; Bentley et al. 2005). Substantial discrepancies were identified in 1997 between the estimated and weighed catches in CRA 5 (Vignaux & Kendrick 1998) and were attributed to fishers including all rock lobster catch in the estimated total, including those returned to the sea. This led to an overestimate of CPUE, but this problem appeared to be confined to CRA 5.

After 1998, all CELR catch data have been modified to reflect the actual landed catch (bottom of form) rather than the estimated catch (top of form). This resulted in changes to the CPUE values compared to those reported before 1998.

In 2003, it was concluded that the method used to correct estimated to landed catch (“Method C1”, Bentley et al. 2005) was biased because it dropped trips with no landings, leading to estimates of CPUE which were too high. In some areas, this bias was getting worse because of an increasing trend of passing landings through holding pots to maximise the value of the catch. The catch/effort data system operated by MFish makes no attempt to link catch derived from the effort expended on a trip with the landings recorded from the trip. Therefore, landings from previous trips, held in holding pots, can be combined with landings from the active trip, which in turn means that tracing capture from the fishing event to the landing event for the same lobster is not possible under the current system.

The catch and effort data used in these analyses have been calculated using a revised procedure since 2003. This procedure sums all landings and effort for a vessel within a calendar month and allocates the landings to statistical areas based on the area distribution of the estimated catches. The revised method assumes that landings from holding pots tend to even out at the month level. However, in some areas there are vessel/month combinations with no landings, indicating that the problem has not been completely solved by this approach. In these instances, the method is modified by dropping all data for the vessel in the month with zero landings and the following month; it was thought that a method that excludes uncertain data is preferable to one that might incorrectly reallocate landings. This method is described as “Method B4” in Bentley et al. (2005).

The CPUE estimates in Tables 2 and 3 have been subjected to the same error screening as those used for standardised CPUE analysis – in all cases, CPUE is calculated from the sum of catch divided by the sum of pots for each stock, sub-stock or CRA Fishstock by fishing year.

Another potential problem with assuming CPUE indices are proportional to abundance has been identified by the Working Group. Fishers may sort their catch, discarding parts not expected to provide a reasonable economic return. This “high-grading” (permitted by legislation) could lead to biases in the estimated CPUE relative to previous years when sorting did not occur. The practice has become more prevalent in recent years, especially in areas where rock lobster abundance has increased. The Working Group agreed to identify this issue for further investigation.

***Jasus edwardsii*, NSI stock**

NSI landings were relatively stable from about 1960 until the late 1980s, when landings declined (Table 2). CPUE was around 1.0 kg per potlift in the late 1970s and early 1980s, and decreased slowly until the late 1980s. Catch per pot lift in NSI declined to 0.48 kg in 1992–93 and has since recovered to levels near 1.0 kg per potlift (Table 2).

Table 2. Reported commercial landings (t) to 31 March 2006 and CPUE (kg per pot lift) for *Jasus edwardsii* NSI and CHI stocks, and NSN, NSC and NSS substocks, for the 1979–80 to 2005–06 fishing years. Sources of data: catch and CPUE data from 1979–80 to 1985–86 from the QMS-held FSU data; catch data from 1986-87 to 2004–05 from QMR or MHR reports held by the Ministry of Fisheries (total catches in 1986–87 and 1987–88 have been divided among substocks using the FSU data because the QMR did not report individual CRA areas in those years); CPUE data from 1986–87 to 1988–89 from the QMS-held FSU data; CPUE data from 1989–90 to 2005–06 from the CELR data held by the Ministry of Fisheries corrected for actual landings. *See* Booth et al. (1994) for a discussion of problems with the QMS-held FSU data.

	NSI Substocks						NSI Total		CHI	
Fishing	NSN (CRA1 & 2)		NSC (CRA3, 4 & 5)		NSS (CRA7 & 8)		CRA 1–5 & CRA 7–9		CRA6	
Year	Landings	CPUE	Landings	CPUE	Landings	CPUE	Landings	CPUE	Landings	CPUE
1979–80	408	0.57	1 386	0.85	2 129	1.58	4 012	1.06	400	2.33
1980–81	626	0.69	1 719	0.88	1 761	1.49	4 203	1.02	356	2.18
1981–82	574	0.66	1 664	0.85	1 663	1.48	3 973	0.99	465	2.19
1982–83	549	0.59	2 213	0.91	1 632	1.35	4 453	0.96	472	1.78
1983–84	506	0.55	2 303	0.85	1 634	1.09	4 514	0.87	548	1.73
1984–85	482	0.51	2 294	0.76	1 741	1.09	4 598	0.82	492	1.35
1985–86	556	0.54	2 227	0.71	2 185	1.21	5 048	0.83	604	1.41
1986–87	486	0.48	2 144	0.72	1 927	1.07	4 650	0.79	580	1.66
1987–88	442	0.45	1 781	0.57	1 961	1.12	4 277	0.72	448	1.48
1988–89	401	0.45	1 399	0.51	1 262	0.80	3 087	0.58	450	1.40
1989–90	427	0.55	1 457	0.53	1 352	0.80	3 262	0.62	318	1.34
1990–91	369	0.55	1 156	0.46	968	0.75	2 538	0.56	370	1.38
1991–92	358	0.49	1 087	0.41	1 140	0.82	2 633	0.54	388	1.29
1992–93	301	0.44	946	0.40	1 008	0.62	2 300	0.48	329	1.14
1993–94	342	0.51	983	0.49	1 034	0.87	2 404	0.61	342	1.07
1994–95	343	0.61	945	0.60	976	0.79	2 309	0.67	313	1.07
1995–96	339	0.77	942	0.73	907	0.76	2 233	0.75	315	1.09
1996–97	343	0.87	997	0.88	925	0.74	2 312	0.83	378	1.02
1997–98	364	0.87	1 013	1.15	822	0.66	2 246	0.87	339	0.88
1998–99	361	0.95	1 117	1.22	867	0.71	2 392	0.94	334	1.17
1999–00	361	0.82	1 252	1.24	766	0.73	2 426	0.96	322	1.19
2000–01	366	0.83	1 249	1.21	791	0.81	2 453	0.98	343	1.15
2001–02	356	0.71	1 213	1.08	649	0.81	2 264	0.91	329	1.15
2002–03	336	0.58	1 216	1.01	656	0.94	2 255	0.89	336	1.16
2003–04	325	0.58	1 142	1.04	649	1.31	2 161	0.99	290	1.10
2004–05	328	0.59	1 077	0.95	697	1.36	2 149	0.96	323	1.21
2005–06	356	0.60	1 020	0.90	698	1.62	2 120	0.97	351	1.35

Jasus edwardsii, NSN substock

Landings in the NSN substock were high in the early 1980s but CPUE was less than 1.0 kg per potlift. Both measures gradually declined into the early 1990s. Catch per pot lift was around 0.7 kg in the early 1980s but the period from 1986–87 to 1992–93 had catch rates around 0.5 kg (Table 2). From 1994, CPUE increased to levels considerably higher than those observed at the beginning of the time series peaking in 1998–99 at 0.95 kg per potlift. CPUE levels in CRA 1 and CRA 2 differ, with CRA 1 maintaining higher catch rates since the late 1990s while CRA 2 declined to less than 0.5 kg/potlift in 2002–03 and has since remained at that level (Table 3). The combined NSN catch rate has held steady at about 0.6 kg per potlift since 2002–03.

Jasus edwardsii, NSC substock

Landings in the NSC substock were very high up to the mid 1980s, exceeding 2 000 t per fishing year for five fishing years in succession. During that time CPUE dropped from 0.9 kg/potlift to 0.7 kg/potlift (Table 2). Commercial catches then gradually decreased to below 1 000 t by the early 1990s and CPUE dropped to below 0.5 kg per potlift over the same period. From 1993–94, CPUE increased to a peak of 1.24 kg/potlift in 1999–2000 (Table 2). CPUE has subsequently fallen near to or below 1.0 kg per potlift since 2001–02, which is still higher than the catch rates observed prior to 1997–98. Trends in CPUE have differed between the three component QMAs in the NSC, with CPUE peaking in CRA 3 in 1997–98, in CRA 4 in 1998–99, and in CRA 5 in 2003–04 (Table 3).

Jasus edwardsii, NSS substock

Catches and CPUE were high for this substock (greater than 1 500 t per fishing year and well over 1.0 kg per potlift) throughout most of the 1980s. However, both measures gradually declined during that period, dropping below 1 000 t per fishing year and below 1.0 kg per potlift by the early- to mid-1990s (Table 2). CPUE has been increasing since 1997–98 and is now 1.62 kg per potlift (Table 2). Catches and CPUE are relatively low in CRA 7 compared with those in other areas (Table 3), but CPUE has been rising in this QMA, with CPUE presently at its highest level in the most recent nine years.

Jasus edwardsii, Westland/Taranaki (CRA 9)

Catch per pot lift fluctuated about 0.9 kg per potlift between 1995–96 and 2001–02, but has increased to over 2 kg per potlift in 2004–05 and 2005–06 (Table 3).

Jasus edwardsii, CHI stock

CPUE in the CHI fishery was higher than in the other New Zealand CRA areas in the 1980s (Table 2). However, CPUE since the mid-1980s has declined to levels similar to those in other CRA QMAs (Table 3). CPUE has been stable at over 1.1 kg/potlift since 1998–99. Landings were around 400 to 500 t per fishing year in the 1980s but fell below 400 t per year in the 1990s. The reasons for the decline in catch and in CPUE are unknown. Size frequencies of lobsters in the landed catch have changed little since the development of this fishery.

