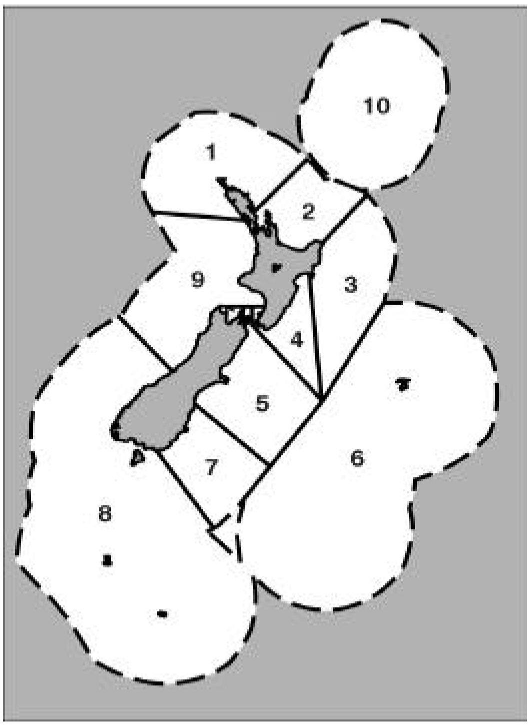
ROCK LOBSTER (CRA and PHC)

(*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 only at the Fishstock level, i.e. for CRA 1, CRA 2 &c.

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 3275 t for the year commencing 1 April 1990. This total was reduced in each year until 1993–94 to reach 2380 t (taking into account some increases in individual ITQs resulting from appeals over catch histories by fishers). The total TACC for the NSI stock has fluctuated since, with TACC increases and decreases, and was 2325 t for the 2003–04 season. The TACC for the NSI stock was increased to 2366 t for the 2004–05 season through increases in the CRA 7 and CRA 8 TACCs from the operation of the NSS Decision Rule in 2003. The TAC and the TACC for CRA 3 were reduced to 319 t and 190 t respectively beginning in 2005–06.

The TACC for the CHI stock (CRA 6) was set at 518 t in 1990 but increased through appeals to 530.6 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, which is the full 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 are permitted to retain males at least 52 mm TW but females cannot 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 then closed 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. The commercial and recreational MLS measure for packhorse rock lobster is 216 mm TL for both sexes.

(a) 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	215.8	327.0	453.0
2004–05	130.8	131.1	–	197.3	236.1	452.6	162.0	327.0	453.0
2005–06		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	344.9	350.0	467.0	321.7	360.0	370.0
2005–06		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	1 152.4	–
1991–92	177.7	164.7	–	962.7	1 054.6	–
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	–	709.8	711.0	–
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	602.5	603.4	690.4
2005–06		94.9	114.9		603.4	690.4

	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	2844.1	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	–	2451.4	2685.2	3277.6
2004–05	47.0	47.0	–	2470.2	2726.5	3318.8
2005–06		47.0	–		2589.4	3184.8

i) 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 approach was modified by dropping all data for the vessel in the month with zero landings as well as in 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.

ii) *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 2005 and CPUE (kg per pot lift) for *Jasus edwardsii* NSI and CHI stocks, and NSN, NSC and NSS substocks, for the 1979–80 to 2004-05 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 2004-05 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.

Fishing	NSI Substocks						NSI		CHI	
	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	0.81	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	1.31
1992–93	301	0.44	946	0.40	1 008	0.62	2 300	0.48	329	1.15
1993–94	342	0.51	983	0.49	1 034	0.87	2 404	0.61	342	1.08
1994–95	343	0.61	945	0.60	976	0.79	2 309	0.67	313	1.07
1995–96	339	0.78	942	0.73	907	0.76	2 233	0.76	315	1.09
1996–97	343	0.87	997	0.88	925	0.74	2 312	0.83	378	1.02
1997–98	364	0.88	1 013	1.15	822	0.66	2 246	0.87	339	0.88
1998–99	361	0.97	1 117	1.22	867	0.71	2 392	0.94	334	1.17
1999–00	361	0.83	1 252	1.24	766	0.73	2 426	0.97	322	1.19
2000–01	366	0.84	1 249	1.21	791	0.81	2 453	0.99	343	1.15
2001–02	356	0.71	1 213	1.08	649	0.82	2 264	0.91	329	1.15
2002–03	336	0.59	1 216	1.01	656	0.94	2 255	0.89	336	1.16
2003–04	325	0.59	1 141	1.05	649	1.31	2 161	0.99	290	1.10
2004-05	328	0.60	1 077	0.95	697	1.36	2 149	0.96	322	1.23

iii) *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 0.97 kg per potlift. Recent trends in CPUE for CRA 1 and CRA 2 differ, with CRA 1 maintaining higher catch rates since 2000–01 while CRA 2 has declined since 1998–99 (Table 3). The combined NSN catch rate from 2002–03 to 2004–05 has held steady at about 0.6 kg per potlift.

iv) *Jasus edwardsii,* NSC substock

Landings in the NSC substock were very high up to the mid 1980s, exceeding 2000 t per fishing year for five fishing years in succession. During that time CPUE dropped from 0.9 kg per potlift to 0.7 kg (Table 2). Commercial catches then gradually decreased to below 1000 t by the early 1990s and CPUE dropped to below 0.5 kg per potlift. From 1993–94, CPUE increased to a peak of 1.24 kg/potlift in 1999–2000 (Table 2). CPUE has subsequently fallen to just below 1.0 kg per potlift since 2001–02, which is still higher than catch rates 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).

v) *Jasus edwardsii,* NSS substock

Catches and CPUE were high for this substock (greater than 1500 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 1000 t per fishing year and below 1.0 kg per potlift by the early 1990s (Table 2). CPUE remained below 1.0 kg per potlift from 1988–89, but has been increasing since 1997–98 and is now 1.36 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.

vi) *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 (Table 3).

vii) *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 about 1.2 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 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).