Table 3. Estimated unstandardised CPUE (kg/potlift) for each CRA quota management area for the nine most recent fishing years. Data are from the Ministry of Fisheries CELR database and estimated catches have been corrected by the amount of fish landed from the bottom part of the form (see Section 1 in text for explanation).

QMA	1996–97	1997–98	1998–99	1999–2000	2000–01	2001–02	2002–03	2003–04	2004–05	2005–06
CRA 1	0.94	0.89	1.04	1.09	1.17	1.30	1.20	1.22	1.23	1.14
CRA 2	0.83	0.85	0.91	0.71	0.71	0.56	0.44	0.43	0.43	0.47
CRA 3	1.76	2.18	1.63	1.56	1.19	0.95	0.73	0.62	0.52	0.62
CRA 4	1.03	1.24	1.31	1.27	1.26	1.06	1.09	1.14	1.00	0.88
CRA 5	0.56	0.78	0.89	1.00	1.16	1.27	1.26	1.39	1.26	1.17
CRA 6	1.02	0.88	1.17	1.19	1.15	1.15	1.16	1.10	1.21	1.34
CRA 7	0.25	0.24	0.30	0.22	0.35	0.46	0.52	0.58	0.75	1.12
CRA 8	0.87	0.72	0.79	0.84	0.98	0.92	1.10	1.67	1.58	1.75
CRA 9	0.98	0.79	0.92	0.87	0.93	0.82	1.11	1.63	2.14	2.22

Sagmariasus verreauxi, PHC stock

QMS reported catches of the PHC stock halved between 1998–99 and 2001-02 but have since increased (Table 4). Reasons for low level of landings relative to the TACC (40 t) are unknown.

Table 4. Reported landings of *Sagmariasus verreauxi* from 1990–91 to 2004–05. Data from QMR or MHR (after 1 Oct 2001). NA – not available.

Year	Landings (t)	Year	Landings (t)
1990–91	7.4	1998–99	16.2
1991–92	23.6	1999–00	12.6
1992–93	11.1	2000–01	9.8
1993–94	5.7	2001–02	7.8
1994–95	7.9	2002–03	8.6
1995–96	23.8	2003–04	16.4
1996–97	16.9	2004–05	20.8
1997–98	16.2	2005–06	26.7

Jasus edwardsii, Catch-per-unit effort by statistical area

Table 5 shows the CPUE (kg/potlift) for the most recent six years within each CRA area for each rock lobster statistical area reported on the CELR forms (Figure 1). The values of CPUE and the trends in the fisheries vary both within and between CRA areas.

Table 5. **Unstandardised CPUE (kg/potlift) for each statistical area for the six most recent fishing years. Data are from the Ministry of Fisheries CELR database and estimated catches have been corrected by the amount of fish landed from the bottom part of the form (see Section 1 in text for explanation). – value withheld because fewer than three vessels were fishing or no fishing.**

CRA	Stat Area	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	CRA	Stat Area	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06
1	901	2.82	2.92	2.05	–	3.48	3.19	6	940	0.92	0.98	1.12	1.15	1.14	1.30
1	902	1.22	2.77	3.04	3.29	2.01	2.19	6	941	0.91	0.86	0.99	0.76	0.89	0.91
1	903	0.72	0.77	0.72	0.79	1.09	0.81	6	942	1.54	1.47	1.31	1.40	1.53	1.68
1	904	0.40	0.50	0.36	0.36	0.58	–	6	943	0.83	1.15	1.18	0.99	1.04	1.51
1	939	0.89	0.86	0.96	0.81	0.69	0.57	7	920	0.27	0.45	0.45	0.45	0.55	0.83
2	905	0.72	0.59	0.43	0.53	0.56	0.51	7	921	0.49	0.50	1.07	1.88	1.61	1.81
2	906	0.65	0.47	0.36	0.36	0.39	0.47	8	922	–	–	–	–	–	–
2	907	0.89	0.65	0.49	0.46	0.47	0.47	8	923	1.20	1.44	–	2.75	2.46	4.27
2	908	0.70	0.67	0.53	0.46	0.44	0.43	8	924	1.26	1.33	1.34	2.32	1.92	3.08
3	909	1.45	1.00	0.81	0.88	0.82	0.82	8	925	1.56	0.61	–	1.57	1.15	–
3	910	0.93	0.71	0.55	0.60	0.55	0.59	8	926	1.28	1.04	1.29	1.92	1.74	1.92
3	911	1.61	1.22	0.93	0.60	0.42	0.61	8	927	0.82	0.79	0.93	1.56	1.43	1.21
4	912	1.16	0.93	1.08	1.10	0.77	0.60	8	928	0.55	0.64	0.74	0.94	1.13	1.50
4	913	1.91	1.17	1.18	1.36	1.20	0.94	9	929	0.72	–	–	–	–	–
4	914	1.14	1.08	1.02	1.08	1.06	0.94	9	930	0.70	0.54	–	–	–	–
4	915	1.12	1.11	1.21	0.90	0.69	0.81	9	931	–	1.81	–	1.79	–	–
4	934	0.95	0.81	–	–	–	–	9	935	0.74	0.66	1.21	2.21	2.30	–
5	916	3.48	2.84	2.25	2.36	2.21	1.90	9	936	0.47	–	–	–	–	2.15
5	917	0.83	0.83	0.93	1.11	0.98	0.97	9	937	–	0.92	–	–	–	–
5	918	1.40	1.64	1.31	1.38	1.37	1.72	9	938	–	–	–	–	–	–
5	919	0.27	0.45	0.45	0.45	0.55	0.83								
5	932	–	–	–	–	–	–								
5	933	0.97	1.06	0.88	0.86	0.87	0.70								

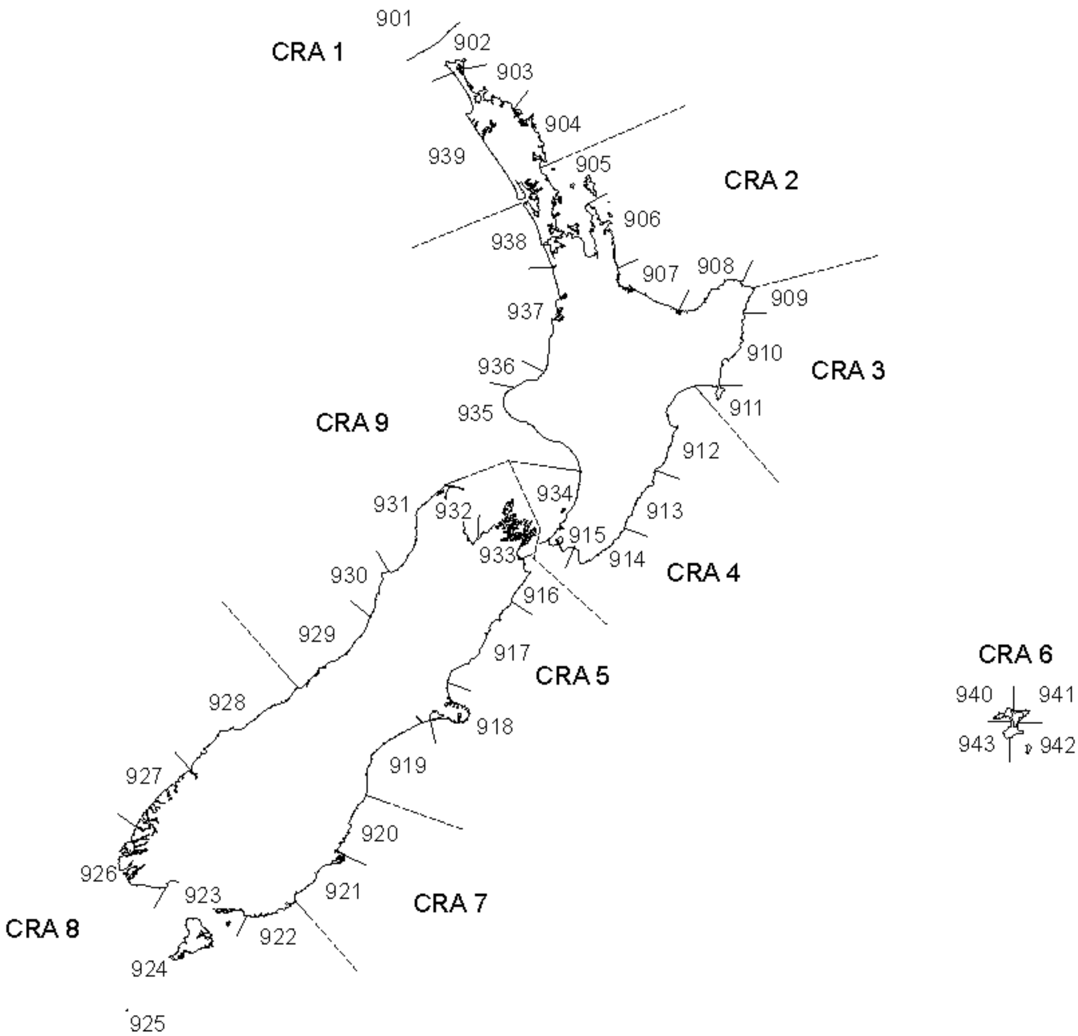


Figure 1. Rock lobster statistical areas as reported on CELR forms.

Recreational fisheries

Recreational catches have been estimated from a series of regional and national surveys based on telephone interviews and a sub-sample of diarists. Each survey estimated the New Zealand recreational catch by scaling up the reported catch in numbers by diarists with the ratio of diarists to the total estimated New Zealand population. The catch in numbers was then converted to catch in weight using mean weights of recruited lobsters observed in the appropriate catch sampling or voluntary logbook programs during the survey years. Results for rock lobster from each of these recreational surveys [South region (1991–92), Central region (1992–93), North region (1993–94), the 1996 National Diary Survey, and the 1999–2000 National survey] are presented in Table 6.

Table 6. All available estimates of recreational rock lobster harvest (in numbers and in tonnes by QMA, where available) from regional telephone and diary surveys in 1992, 1993, 1994, 1996, 2000 and 2001 (Bradford 1997; Teirney et al. 1997). Data were provided by the chairman of the Recreational Fisheries Fishery Assessment Working Group (Peter Todd, MFish; *pers. comm.*)

QMA/FMA	Number	c.v. (%)	Nominal point estimate (t)
Recreational Harvest South Region 1 Sept 1991 to 30 Nov 1992			
CRA5	65,000	31	40
CRA7	8,000	29	7
CRA8	29,000	28	21
Recreational Harvest Central Region 1992–93			
CRA1	1,000		
CRA2	4,000		
CRA3	8,000		
CRA4	65,000	21	40
CRA5	11,000	32	10
CRA8	1,000		
Northern Region Survey 1993–94			
CRA1	56,000	29	38
CRA2	133,000	29	82
CRA9	6,000		
1996 Survey			
CRA1	74,000	18	51
CRA2	223,000	10	138
CRA3	27,000		
CRA4	118,000	14	73
CRA5	41,000	16	35
CRA7	3,000		
CRA8	22,000	20	16
CRA9	26,000		
2000 Survey			
CRA1	107,000	59	102.3
CRA2	324,000	26	235.9
CRA3	270,000	40	212.4
CRA4	371,000	24	310.9
CRA5	151,000	34	122.3
CRA7	1,000	63	1.3
CRA8	13,000	33	23.3
CRA9	65,000	64	52.8
2001 Roll Over Survey			
CRA1	161,000	68	153.5
CRA2	331,000	27	241.4
CRA3	215,000	48	168.7
CRA4	419,000	22	350.5
CRA5	226,000	22	182.4
CRA7	10,000	67	9.4
CRA8	29,000	43	50.9
CRA9	34,000	68	27.7

In previous assessments, the Rock Lobster WG has not accepted results from the 1999–2000 national survey and the subsequent “roll-over” survey (Table 6), both of which tended to have higher catch estimates in most of the CRA QMAs when compared to the earlier surveys. However, this is not the case for the estimates for CRA 7 and CRA 8, which are similar across all four available surveys in terms of number of lobster captured. The Working Group agreed to use all four estimates because of this consistency (Table 7). As has been the practise in previous assessments, catch in weight was estimated using the mean weight for lobster taken from the commercial sampling data for the relevant year or years, calculated using the recreational MLS (Table 7). The Working Group has little confidence in these estimates of recreational catch.

Recreational landings made by commercial vessels under the provisions of Section 111 of the Fisheries Act were added to the survey recreational catch estimates. These were identified as greenweight landings which used the destination code "F" in the MFish landing data. The maximum annual values in this category between 1989–90 and 2005–06 were 153 kg for CRA 7 and 4 552 kg for CRA 8. These values were used as the estimated weight of the Section 111 landed lobsters and were added to the estimated recreational catch (Table 7). A single recreational catch value was used for all assessment years.

Table 7. Information used to estimate recreational catch for CRA 7 and CRA 8. All catches in kg.

	CRA 7	CRA 8
Available catch estimates (in numbers of lobsters)		
1992	8000	29000
1996	3000	22000
2000	1000	13000
2001	10000	29000
Calculation of recreational catch by weight		
1992/1996 average numbers	5500	25500
1992/1996 SS mean weight (kg)	0.669	0.663
1992/1996 average catch (kg)	3680	16912
2000/2001 average numbers	5500	21000
2000/2001 SS mean weight (kg)	0.917	0.676
2000/2001 average catch (kg)	5044	14186
Mean [1992/1996] & [2000/2001]	4362	15549
Section 111 reported landings		
Maximum reported landings	153	4552
Total estimated recreational catch	**4514**	**20101**

Mäori customary fisheries

The Ministry of Fisheries provided preliminary estimates of the Mäori customary catch for some Fishstocks for the 1995–96 fishing year. Updates of these estimates are not available. The estimates for the 1995–96 fishing year were: CRA 1, 2.0 t;, CRA 2 ,16.5 t; CRA 8, 0.2 t; CRA 9, 2.0 t; and PHC 1, 0.5 t.

MFish provided collated returns for harvest enacted under customary authorisations issued by Tangata Tiaki for CRA 7 and CRA 8 (Table 8). These values should be considered minimum estimates of the actual catch as they include only catches that were authorised and then subsequently indicated as being taken. When these catch reports in numbers of lobsters were converted to weight, the estimates for CRA 7 are negligible and the CRA 8 estimate is about 1 t/year (Table 8). Provisional estimates of customary catch of 1 t for CRA 7 and 2 t for CRA 8 were used in the stock assessment and the same value was applied to each year in each QMA.

Table 8. CRA 7 and CRA 8 customary catch estimates from Tangata Tiaki authorisations. Mean weight values of 0.38 and 0.49 kg/lobster were used for CRA 7 and CRA 8 respectively. These are the mean weights from all 2003 to 2005 samples in each of the CRA QMAs.

	Taken in numbers		Taken in kg	
Year	**CRA 7**	**CRA 8**	**CRA 7**	**CRA 8**
2003/04	0	2408	0	1174
2004/05	0	2250	0	1097
2005/06	60	796	23	388

Illegal catches

For the years 1945–1973 and 1981–82 to 1989–90, unreported or illegal catch is estimated based on the average ratio of annual exports of rock lobster relative to the reported catch in each year from 1974 to 1980. This ratio is calculated for each QMA by assuming that the exports are distributed by QMA in the same proportion as the reported catches. This ratio for CRA 7 (1.18) and CRA 8 (1.19) was applied as a constant multiplier to the reported legal catch in each of the years without export information.

Ministry of Fisheries Compliance staff have supplied illegal catch estimates for CRA 7 and CRA 8 over a number of years, with the last available estimate for 2001–02 (Table 9). Values for years without estimates were obtained by interpolation.

In the past, MFish Compliance has provided estimates of the amount of illegal catch that subsequently was reported against quota. An estimate of this quantity is required to avoid counting the same catch twice. Catches listed in Table 9 and shaded in grey were assumed to be estimates of the commercial catches that eventually were reported through legal channels. These estimates appeared to be reasonably consistent over the three available years; therefore, the Working Group agreed to use 0.80 for CRA 7 and 0.76 for CRA 8 (the mean of the 1990–91, 1992–93 and 1996–97 "commercial" illegal catch estimates relative to the total illegal catch estimates in each QMA; Table 9) as an estimate of the "reported illegal" catch. This proportion was applied to all illegal catch estimates from 1990–91 and subtracted from the legal commercial catch for the same years.

Table 9. Estimates of illegal catches (t) for CRA 7 and CRA 8 used in the 2006 assessment. The estimates by indicated category were provided by MFish Compliance. Categories shaded in grey were assumed to have been eventually reported as legal catch in the QMS.

		Estimate (t)	
Fishing year	**Explanation/notes**	**CRA 7**	**CRA 8**
1990/91	commercial illegal	34	25
	non-commercial illegal	10	5
	total	44	30
1992/93	commercial illegal	34	60
	non-commercial illegal	5	5
	total	39	65
1994/95	includes "traditional"	25	65
1995/96	illegal	15	45
	traditional	–	0.2
	total	15	45
1996/97	reported illegal (t)	15	30
	unreported illegal (t)	5	28
	total	20	58
2001/02	illegal	1	18

The Working Group members have little confidence in the estimates of illegal catch, as the estimates cannot be verified.

Other sources of mortality

Other sources of mortality include handling mortality caused by the return of under-sized and berried female lobsters to the water, and predation by octopus and other predators within pots. Although these cannot be quantified, the assessment assumes that handling mortality is 10%.

2. BIOLOGY

Although they cannot be aged, rock lobsters are thought to be relatively slow-growing and long-lived. *J. edwardsii* and *S. verreauxi* occur both in New Zealand and southern Australia. The following summary applies only to *J. edwardsii* in New Zealand.

Sexual maturity in females is reached at about 34–77 mm TW (about 60–120 mm carapace length), depending on locality. Mating takes place after moulting in autumn, and the eggs hatch in spring into the short-lived naupliosoma larvae. Most of the phyllosoma larval development takes place in oceanic waters tens to hundreds of kilometres offshore over at least 12 months. Near the edge of the continental shelf the final-stage phyllosoma metamorphoses into the settling stage, the puerulus. Puerulus settlement takes place mainly at depths less than 20 m, but not uniformly over time or between regions. Settlement indices measured on collectors can fluctuate widely from year to year. Most females in the south and southeast of the South Island do not breed before reaching MLS.

Some rock lobsters undertake long-distance migrations in some areas. During spring and early summer, variable proportions of usually small males and immature females move various distances against the current from the east and south coasts of the South Island towards Fiordland and south Westland.

Values used for some biological parameters in the CRA 7 and CRA 8 stock assessment are shown in Table 10.

Table 10. Values used for some biological parameters.