	1996–97	1997–98	1998–99	1999–2000	2000–01	2001–02	2002–03	2003–04	2004-05
CRA 1	0.95	0.89	1.04	1.09	1.17	1.30	1.20	1.22	1.24
CRA 2	0.83	0.88	0.93	0.73	0.73	0.56	0.44	0.43	0.45
CRA 3	1.76	2.18	1.63	1.56	1.19	0.95	0.73	0.63	0.52
CRA 4	1.03	1.24	1.31	1.27	1.26	1.06	1.09	1.14	1.00
CRA 5	0.56	0.79	0.89	1.00	1.16	1.27	1.27	1.42	1.27
CRA 6	1.02	0.88	1.17	1.19	1.15	1.15	1.16	1.10	1.23
CRA 7	0.25	0.24	0.30	0.22	0.35	0.46	0.52	0.58	0.75
CRA 8	0.87	0.72	0.79	0.84	0.98	0.92	1.11	1.67	1.58
CRA 9	0.98	0.79	0.92	0.88	0.93	0.82	1.11	1.63	2.14

viii) *Sagmariasus verreauxi*, PHC stock

QMS reported catches of the PHC stock have halved since 1998–99 (Table 4). Reasons for the decline and the 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).

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		

ix) *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. Estimated 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	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	CRA	Stat Area	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05
1	901	2.85	2.82	2.92	2.05	–	3.48	6	940	0.97	0.92	0.98	1.12	1.15	1.14
1	902	1.13	1.22	2.77	3.04	3.30	2.01	6	941	0.94	0.92	0.87	0.99	0.76	0.90
1	903	0.48	0.72	0.77	0.72	0.79	1.14	6	942	1.71	1.54	1.47	1.31	1.40	1.59
1	904	0.34	0.40	0.50	0.36	0.36	0.58	6	943	0.83	0.84	1.15	1.18	0.99	1.03
1	939	1.16	0.89	0.86	0.96	0.81	0.69	7	920	0.20	0.27	0.45	0.45	0.45	0.55
2	905	0.75	0.72	0.59	0.48	0.56	0.61	7	921	0.31	0.49	0.50	1.07	1.88	1.61
2	906	0.71	0.68	0.47	0.36	0.36	0.40	8	922	–	–	–	–	–	–
2	907	1.18	0.89	0.65	0.49	0.46	0.47	8	923	0.75	1.20	1.44	–	2.75	2.46
2	908	0.47	0.70	0.67	0.53	0.46	0.44	8	924	0.88	1.26	1.33	1.34	2.34	1.93
3	909	1.69	1.45	1.00	0.81	0.88	0.82	8	925	0.82	1.56	0.61	–	1.57	1.15
3	910	1.50	0.93	0.71	0.55	0.60	0.55	8	926	1.14	1.28	1.04	1.29	1.92	1.74
3	911	1.61	1.61	1.22	0.93	0.60	0.43	8	927	0.89	0.82	0.79	0.93	1.56	1.43
4	912	1.38	1.16	0.93	1.08	1.10	0.77	8	928	0.52	0.55	0.64	0.75	0.94	1.15
4	913	1.80	1.91	1.17	1.18	1.36	1.20	9	929	–	0.72	–	–	–	–
4	914	1.05	1.14	1.08	1.02	1.08	1.06	9	930	0.74	0.70	0.54	–	–	–
4	915	1.24	1.12	1.11	1.21	0.90	0.69	9	931	0.99	–	1.81	–	1.79	–
4	934	0.84	0.95	0.81	–	–	–	9	935	1.01	0.74	0.66	1.21	2.21	2.30
5	916	2.13	3.49	2.85	2.25	2.36	2.21	9	936	–	0.47	–	–	–	–
5	917	0.77	0.83	0.84	0.96	1.18	1.00	9	937	–	–	0.92	–	–	–
5	918	0.87	1.40	1.64	1.31	1.38	1.37	9	938	–	–	–	–	–	–
5	919	–	–	–	–	–	–								
5	932	–	–	–	–	–	–								
5	933	0.91	0.97	1.06	0.88	0.86	0.87								

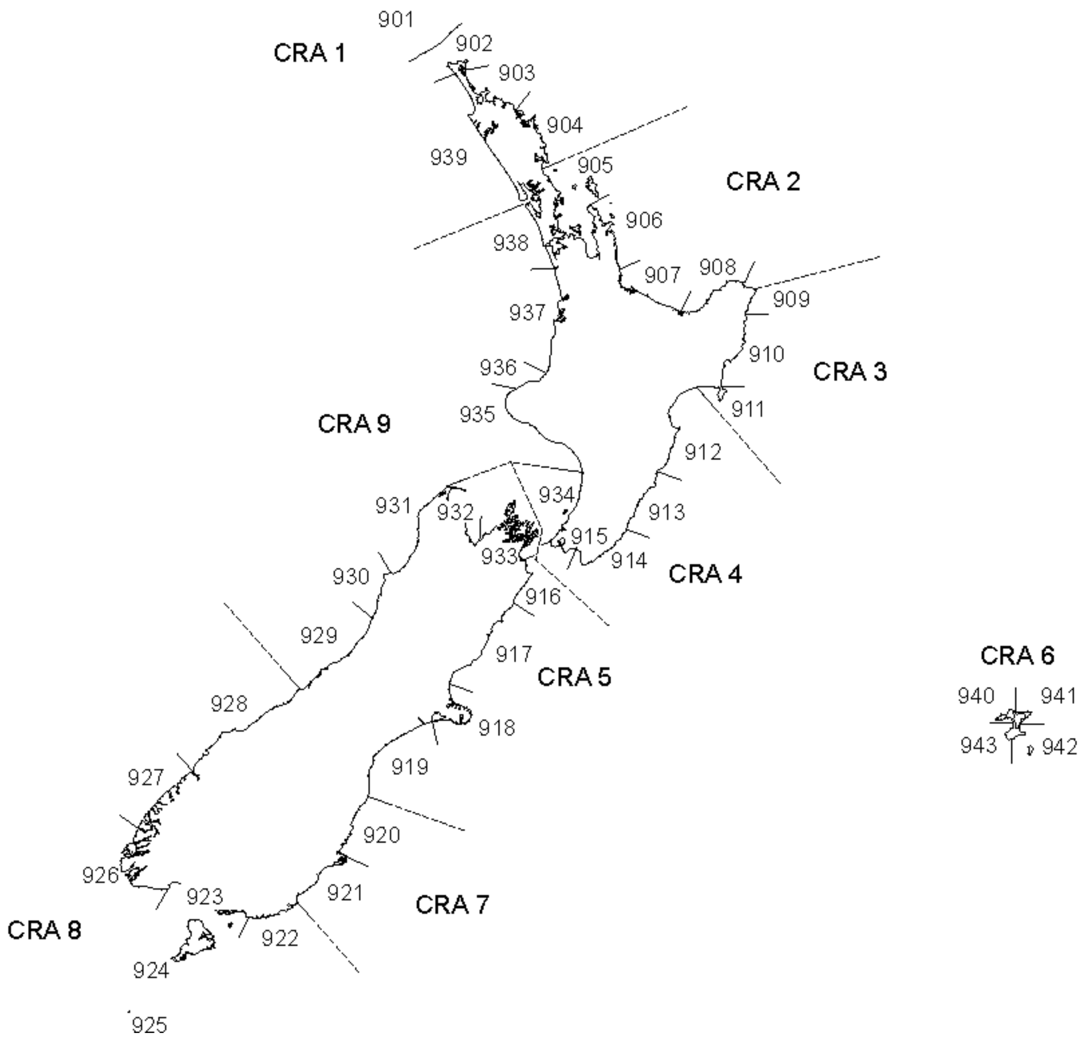


Figure 1. Rock lobster statistical areas as reported on CELR forms.

(b) Recreational fisheries

Recreational catches have been estimated from a series of regional and national telephone and diary surveys. The results from the South region (1991–92), Central region (1992–93) and North region (1993–94) are shown in Table 6 (Bradford 1997, Teirney et al. 1997). Results from the 1996 National Diary Survey (Table 7) were reported by Bradford (1998). The total New Zealand recreational catch was estimated by scaling up the reported catch by diarists by 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 (Table 6).

Estimates from a more recent national survey (1999–2000) are higher than those from the earlier surveys, but the Working Group, in the absence of documented acceptance of these results from MFish, followed its previous practice of setting these aside for the assessments. However, higher levels of recreational catch were considered in a sensitivity test to the basecase runs for the CRA 4 assessment reported below. For the base case CRA 4 assessment, catch in weight was estimated from the 1994 and 1996 surveys as described above and assumed for 1979 onwards; this was 46.7 t. It was assumed that recreational catch in 1945 was 20% of this estimate, and that recreational catches from 1946 through 1978 increased linearly to the 1994-1996 estimate. The Working Group had little confidence in the estimates of recreational catch.

Table 6. Estimates of the recreational rock lobster harvest (t) from regional telephone and diary surveys in 1992, 1993 or 1994 (-, not available). For CRA 1 and CRA 2, two estimates of catch in tonnes are presented based on two sources of mean weight: from the diary survey and from the Industry Logbook Program for CRA 2 (Bradford 1997). Mean weights used in the other CRA areas are based either on weights reported in the diaries or from boat ramp surveys (Teirney et al. 1997).

Fishstock	Estimated number of lobsters	Mean weight (g)	Estimate (t)
CRA 1	56 000	871[1] or 674[2]	48 or 38
CRA 2	142 000	871[1] or 674[2]	123 or 95
CRA 3	8 000	–	2 to 8
CRA 4	65 000	–	25 to 60
CRA 5	67 000	–	23 to 117
CRA 7	6 000	–	1 to 6
CRA 8	32 000	–	15 to 60
CRA 9	6 000	–	2 to 6

[1] diary estimate of mean weight
[2] logbook estimate of mean weight

Table 7. Estimates of the recreational rock lobster harvest (t) from the 1996 National telephone and diary survey (-, not available). Because the sex of the sampled lobster was not determined when measured in the boatramp surveys, the mean weight is based on the average size measured assuming a 50-50 sex ratio (Bradford 1998).

Fishstock	Estimated Number of lobsters	Mean weight (g)	Estimate (t)
CRA 1	74 000	686	51
CRA 2	223 000	618	138
CRA 3	27 000	–	–
CRA 4	118 000	618	73
CRA 5	41 000	858	35
CRA 7	3 000	–	–
CRA 8	22 000	700[1]	16
CRA 9	26 000	–	–

[1] assumed

(c) Maori customary fisheries

The Ministry of Fisheries provided a preliminary estimate of the Maori 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).

The Ministry of Fisheries provided an estimate of 20 t for CRA 4 for the 2004–05 fishing year. The CRA 4 assessment assumed a constant level of customary catch of 20 t per year from 1945 to 2005–06. The Working Group had little confidence in the estimates of customary catch.

(d) 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 4 (1.18) was applied as a constant multiplier to the reported legal catch in each of the years without export information.

The Ministry of Fisheries Compliance staff supplied updated illegal catch estimates for CRA 4 for 2004–05 (Table 8). There are existing estimates for CRA 4 provided by MFish Compliance from 1990–91 that were also used in the CRA 4 assessment (Table 8). 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 8 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 quite large in the early years of the introduction of rock lobster to the QMS, possibly due to transition issues as the management regimes changed. Estimates of the level of non-compliant catch that eventually found its way in the legal reporting system appeared to drop after 1995–96. Given this information, the Working Group agreed to use 0.80 (the mean of the 1990–91 and 1992–93 "commercial" illegal catch estimates relative to the total illegal catch estimates; Table 8) as an estimate of the "reported illegal" catch. This proportion was applied to the illegal catch estimates from 1990–91 to 1995–96 and this value was subtracted from the legal commercial catch for the same years. The proportion applied changed in 1996–97 to 0.133 (the mean of the 1996–97, 2002–03 and 2004–05 estimates of "reported illegal" or "illegal commercial" catches relative to the total illegal catch estimates; Table 8). The lower proportion was used with all illegal catch estimates after that fishing year and to the projection catches. It was decided for this assessment that the concept of "reported illegal" catches did not exist prior to the introduction of rock lobster to the QMS and the Working Group agreed to drop the practice of reducing the reported commercial catch by an equivalent proportion in the years prior to 1990–91.