1. Natural mortality (M) [1]

Area	Both Sexes
CRA 1, 2 ,3, 4, 5	0.12
NSS	0.12

[1] This value was used as the mean of an informative prior; *M* was estimated as a parameter of the model.

2. Fecundity = a TW^b (TW in mm) (Breen & Kendrick 1998)[2]

Area	a	B
NSN	0.21	2.95
CRA 4 & CRA 5	0.86	2.91
NSS	0.06	3.18

[2] Fecundity was not used by post-1999 assessment models.

3. Weight = a TW^b (weight in kg, TW in mm) (Breen & Kendrick, Ministry of Fisheries unpublished data)

	Females		Males	
Area	**a**	**b**	**a**	**b**
CRA 1, 2, 3, 4, 5	1.30 E-05	2.5452	4.16 E-06	2.9354
NSS	1.04 E-05	2.6323	3.39 E-06	2.9665

Growth modelling

Before the 1999 assessment, growth increments from tagging data collected in the late 1970s and early 1980s were used to estimate growth rates for *J. edwardsii*. Growth rates were estimated from the estimated frequency of moulting by size and sex and the estimated increment-at-length for each sex. In assessments before 1998, these estimates were converted to a von Bertalanffy equation, then size data from catch sampling were used in length-converted catch curves to estimate total mortality. This procedure did not incorporate the variability of growth.

The 1998 assessment moved from an age-structured model to a length-based model (Starr et al. 1999; Breen & Kendrick 1999). The length-based model has been refined for each subsequent assessment. Growth-at-size is represented stochastically by growth transition matrices for each sex. The growth increments at size are assumed to be normally distributed with means and variances determined from a growth model. The transition matrices contain the probabilities that a lobster will move into specific size bins given its initial size.

Sex-specific discrete growth models were used in the stock assessment models applied from 2003 to 2005 using two parameters representing the expected growth increment of lobsters at 50 mm TW and 80 mm TW. Another two parameters described the CV of the increment for each sex, along with two additional CV parameters which applied to both sexes: the minimum standard deviation and the magnitude of observation error. The model was over-parameterised if all parameters were estimated, so the last two parameters were usually fixed. A shape parameter for each sex could also be estimated. The discrete model assumed, based on analysis of the tag-recapture data, that males moulted twice yearly and that females moulted once yearly at the beginning of autumn. Growth rates were estimated simultaneously with other parameters of the assessment model, so that growth estimates would be affected by the size frequency and CPUE as well as the tagging data.

Growth in the 2006 assessment model was changed from a discrete function to a continuous function, which primarily impacted the fits to the tag-recapture data. Under the discrete model, growth increments were related to the assumed number of moults the fish had undergone while at liberty. Under the continuous growth model, growth increments were related to the total number of days at liberty, thus dropping the requirement to make assumptions regarding the frequency of moulting. Tags which had been at liberty for four months or less and not over a moulting period (March-April and September-October) were excluded from the tag data fitted in the estimation, as well as all tags which had been out for 30 days or less. The parameterisation of the new growth model was the same as described in the previous paragraph, with the model estimating the two growth increment parameters as well as the shape parameter. All the CVs associated with the growth model were fixed at reasonable values determined from the tagging data. For instance, the observation error CV was determined from a set of tag recovery data which had been selected because the recoveries had a very low moulting probability. The growth CV parameter was fixed at values close to the MPD estimate derived from early model fits because little variation was noted in this parameter under alternative run assumptions.

(b) Settlement indices

Annual levels of puerulus settlement have been estimated for periods of up to 25 years at 6 sites from Gisborne to Otago, on the northeast of Stewart Island, at Chalky Inlet, and at Jackson's Bay on the west coast of the South Island.

The settlement data for NSC (based on the sites Gisborne, Napier, Castlepoint, Wellington, and Kaikoura) show that there was a strong settlement pulse during the period 1991–92 (and into 1993 at some sites). Settlement then declined markedly (except for a moderate year in 1998), in 1999 reaching the lowest ever seen. From 2000 there was a recovery in levels of settlement, 2001–04 being near the long-term average and slightly higher in 2005 (but well above average at Kaikoura in 2003). Recruitment of lobsters to the fishery from the high 1991–93 settlements may have contributed to the increase in CPUE in the NSC fishery in the mid to late 1990s.

The years 1981, 1983, 1987, 1991, 1992, and 1993 were high settlement years, and 1999 a very low settlement year, over broad areas of the east coast. The extent of these areas suggests that factors that drive larval settlement are widespread.

For the east coast of NSS (settlement sites Moeraki and Halfmoon Bay), puerulus settlement on collectors has been low since the relatively high values of the early 1980s, except for a marked increase at Moeraki (and to a less extent at Halfmoon Bay) starting in 2000, and continuing into 2003. Settlement has been low since then. For the southwest coast (Chalky Inlet), settlement since sampling began in 1987 has been high compared to the east coast of NSS, but variable from year to year. Further north, at Jackson's Bay, it has also been variable, but lower than at Chalky Inlet.

3. STOCKS AND AREAS

There is no evidence for genetic subdivision of lobster stocks within New Zealand based on biochemical genetic and *mt*DNA studies. The observed long-distance migrations in some areas and the long larval life probably result in genetic uniformity among areas. Gene flow probably also occurs to New Zealand from populations in Australia (Chiswell et al. 2003).

Subdivision of the NSI stock on other than genetic grounds has been considered (Booth & Breen 1992; Bentley & Starr 2001). There are geographic discontinuities in the frequency of antennal banding, size at onset of maturity in females, migratory behaviour, some fishery catch and effort patterns, phyllosoma abundance patterns, and puerulus settlement levels. These observations have led to division of the NSI stock into three substocks (NSN, NSC, and NSS) for assessment. Cluster analysis based on similarities in CPUE trends between rock lobster statistical areas provides support for the current stock definitions (Bentley & Starr 2001).

Although considered separately for stock assessment purposes, the CHI stock (CRA 6) also appears to be genetically the same as the NSI stock. It may depend upon the NSI stock as a source of recruitment, but changes in abundance within the CHI stock are unlikely to affect the NSI stock.

Sagmariasus verreauxi forms one stock centred in northern New Zealand, and may to be genetically subdivided from populations of the same species in Australia.

4. DECISION RULES AND MANAGEMENT PROCEDURE

This section presents evaluations of the rock lobster decision rules and the NSS management procedure for the 2007–08 fishing year, based on CPUE data extracted in August 2006.

Data preparation procedures

For decision rule analyses, the data were extracted using method "B4" (Bentley et al. 2005) and aggregated by fishing year, month, rock lobster statistical area, and vessel. The standardisation procedure (Maunder & Starr 1995) uses month, statistical area and fishing year as explanatory variables. The data were restricted to the appropriate QMAs for each analysis and all data were used except for coded vessel number 4548, which has been consistently dropped from the NSN analysis. The decision rule comparisons for the NSN and NSC are based on the exponents of year coefficients calculated by the regression model, which uses `ln(catch/potlifts)` as the dependent variable and bases the test for a significant change on the calculated standard error for each coefficient. The coefficients in these regressions are calculated relative to the fishing year with the smallest standard error.

The NSS management procedure uses the data from CRA 8. This analysis follows the suggestion of Francis (1999) and calculates "canonical" coefficients and standard errors for each fishing year. These coefficients are standardised with respect to the geometric mean of the entire series. This procedure allows calculation of standard errors for every coefficient, including the base year coefficient. A further refinement is to scale each standardised index by the geometric mean of the simple arithmetic CPUE indices (the summed catch divided by summed effort for each fishing year). The geometric mean CPUE is preferred to the arithmetic mean because it is less affected by outliers than the arithmetic mean. This procedure scales the standardised indices to CPUE levels consistent with those observed by fishermen.

Decision Rule for NSN and NSC

The decision rule described by Breen *et al.* (1994) was modified by the National Rock Lobster Management Group (NRLMG) for the NSN and NSC substocks to allow consideration of TAC increases. The original decision rule required that a substock be assessed whenever a "standardised CPUE analysis" (Maunder & Starr 1995) showed a "significant" decrease in the CPUE for a given year relative to the CPUE estimate for 1992–93. A year index is considered "significantly different" from the 1992–93 year index if their standard-error bars do not overlap.

Table 11. Decision rule indices for 1992–93 and 2005–06 fishing years (1 April to 31 March) for the NSN and NSC substocks. The index is the year effect from a standardised CPUE analysis using 1984–85 and 1982–83 as base years for the NSN and NSC respectively. The table also shows the upper and lower bounds, which are the index plus and minus one standard error respectively. The final column indicates the significance of change between the two years (* = significant increase).

Substock	1992–93 Index	1992–93 Lower	1992–93 Upper	2005–06 Index	2005–06 Lower	2005–06 Upper	Result
NSN	0.971	0.939	1.004	1.397	1.343	1.453	*
NSC	0.394	0.387	0.402	0.958	0.934	0.982	*

NSN

The standardised CPUE for the NSN substock increased steadily between the 1992–93 and 1998–99 fishing years (Figure 2). There were four consecutive years of decrease between 1998–99 and 2002–03, but this trend appears to have levelled off and the standardised indices for both 2004–05 and 2005–06 show increases relative to 2003–04. The increase in the NSN series relative to the 2003–04 fishing year extends to both components of the NSN (CRA 1 and CRA 2). Figure 3 shows that the standardised index and the simple arithmetic mean show similar trends and that both are above the low abundance observed in the late 1980s and early 1990s.