Table 8. Estimates of illegal catches (t) for CRA 4 used in the 2005 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.

	Commercial	Non-commercial	Illegal	Traditional	Reported illegal	Unreported illegal	Poaching	Recreational	Total
1990–91	125	35							160
1992–93	25	5							30
1994–95									70*
1995–96			64	0					64
1996–97					0	75			75
2001–02			64	0					64
2002–03					9		17	34	60
2004–05					10		20	10	40

* includes traditional

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

(e) 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 4 stock assessment are shown in Table 9.

Table 9. Values used for some biological parameters.

1. Natural mortality (M) [1]

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

(a) 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.

From the 2003 stock assessment, the sex-specific growth models have been parameterised with two parameters representing the expected growth increment of lobsters of 50 mm TW and the difference between the increment at 50 and 80 mm TW. Another two parameters describe the CV of the increment for each sex, one describes the minimum standard deviation and one describes the magnitude of observation error. The model is over-parameterised when all parameters are estimated, so the last two parameters are usually fixed. A shape parameter for each sex can also be estimated. It is assumed, based on analysis of the tag-recapture data, that males moult twice yearly and that females moult once yearly, at the beginning of autumn. Growth rates are estimated simultaneously with other parameters of the assessment model, so that growth estimates are affected by the size frequency, CPUE and tagging data.

(b) Settlement indices

Annual levels of puerulus settlement have been estimated for periods of up to 24 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 to the end of 2004 (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 (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

Evaluations for the 2004–05 fishing year of the rock lobster decision rules and management procedure were made based on CPUE data extracted in August 2005 (MFish replog 5986).

(a) Data preparation procedures

The data used in all the CPUE evaluations for the NSN and NSC decision rules and the NSS management procedure were extracted from the CRACE database using procedures described in Bentley et al. (2005). All error checks were set to "Level 1", which screens out all obvious data errors. Corrections were made to the catch estimates provided in the effort section of the form based on the landing information provided at the end of the trip on the bottom part of the form. Problems with previous correction methods were documented in the 2003 and 2004 Plenary Reports (Annala et al. 2003; Annala et al. 2004). The correction method used in this analysis is the method agreed by the Rock Lobster Fishery Assessment Working Group as being the most reliable to deal with the holding pot problem ("Method B4" – see Bentley et al. 2005). This method sums all landings and effort for a vessel within a calendar month and allocates the landings to statistical areas based on the distribution of the estimated catches by area. This method assumes that landings from holding pots tend to even out at the level of a month. However, in some areas there are vessel/month combinations with no landings, indicating that the problem has not been completely solved by the vessel/month approach. In these instances, the approach was modified by dropping all data for the vessel in the month with zero landings as well as in the following month: a method that excludes uncertain data is thought preferable to one that might incorrectly reallocate landings.

Method "B4" probably has little effect on the operation of the NSN and NSC decision rules because they are defined in relative terms. For the NSS, problems created by keeping lobsters in holding pots, and the associated positive bias created, were discussed thoroughly in 2003 and the Minister accepted a revision to the decision rule, extending the rebuild period to maintain the existing slope of the CPUE target trajectory (Annala et al. 2003).

For decision rule analyses, the data are aggregated by fishing year, month, rock lobster statistical area, and vessel. The standardisation procedure was described by Maunder & Starr (1995) and 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 arithmetic index is the summed mean of the total catch and effort for each fishing year: $\left(b_{year} = \sum catch_{year} \Big/ \sum potlifts_{year} \right)$.

The geometric mean CPUE is preferred to the arithmetic mean because it is less affected by outliers than the arithmetic mean.

Because the canonical process scales the standardised series to a geometric mean of one, this refinement scales the standardised indices to CPUE levels consistent with those observed by fishermen.

(b) 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 the standard error bars of the two years do not overlap.

Table 10. Decision rule indices for 1992–93 and 2004–05 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	2004–05 Index	2004–05 Lower	2004–05 Upper	Result
NSN	0.973	0.940	1.007	1.446	1.390	1.505	*
NSC	0.394	0.386	0.402	1.036	1.011	1.062	*

i) 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 index for 2004–05 shows an increase relative to 2003–04. Figure 3 shows that both the standardised index and the simple arithmetic mean show similar trends and that both are above the low abundance of the late 1980s and early 1990s. Under the NSN decision rule, the 2004 CPUE is significantly above the 1992 CPUE (Table 10).

ii) NSC

As for the NSN substock, the 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 has occurred in all three components of the NSC (CRA 3, CRA 4 and CRA 5), although the CRA 5 index is equal to the second highest index in the series. As for the NSN substock, the standardised index for 2004–05 is above the lowest level, which was observed in 1992–93. Figure 5 compares the standardised index with the simple arithmetic mean, which shows a similar trend remaining above the period of low abundance 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 2003 CPUE is significantly above the 1992 CPUE (Table 10).

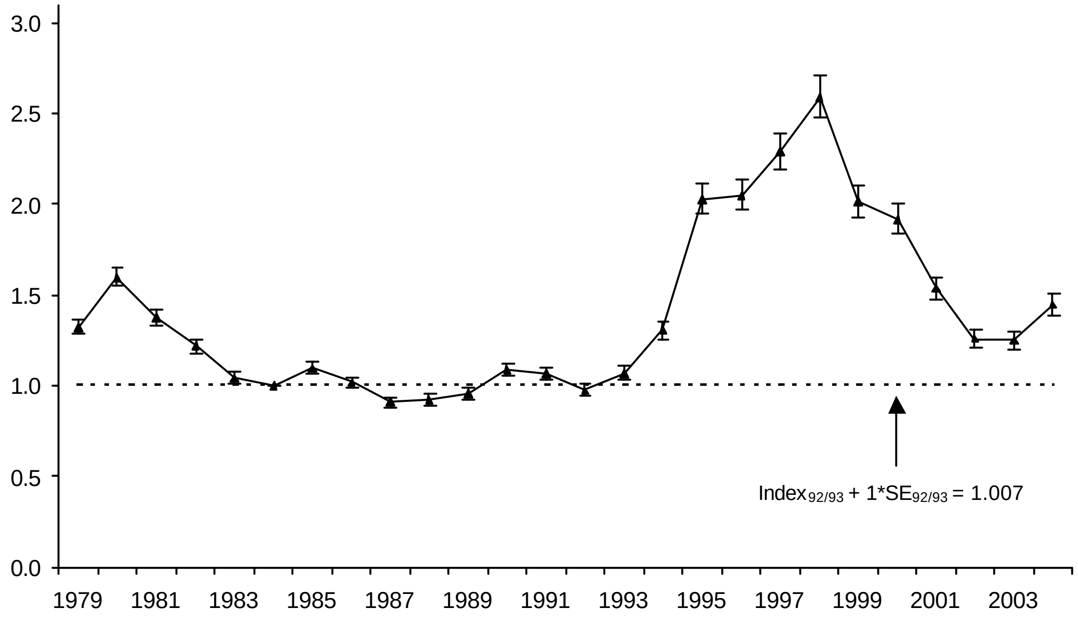


Figure 2. **Values of the year index from the standardised CPUE analysis for the NSN substock showing plus and minus one standard error for each year. Horizontal line shows the upper bound of the 1992–93 standardised index which is the threshold for triggering this decision rule. Each year index is relative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

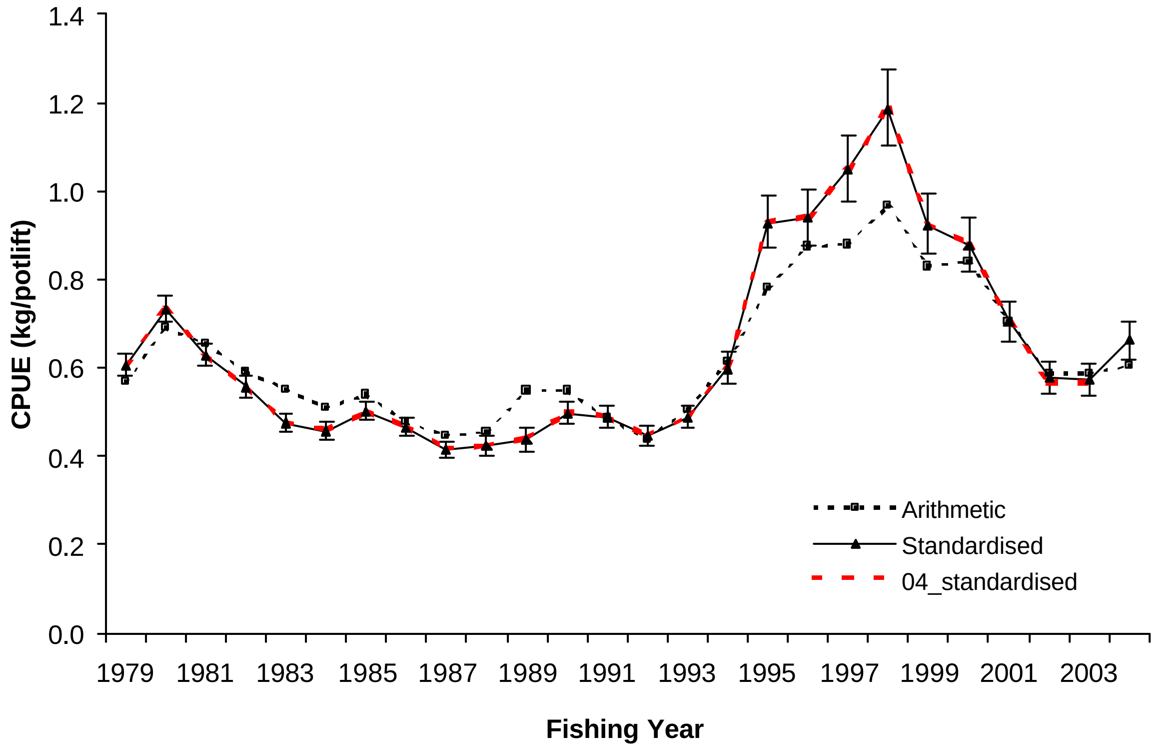


Figure 3. **Values for the NSN standardised annual CPUE indices compared with the mean arithmetic annual CPUE (sum of annual catch divided by sum of potlifts). The standardised series is scaled to the geometric mean of the arithmetic annual CPUE (kg/potlift). Also shown is the equivalent standardised series calculated in September 2004.**