Under the NSN decision rule, the 2005 CPUE is "significantly" above the 1992 CPUE (Table 11).

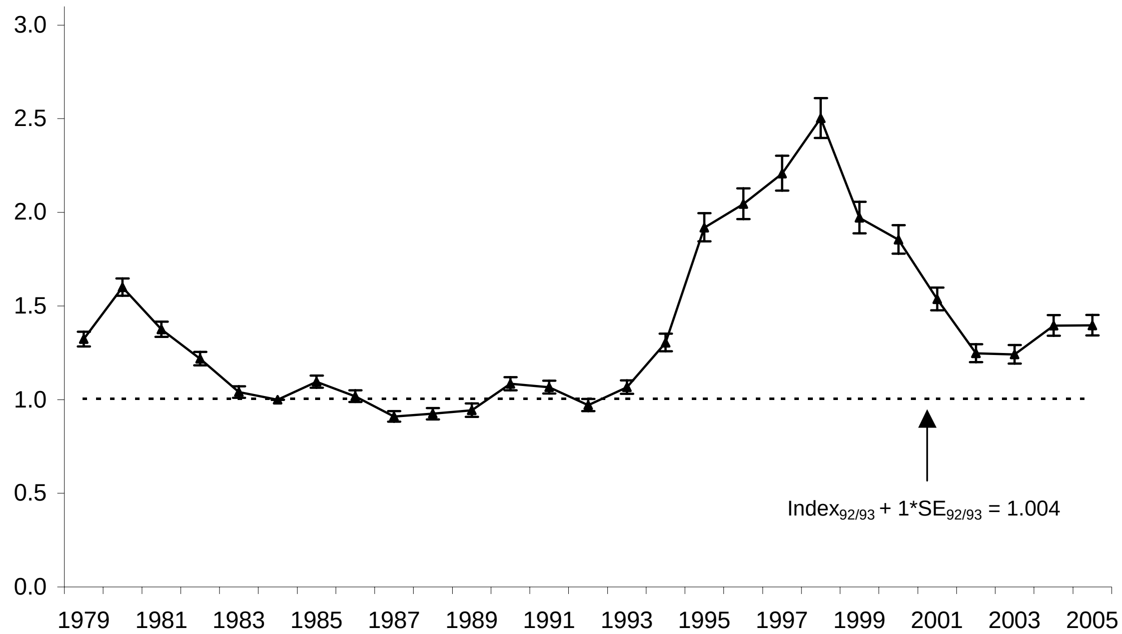


Figure 2. Values of the year index from the standardised CPUE analysis for the NSN substock showing plus and minus one standard error for each year. Horizontal line shows the upper bound of the 1992–93 standardised index which is the threshold for triggering this decision rule. Each year index is relative to the 1984-85 fishing year (the year with the lowest standard error).

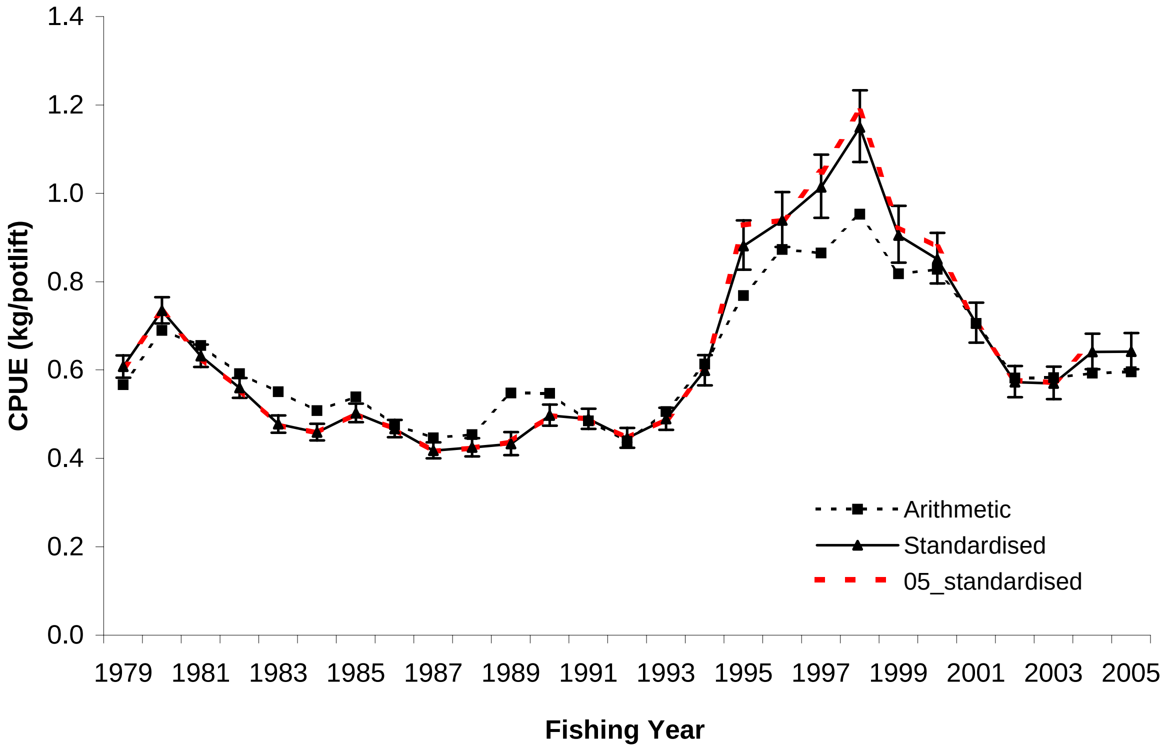


Figure 3. Values for the NSN standardised annual CPUE indices compared with the mean arithmetic annual CPUE (sum of annual catch divided by sum of potlifts). The standardised series is scaled to the geometric mean of the arithmetic annual CPUE (kg/potlift). Also shown is the equivalent standardised series calculated in September 2005.

NSC

As in the NSN substock, standardised CPUE for the NSC substock increased steadily between the 1992–93 and 1998–99 fishing years (Figure 4). Since then, there has been a continuous drop in CPUE to a level about 40% below the 1998–99 peak. This decline occurred in all three components of the NSC (CRA 3, CRA 4 and CRA 5), although not in synchrony, and the CRA 5 index has only dropped slightly from its 2003 peak. As for the NSN substock, the standardised index for 2005–06 is well above the lowest level, which was observed in 1992–93.

Figure 5 compares the standardised index with the simple arithmetic mean: both show similar trends and remain above the low abundance seen in 1992–93. The unstandardised index is lower than the standardised index for this substock, probably reflecting the switch to a winter fishery with generally lower catch rates. It is likely that the standardisation model interprets the relatively high catch rates in these winter months as indicative of higher abundance.

Under the decision rule, the 2005 CPUE is "significantly" above the 1992 CPUE (Table 11).

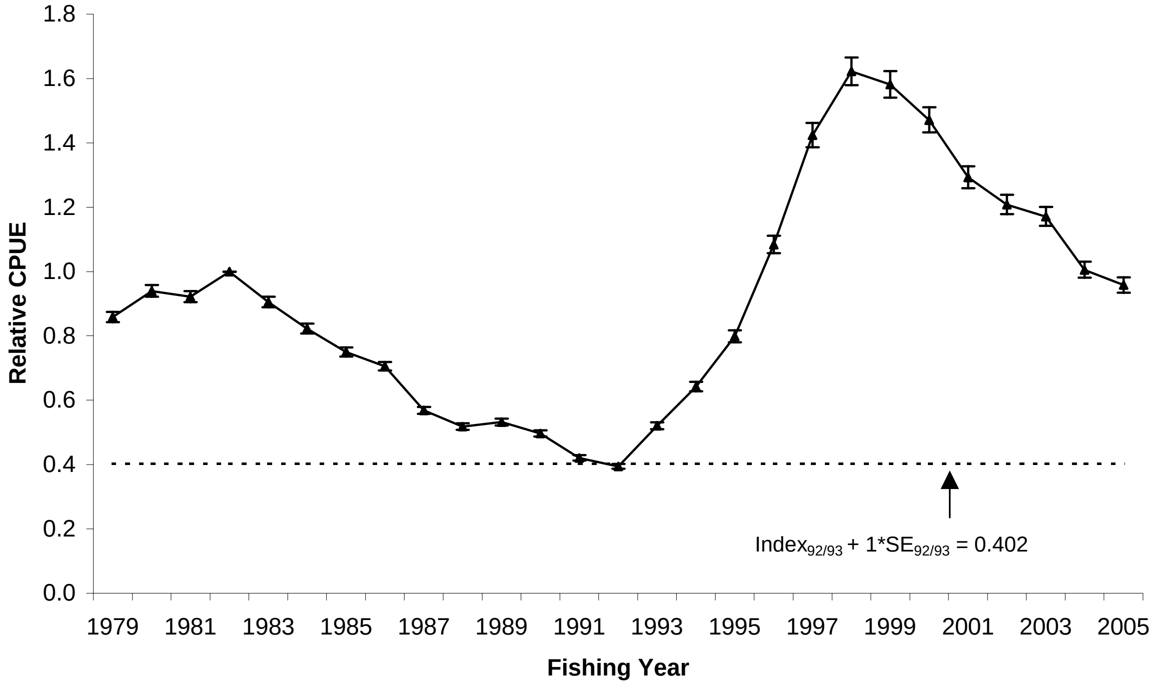


Figure 4. Values of the year index from the standardised CPUE analysis for the NSC substock showing plus and minus one standard error for each year. Horizontal line shows the upper bound of the 1992–93 standardised index which is the threshold for triggering this decision rule. Each year index is relative to the 1982-83 fishing year (the year with the lowest standard error).