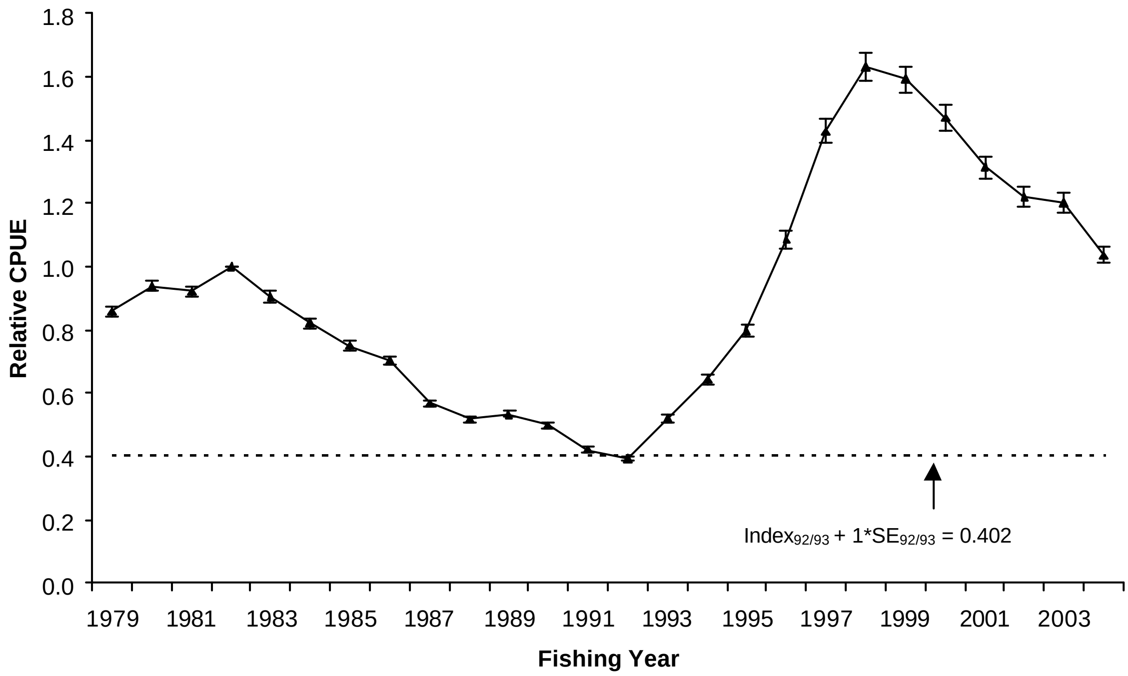


Figure 4. **Values of the year index from the standardised CPUE analysis for the NSC substock showing plus and minus one standard error for each year. Horizontal line shows the upper bound of the 1992–93 standardised index which is the threshold for triggering this decision rule. Each year index is relative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

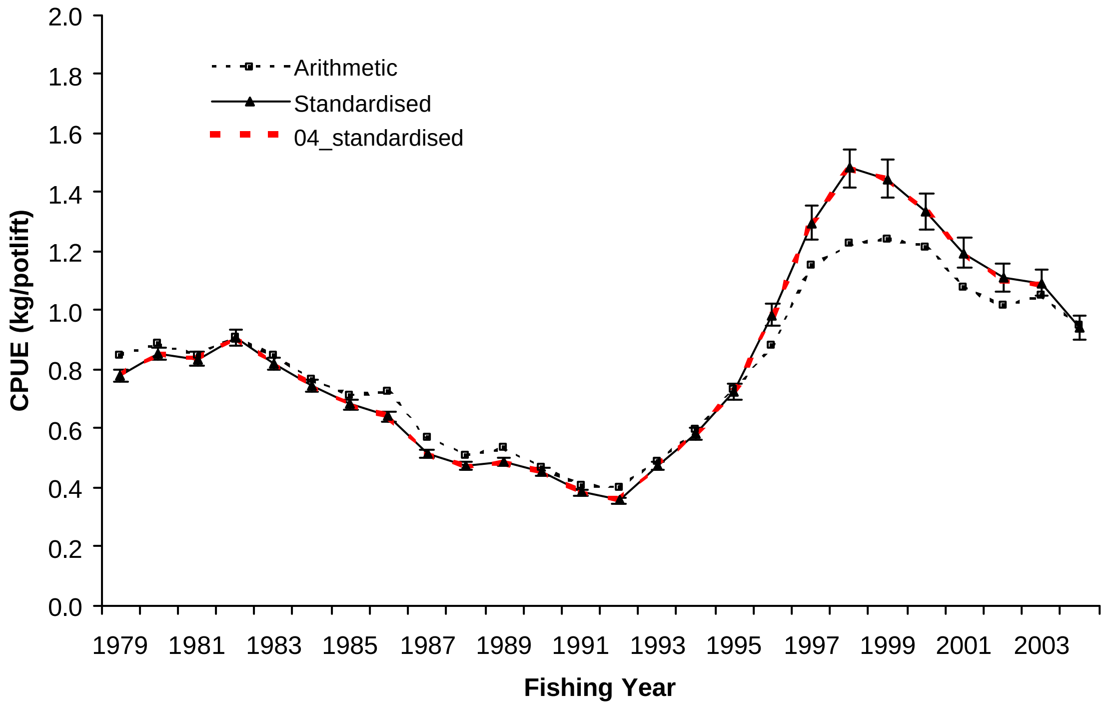


Figure 5. **Values for the NSC standardised annual CPUE indices compared with the mean arithmetic annual CPUE (sum of annual catch divided by sum of potlifts). The standardised series is scaled to the geometric mean of the arithmetic annual CPUE (kg/potlift). Also shown is the equivalent standardised series calculated in September 2004.**

(c) 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 used a family of "harvest control rules" generated by a range of parameters which drove a generic procedure to set the final 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 have agreed to abide by the functioning of the CRA 8 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 parameters of the harvest control rule represent a compromise between maximised fishery harvest goals and minimised stock risk goals while staying within the rebuilding time frame. The criteria used to select this specific harvest control rule, and its performance relative to all the other evaluated rules, are presented in Bentley et al. (2003).

i) 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 average CPUE for these years was higher than at any subsequent time. A target CPUE two to three times as large as 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, 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.

ii) Description of the harvest control rule

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

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

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 11 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:

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

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 11).

$Z_t = 1$	For –*Minimum* = (R_t) = *Minimum*
$Z_t = 1 + R_t$	for –*Maximum* = (R_t) < -*Minimum* and
	for *Minimum* < (R_t) = *Maximum*
$Z_t = 1 - Maximum$	For (R_t) <- *Maximum*
$Z_t = 1 + Maximum$	For (R_t) > *Maximum*

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

Table 11. Parameters of the new 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

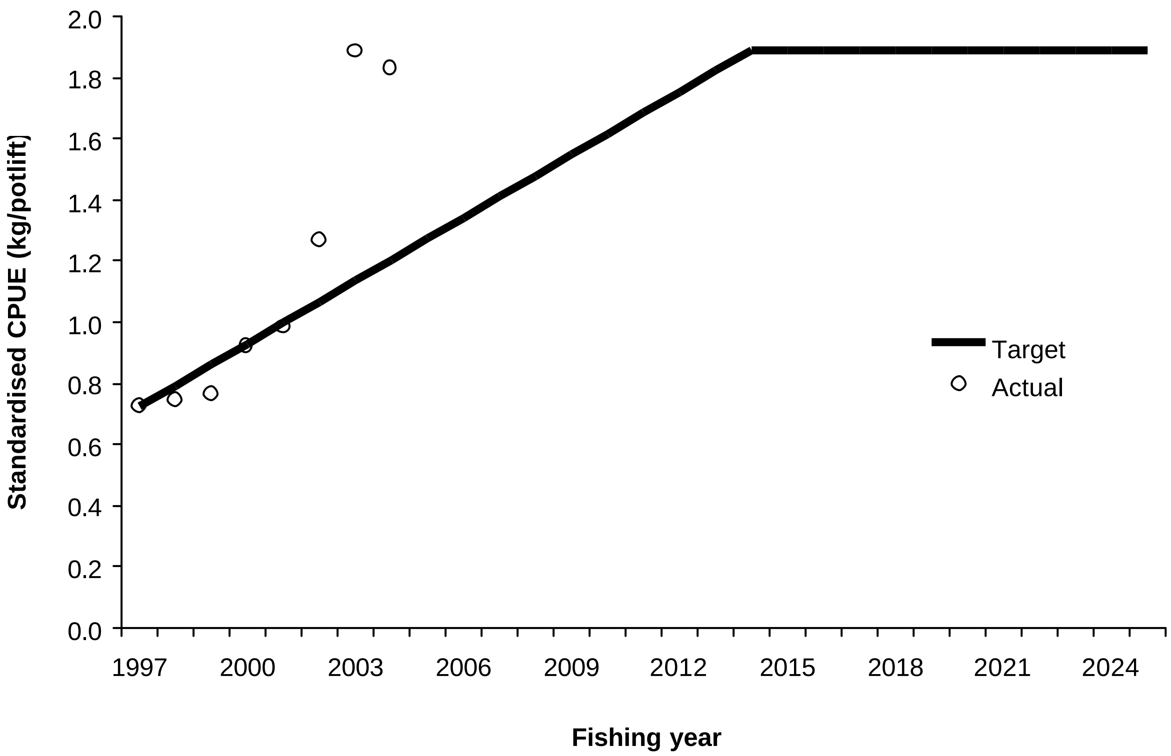


Figure 6. Observed and target CPUE used by the NSS harvest control rule in 2005. The target biomass trajectory for CRA 8 is generated by plotting a straight line from the observed starting value in the 1997–98 fishing year to the mean [1979–80 to 1981–82] CPUE, which is to be achieved in 2015–16 using a constant slope of 0.06857 kg/potlift/year. Observed CPUE is generated from the standardised CPUE analysis for CRA 8 multiplied by the geometric mean of the arithmetic (sum of annual catch divided by sum of potlifts) CPUE indices.

Table 12. Implementation of NSS decision rule for 2006-07, based on a constant slope of 0.06857 kg/potlift/year: dashes indicate values not required for the evaluation.

Fishing year	Target Rebuild CPUE	Observed Standardised CPUE	Status Indicator	Gradient Indicator	A_t^*	R_t	Z_t
2001–02	0.999	0.984	–	–			
2002–03	1.068	1.269	0.188	0.221			
2003–04	1.136	1.885	0.659	0.422			
2004–05	1.205	1.833	0.521	-0.088			
Mean	–	–	0.456	0.185	0.293	0.220	1.220

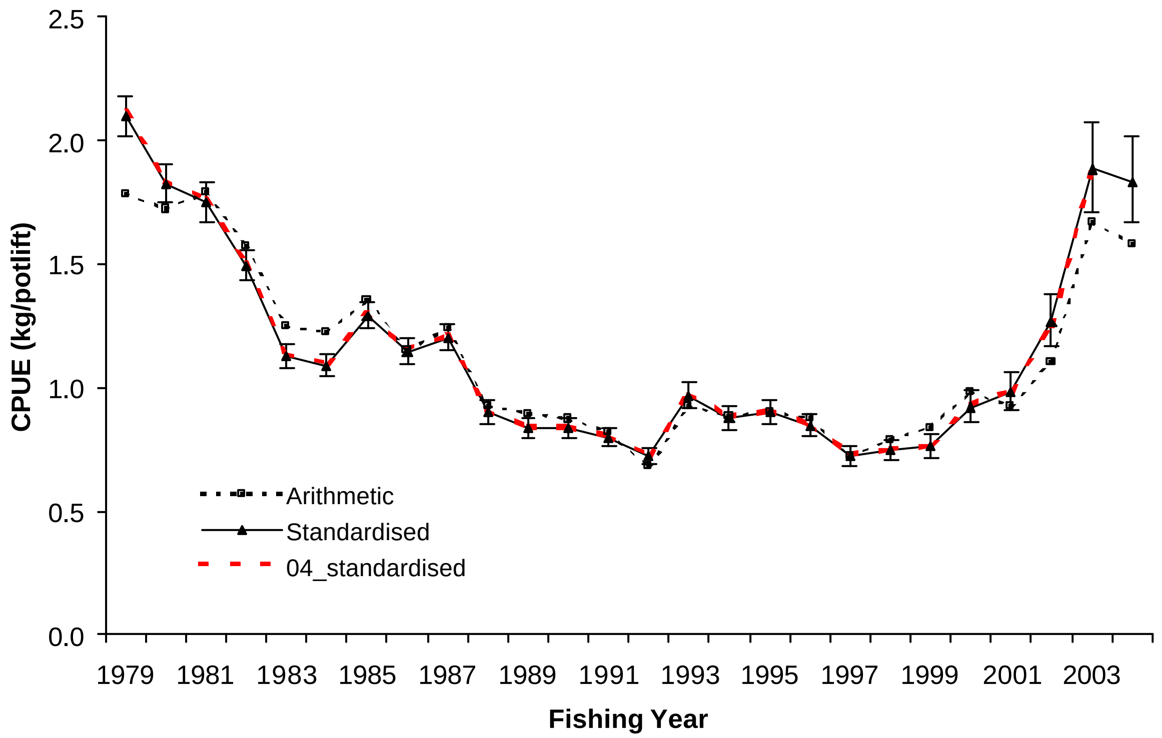


Figure 7. **Values for the 2005 CRA 8 standardised annual CPUE indices compared with the mean arithmetic annual CPUE (sum of annual catch divided by sum of potlifts). The standardised series is scaled to the geometric mean of the arithmetic annual CPUE (kg/potlift). Also shown is the equivalent standardised series calculated in September 2004.**

iii) Implementation of NSS harvest control rule for 2005-06

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 2004 is about the same as the index calculated for 2003, corroborating the strong increase observed in 2003 (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 11) is 0.456 (Table 12). 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 11) is 0.185. When these two indicators are averaged using the weighting parameter *W* (

Table 11), the resulting value $\left(A_t^*\right)$ is 0.293 (Table 12). This value is scaled by the scaling parameter *S* (

Table 11) to create a response $\left(R_t\right)$ of 0.220 (Table 12). This value is greater than the agreed minimum change value (0.05;

Table 11) and is not greater than the agreed maximum change value for the management procedure (0.25;

Table 11), so the value of Z_t is set to 1.220 (Table 12). This result implies an increase in the TAC of 22% from 1 April 2006, given that this is not a "latent" year. The resulting new TACs are shown in Table 13.