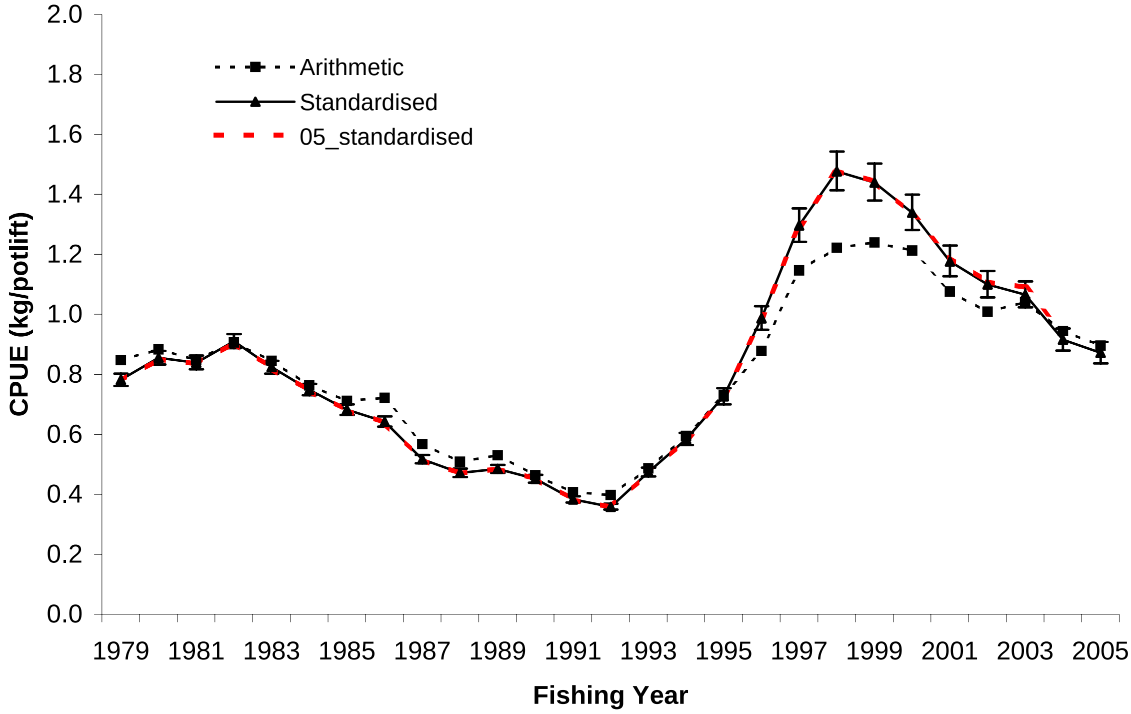


Figure 5. Values for the NSC standardised annual CPUE indices compared with the mean arithmetic annual CPUE (sum of annual catch divided by sum of potlifts). The standardised series is scaled to the geometric mean of the arithmetic annual CPUE (kg/potlift). Also shown is the equivalent standardised series calculated in September 2005.

Management Procedure for NSS

A management procedure was proposed by the National Rock Lobster Management Group and accepted by the Minister of Fisheries in 1996. This resulted in TAC and TACC decreases in 1999 and 2001. A revised management procedure was proposed and accepted in 2002. Evaluation of the revised procedure is documented in Bentley et al. (2003); this considered a number of different stock and recruitment hypotheses across a series of management strategies for the two NSS QMAs. This work evaluated a family of "harvest control rules" operating within generic procedure to set the annual TAC. Both the old and new management procedures are rebuilding rules designed to achieve a specific target CPUE within a specified number of years.

This rule was revised again in 2003 to reflect a change in the CPUE standardisation procedure, in turn made necessary by the increasing practice of landing lobsters to holding pots (discussed above). Recent CPUE estimates were decreased by the change, but the target CPUE was unchanged because it is based on early data unaffected by the holding pot problem. The Minister agreed to extend the projected rebuilding time and to retain the original slope of the rebuilding trajectory.

The new management procedure currently applies to the entire NSS substock but is based entirely on data from the CRA 8 QMA because the CRA 7 quota holders wanted the option of adopting a different management procedure at a later date. In the interim, CRA 7 stakeholders agreed to abide by the results from the NSS management procedure.

The harvest control rule evaluates how well the observed CRA 8 CPUE tracks the rebuilding trajectory (through a "status" indicator) and how well the CPUE trend compares with the increasing target trajectory (through a "gradient" indicator). The harvest control rule represent a compromise between fishery harvest goals and stock risk goals while staying within the rebuilding time frame. The criteria used to select this specific harvest control rule are presented in Bentley et al. (2003), along with its performance relative to other evaluated rules.

Revised target biomass level and slope

Legislation requires that New Zealand fisheries be managed to maintain stocks at or above B_{MSY}, the recruited biomass associated with the maximum sustainable yield (*MSY*). However, B_{MSY} is not defined in the legislation and Francis (1999) has observed that B_{MSY} will vary depending on the harvest strategy adopted, which is frequently undefined. A workshop on the use of B_{MSY} in New Zealand fisheries management held in 2001 suggested that

> "*a more pragmatic management approach, consistent with the Purpose of the Act, is to ensure that stocks are managed above, for example, the lowest observed stock size that has been known to give rise to good recruitment*" (Stokes *et al.* 2001).

Following this suggestion, a target level of CPUE based on the history of the fishery is being used. This approach continues the use of commercial CPUE as an index of abundance in rock lobster fisheries and uses the average of the standardised CPUE indices from CRA 8 from 1979–80 through 1981–82. These are the first three years for which reliable CPUE data are available, and the CPUE indices for these three years were higher than at any subsequent time until the 2005–06 fishing year. A target CPUE which is between two and three times larger than the lowest levels observed in the late 1990s should serve as a reasonable and achievable reference biomass level.

Thus the target CPUE is the mean of standardised CPUE for 1979–80 through 1981–82. The slope to this target begins at the standardised CPUE for 1997–98. When the decision rule was revised in 2003, it was agreed to use the slope that was operative at that time. This was based on a target of 1.9 kg per potlift and a starting point of 0.94 kg/potlift, giving a slope of 0.068571 kg/potlift/year. This value has been retained in the current calculations.

Description of the harvest control rule

The new rule acts by calculating a multiplier that determines the new catch from the existing catch:

$$TAC_{t+2} = Z_t \, TAC_{t+1}$$

The Z_t is calculated from observed and target values for CPUE in any year and from the three parameters of the rule:

- *N*, the number of years used for averaging CPUE in the rule;
- *W*, relative weight given to the distance between observed and target CPUE, relative to the difference between target and observed gradients; and
- *S*, a scaling or sensitivity parameter used to determine the rule's response.

These three parameters thus define a large family of candidate harvest control rules and the rule selected by the NRLMG in Table 12 is one specific member of this family. In this family of rules, the difference between target and observed CPUE is calculated in a "status indicator" for each year of data:

$$A_t^s = I_t^{obs} \big/ I_t^{pred} - 1$$

where I_t^{obs} and I_t^{pred} are the observed and predicted (target) CPUE observations.

Similarly, the difference between the target and observed gradient is calculated in a "gradient indicator:

$$A_t^g = \left(\left(I_t^{obs} - I_{t-1}^{obs}\right)/ I_{t-1}^{obs}\right) - \left(\left(I_t^{pred} - I_{t-1}^{pred}\right)/ I_{t-1}^{pred}\right)$$

Each is averaged for *N* years:

$$\overline{A}_t^s = \frac{1}{N}\sum_{d=t-N+1}^{d=t} A_d^s$$

and similarly for A_t^g to obtain $\overline{A}_t^g$. The mean gradient and status indicators are combined, using the relative weight *W*:

$$A_t^* = W\overline{A}_t^s + (1-W)\overline{A}_t^g$$

Now the combined mean indicator is used with the scalar *S* to determine a response:

$$R_t = SA_t^*$$

Then this response is used to determine the multiplier Z_t, taking into account the sign of R_t and limiting the magnitude with minimum and maximum thresholds (Table 12).

$Z_t = 1$	for $-Minimum \le (R_t) \le Minimum$
$Z_t = 1 + R_t$	for $-Maximum \le (R_t) < -Minimum$ and
	for $Minimum < (R_t) \le Maximum$
$Z_t = 1 - Maximum$	for $(R_t) < -Maximum$
$Z_t = 1 + Maximum$	for $(R_t) > Maximum$

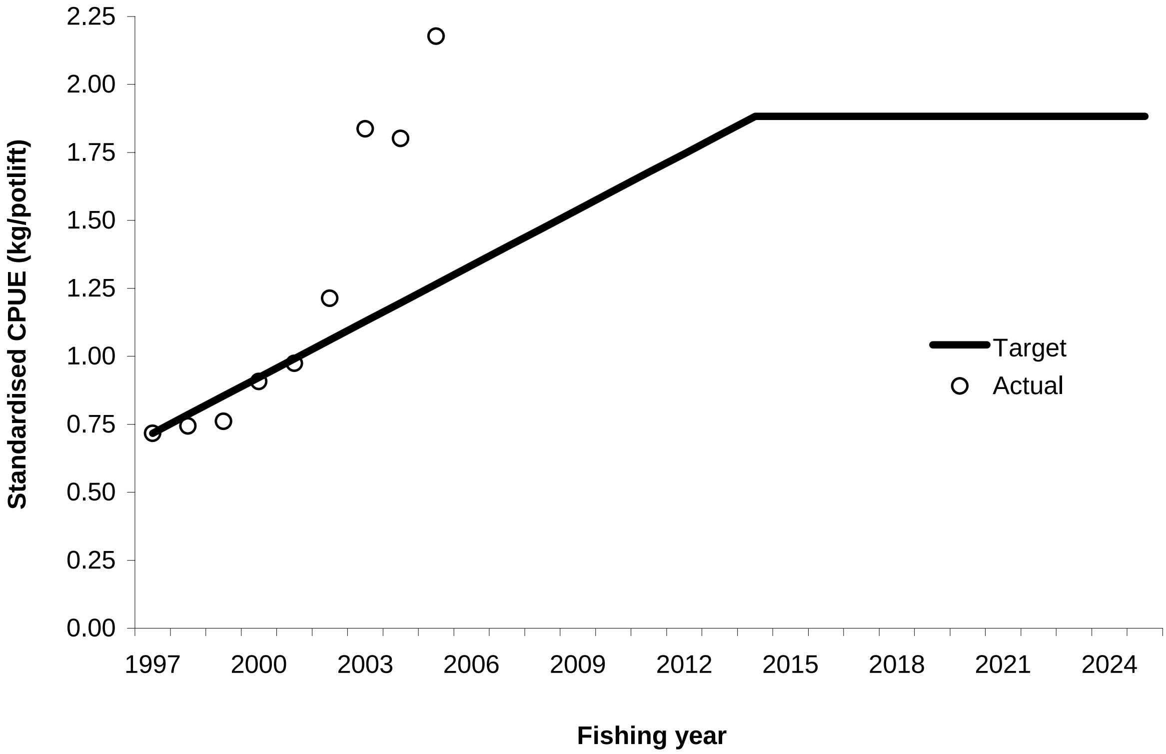


Figure 6: Operation of the NSS harvest control rule for 2006. The description of how the "target" and "actual" data sets are generated is described in the text under the "Revised target biomass level and slope" section.

As in the previous NSS management procedure, a "latent year" is specified, prohibiting changes to the TAC in two consecutive years.

Table 12. Parameters of the NSS harvest control rule.

Parameter	Value
N (number of years in running average for both the "status" and "gradient" indicators)	3
W (relative weight for the "status" indicator)	0.40
S (scalar for management decision)	0.75
Minimum (minimum management action accepted)	0.05
Maximum: (maximum management action accepted)	0.25

Table 13: Implementation of NSS decision rule for 2006, based on a constant slope of 0.06857 kg/potlift/year –: not required for the evaluation.

Fishing year	Target Rebuil CPUE	Observed Standardised CPUE	Status Indicator	Gradient Indicator	A_t^*	R_t	Z_t
2002–03	1.060	1.213	–	–			
2003–04	1.129	1.837	0.627	0.449			
2004–05	1.197	1.802	0.505	-0.080			
2005–06	1.266	2.178	0.720	0.151			
Mean	–	–	0.618	0.174	0.351	0.263	1.250

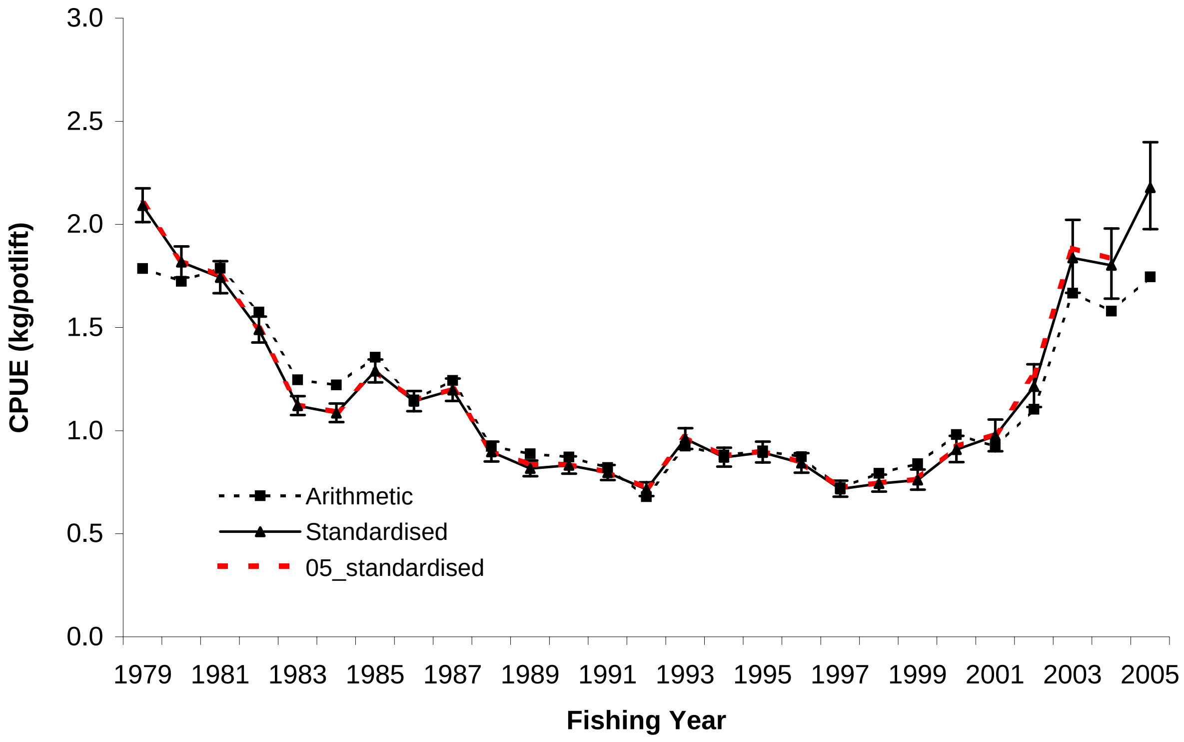


Figure 7: Values for the 2005 CRA 8 standardised annual CPUE indices compared with the mean arithmetic annual CPUE (sum of annual catch divided by sum of potlifts). The standardised series is scaled to the geometric mean of the arithmetic annual CPUE (kg/potlift). Also shown is the equivalent standardised series calculated in September 2005.

Implementation of NSS harvest control rule for 2005

A plot of the observed standardised CPUE indices compared with the agreed CRA 8 rebuilding trajectory is provided in Figure 6. The CPUE index for 2005 is considerably higher than the indices calculated for 2003 and 2004, corroborating the increases observed in these years (Figure 7). The status indicator measures the amount that the observed CPUE indices deviate from the target trajectory. The mean value for this indicator over the last three years (*N*; Table 12) is 0.618 (Table 13). The gradient indicator measures the degree to which the slope of the observed CPUE differs from the slope of the rebuilding trajectory. The mean value for this indicator over the last three years (*N*; Table 12) is 0.174. When these two indicators are averaged using the weighting parameter *W* (Table 12), the resulting value $\left(A_t^*\right)$ is 0.351 (Table 13). This value is scaled by the scaling parameter *S* (Table 12) to create a response $\left(R_t\right)$ of 0.263 (Table 13). This value is greater than the agreed maximum change value for the management procedure (0.25; Table 12), so the value of Z_t would be set to 1.250 (Table 13). However, there cannot be an increase in the TAC for 2006–07 because an increase was awarded in 2005–06.

5. STOCK ASSESSMENT

A new multi-stock length-based model was developed in 2006 based on the model previously used for rock lobster stock assessments. When multiple regions are modelled, separate parameters can be estimated for each region or common parameters can be estimated and shared by the regions. The dynamics allow for movement among regions. Other changes included the use of a continuous growth function and two options for the catch equations (instantaneous or discrete).

The new model was able to closely match the results (MPD estimates) from the 2005 assessment for CRA 4 (when run as a single stock model), indicating that the coding changes were properly implemented. Biomass trajectories and parameter estimates were similar to the original assessment.

CRA 7 and CRA 8 assessments in 2006

New catch histories for each stock were developed within the Working Group and also various other assumptions agreed for recreational and customary catches. Input data to the model included tag recoveries for growth rates, standardised CPUE from 1979-2006, historical catch rate data from 1963-73 and length frequency data from commercial catches (log book and catch sampling data). The start date for the model was set at 1976 to improve the behaviour of the model (to overcome problems with the Hessian matrices).

The Working Group discussed the results from a proposed basecase and 5 sensitivity trials. The results were generally similar indicating that the model had explored the same general solution in all six runs. However, there were some differences in the indicators between the runs. Overall there appeared to be poor MCMC behaviour for all model runs.

A primary diagnostic is the appearance of the traces, simply the parameter value plotted against sample number. These should be well mixed and should not show a trend through the simulation. In the proposed basecase MCMC simulation, the *M* parameter shows a jump after about 900 samples from values between 0.02 and 0.03 up to values between 0.04 and 0.07. This problem is also seen in the running median, running percentile and moving mean plots. These should ideally show good stability through the simulation, but diagnostics for the estimated parameters in this run were not good.

Traces for the *M* parameter did not appear to cover the full range of values that are plausible. For example the MCMC only explored values in the range 0.02 to 0.07 while higher values are plausible. These diagnostics suggest that the MCMC is not properly converged, and that the behaviour of *M* is a prime suspect. Most other posteriors appear to be well-formed.

The proposed basecase was not considered acceptable by the Working Group to report as the final assessment for these stocks. However, the Working Group did not consider there was any current sustainability concern with these stocks. Both stocks show increasing CPUE to levels not seen since the 1980s. CPUE in CRA8 in 2006 (Figure 7) was well above the target set for the rebuilt stock (1.9 kg per potlift).

The Working Group agreed that as no management measures were required in CRA 7 and CRA 8 for 2007, the assessment did not need to be completed before the planned November Plenary meeting (this meeting was subsequently cancelled). However, to allow the management strategy evaluation to be completed for CRA 7 and CRA 8 in 2007 an agreed basecase model will be required early next year. Alternative parameterisations or methodology may be needed to form a base operating model suitable for management strategy evaluation.

6. YIELD ESTIMATES

Estimation of Maximum Constant Yield (MCY)

***Jasus edwardsii*, all stocks**

MCY was not estimated.

***Sagmariasus verreauxi*, PHC stock**

MCY was estimated using the equation $MCY = cY_{av}$ (Method 4). Mean annual landings for 1979–96 were 20.0 t. The best estimate of *M* is 0.1, so the value of *c* was set at 0.9.

$$MCY = cY_{av} = 0.9 * 20 = 18 \text{ t}$$

It is not possible to assess the level of risk to the stock of harvesting the population at the estimated MCY value.

Estimation of Current Annual Yield (CAY)

***Jasus edwardsii*, all stocks**

CAY was not estimated for any stock.

***Sagmariasus verreauxi*, PHC stock**

CAY was not estimated because no biomass estimates are available for this stock.

7. STATUS OF THE STOCKS

***Jasus edwardsii*, NSN substock**

CRA 1

The stock assessment of CRA 1 was not updated in 2006. The 2002 model results suggest that 2001–02 stock abundance was higher than in the 1979–88 reference period, with low exploitation rates under levels of catch used in the assessment. Those levels of catch appear to be sustainable, because model projections at the end of the 5-year projection period have a median expected biomass near the 2001–02 biomass.

However, the projections showed increasing uncertainty on an annual basis and should not be considered reliable much beyond two to three years. Because the projections are made under the assumption of constant catches fixed at levels used in the assessment (commercial 129.2 t, amateur 47.2 t; customary 10 t; unreported illegal 72 t.), an increase in future catch levels would result in an increased probability of a decrease in biomass.

Model results seemed robust to the range of assumptions examined in the sensitivity trials, and also showed good retrospective performance. In particular, the effect of assuming a higher non-commercial catch history in the model resulted in similar current and projected stock status.

CRA 2
The stock assessment of CRA 2 was not updated in 2006. The 2002 model results suggested that 2001–02 stock abundance was higher than in the 1979–88 reference period, with exploitation rates of 20–25% in each season under catch levels used in the assessment. Model results seemed robust to the range of assumptions examined in the sensitivity trials. In particular, the effect of assuming a higher non-commercial catch history in the model resulted in similar current and projected stock status.

The 2001–02 levels of catch as used in the assessment (commercial 225 t, amateur 122.6 t, customary 10 t, illegal 88 t.) appeared to be sustainable, because model projections at the end of the 5-year projection period have a median expected biomass near the 2001–02 biomass. However, in this stock, the projections should be considered less reliable than for CRA 1, as the uncertainty of future recruitment has more impact short-term on projected biomass. Because the projections were made under the assumption of constant catches fixed at the levels used in the assessment, an increase in future catch levels would result in an increased probability of a decrease in biomass.

***Jasus edwardsii*, NSC substock**

CRA 3
The stock assessment of CRA 3 was not updated in 2006. The 2004 assessment resulted in a TACC reduction to 190 tonnes from 1 April 2005. The assessment showed the stock increased sharply from 1992 to 1998 and then decreased. The 2004 index biomass was about 60% of the biomass corresponding to a catch rate of 0.75 kg/pot lift. CPUE rose steadily from 1993, peaked in the 1997–98 season and has declined since.

The projections assume current levels of non-commercial catch and 210 tonnes of commercial catch in the next 3 years. The base case assessment showed a median expectation that the stock would increase by 20% in three years at these levels, but the 5th and 95th percentiles of future stock level were 40% and 280% of the 2004 level, so the stock could increase or decrease. Additional uncertainty in the projections comes from several sources. Levels of recreational, illegal and traditional catches are poorly determined. These catches, especially historical illegal catches, may have been substantial in some years and errors in estimation translate directly into uncertainty in the projections. Further, these non-commercial catches could change, with unpredictable effects on the stock.

The projections rely on an assumption about recruitment (at 32 mm TW in the model) – it was assumed that recruitment would be similar, on average, to that in the period 1991–2000 with variability as seen in those ten years. However, recruitment in the past ten years is not necessarily a good basis for prediction of future recruitment.

The settlement data for NSC to the end of 2002 show that there was a strong settlement pulse in the early 1990s, followed by lower settlement up to 1999. From 2000 there has been a recovery in settlement levels, with 2001–03 near the long-term average.

CRA 4
The stock assessment of CRA 4 was updated in 2005. The 2005 model results suggest that stock abundance in 2005–06 was higher than in the 1979–88 reference period. Exploitation rate peaked in the late 1980s to early 1990s in the spring-summer fishery, and recent exploitation rate is between 20% and 30% of the size-limited catch. Current levels of catch produce a median 6% reduction in model biomass over three years to a level that usually remains higher than the reference levels.

Model results are robust to the range of assumptions examined in the sensitivity trials, including the assumption of domed selectivity and a non-linear CPUE fit. The model also shows stable retrospective performance. In particular, the effect of doubling the non-commercial catch histories in the model resulted in similar current stock status and similar projection results. The basecase was chosen after extensive exploration of model runs that showed sensitivity to data weighting assumptions. This suggests that other credible model structures may exist.

CRA 5

The stock assessment of CRA 5 was not updated in 2006. The 2003 model results suggest that 2002–03 vulnerable biomass is higher than in the 1979–88 reference period, with moderate exploitation rates under levels of catch used in the model. With the 2002-03 assumed levels of catch, model projections at the end of the 5-year projection period show a median biomass smaller than the 2002–03 biomass, but still well above the reference levels. The 2002–03 vulnerable biomass is estimated to be greater than at any time in the last 20 years and the decrease is expected to be modest.

These projections show increasing uncertainty on an annual basis and should not be considered reliable beyond two to three years. Because the projections are made under the assumption of constant catches fixed at 2002–03 levels, an increase in future catch levels would result in an increased probability of a decrease in biomass and likely lower future biomass.

Model results seem robust to the range of assumptions examined in the sensitivity trials, and also show reasonable retrospective performance. The effect of higher alternative non-commercial catch histories in the model resulted in similar current stock status but quite different projected stock status.

Jasus edwardsii, NSS substock

In 2006, CRA 7 and CRA 8 were modelled simultaneously as separate stocks within a new multi-stock model. The assessment was not finalised in the time available, however, both stocks show increasing CPUE to levels not seen since the 1980s. CPUE in CRA8 in 2006 was well above the target set for the rebuilt stock (1.9 kg per potlift). This indicates that it is now time to develop a management strategy designed to maintain stock biomass rather than continue to use the current decision rule which was intended for stock rebuild.

The outcome of the management procedure in 2005 triggered a 22% increase in the TACs for CRA 7 and CRA 8 which was implemented at the beginning of the 2006–07 fishing year. No management action is required this year as the management procedure specifies a “latent year”, which prohibits changes to the TAC in two consecutive years.

Jasus edwardsii, CHI stock

The stock assessment for this substock has not been updated since 1996. The status of this stock is uncertain. Catches have been less than the TACC since 1990 and CPUE showed a declining trend from 1979/1980 to 1997/1998 but has remained stable since. These observations suggest a declining standing stock which may now have stabilised. However, size frequency distributions in the lobster catch have not changed, with a continuing high frequency of large lobsters. Large lobsters would have been expected to disappear from a stock declining under fishing pressure. This apparent discrepancy could be caused by immigration of large lobsters into the area being fished. The models investigated assume a constant level of annual productivity which is independent of the standing stock.

Commercial removals in the 2005–06 fishing year (351 t) were within the range of estimates for *MSY* (300–380 t), and close to the current TACC (360 t). The current TAC (370 t) lies within the range of the estimated *MSY*.

Sagmariasus verreauxi, PHC stock

The status of this stock is unknown.

Summary of yield estimates (t), TACCs and TACs (t), and reported 2005-06 commercial landings. The yield estimates for CRA 6 are the range of yield estimates from a simple production model. (–, not available).

Fishstock	QMA	2005–06 yield estimate	2005–06 Commercial TACC	2005–06 landings	2006–07 TACC	2006–07 TAC
CRA 1	Northland	–	131.1	130.5	131.1	

CRA 2	Bay of Plenty	–	236.1	225.2	236.1	452.6
CRA 3	Gisborne	–	190.0	170.0	190.0	319.0
CRA 4	Wairarapa–Hawke Bay	–	577.0	504.1	577.0	771.0
CRA 5	Canterbury–Marlborough	–	350.0	345.6	350.0	467.0
CRA 6	Chatham Islands	300–380	360.0	351.2	360.0	370.0
CRA 7	Otago	–	94.886	95.0	120.2	140.2
CRA 8	Southern	–	603.37	603.2	755.2	842.2
CRA 9	Westland–Taranaki	–	47.0	46.6	47.0	
CRA 10	Kermadec	–	0.1	0	0.1	
Total			2589.5	2471.2	2766.7	
PHC 1	All QMAs	18	40.3		40.3	

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