Table 13: Current catch limits for CRA 7 and CRA 8, and the revised limits resulting from operation of the NSS management procedure.

		TAC
CRA 7	old	114.9
	new	140.2
CRA 8	old	690.4
	new	842.2

5. STOCK ASSESSMENT

This section reports a new assessment for *J. edwardsii* for CRA 4 from the NSC substock.

5.1 CRA 4 (Wellington-Hawke Bay)

The CRA 4 fishery extends from the Wairoa River on the east coast, southwards along the Hawke Bay, Wairarapa and Wellington coasts, through Cook Strait and north to the Manawatu River.

A CRA 4 TAC was first set in April 1999 and remains at 771 tonnes. In that decision, the TACC was increased from 495.7 tonnes to 577 tonnes, based on a stock assessment made in 1998. Before 1999, the TACC had remained unchanged since April 1993. Within the TAC, allowances were made of 85 t for amateur and 35 t for customary catches, and an implicit allowance of 74 t for illegal catch. A stock assessment was made for CRA 4 in 2003 which did not result in any adjustment to the TAC or TACC.

The TACC of 577 t is distributed amongst 89 quota share owners. The fleet comprised an estimated 64 vessels (Starr & Bentley 2005) in the 2003–04 commercial season, most operating from coastal bases in isolated rural areas. The CRA 4 commercial catch has a landed value of more than $18 million, based on the average landed value, and supports several processing and export operations in Napier and Wellington, Auckland and Canterbury.

The recreational catch history is unknown but was assumed as described in section 1 above, based on the 1994 and 1996 recreational surveys. Most recreational catch is taken in summer by potting and diving.

A comprehensive stock monitoring programme has been established in the CRA 4 fishery. There is a long time series of intensive catch sampling data from Napier, Castlepoint, Cape Palliser, and the Wellington south coast. This series was extended in 2004-05 with 35 samples (days), and 45 samples are planned for 2005-06. Tag recapture data are being routinely reported by commercial fishermen, and 4000 lobsters will be tagged in CRA 4 in 2005-06.

The seasonal CPUE for the 2005 autumn-winter period was estimated using a projection regression model fitted to partial season data (Rock Lobster Working Group document 2005/02). This projection model predicts the seasonal CPUE index using the pattern of historical CPUE indices compared to accumulated partial season data. This model was accepted by the Working Group because it showed good historical prediction performance. The autumn-winter and spring-summer catches for 2005 were also estimated from partial reported data, including allowing an expected overall shortfall of about 35 t from the TACC. Some length frequency data were also available for the 2005 autumn-winter season. The use of these partial year data allowed the extension of the assessment model to the end of 2005 and moved the start of the projection period to the autumn-winter of 2006.

(a) Length-based stock assessment model

The length-based model, used in 2002 (Starr et al. 2003), 2003 (Kim et al. 2004) and 2004 (Haist et al. 2005), was used without major revision for the 2005 assessment.

i) Model structure

The model was fitted to two series of catch rate indices from different periods, and to size frequency and tag-recapture data. The model has three sex categories: male, immature female and mature female, and estimates a maturation schedule for females.

In the model, a year is divided into two seasons: autumn-winter (AW): April through September, and spring-summer (SS): October through March. This captures several biological processes: season- and sex-specific moult patterns, differential seasonal vulnerability between sexes, and a reduction in vulnerability of mature females greater than the MLS in the AW season because of their egg-bearing status. Seasonal structure is important to incorporate because, in the mid 1990s, several fisheries changed from predominantly SS fisheries to AW fisheries that caught mostly male lobsters (this trend has been partially reversed in some areas, including CRA 4).

Significant catches occurred in CRA 4 during the early part of the time series. Different MLS regulations existed in the past and escapement regulations have changed. We therefore incorporate historical information for CRA 4: time series of historical catches, sex-specific MLS regulations and catch per day estimates for the 1960s and early 1970s. Data and their sources are listed in Table 14.

The initial population in 1945 is assumed to be in equilibrium with base recruitment and with no fishing mortality. Each season the number of male, immature female and mature female lobsters within each size class is updated as a result of:

a) **Recruitment**. Each year, new recruits are added equally for each sex and both seasons, into the smallest size classes, beginning with the AW season. The proportion of individuals recruiting to each size class is modelled as a normal distribution with a mean of 32 mm and a standard deviation of 2 mm. This distribution is truncated at the smallest size class in the model (30 mm). Recruitment in a specific year is the product of the base recruitment parameter and an annual deviation parameter. The vector of recruitment deviations is assumed to be normally distributed with assumed standard deviation 0.4. The years for which recruitment deviations were estimated were 1945 to 2003, with the last deviation also applied to 2004 and 2005 in minimisations.

b) **Mortality**. Natural, fishing and handling mortalities are applied to numbers in every sex/size class. Estimated natural mortality is assumed to be independent of sex, year and length. Fishing mortality is determined from observed catch and model biomass, modified by legal sizes, sex-specific seasonal vulnerabilities and size-specific selectivity curves.

Fisheries that respect size limits (SL fisheries – legal commercial and recreational) are differentiated from those which do not (NSL fisheries – most of the illegal fishery plus the Maori customary fishery). It is assumed that size limits and the prohibition of taking berried females apply only to the SL fisheries. Otherwise, selectivity and seasonal vulnerability functions are the same for the SL and NSL fisheries. Relative vulnerability is calculated by assuming that a specified sex in a specified season has the highest vulnerability and estimating the relative vulnerability for other sex/season combinations. Mature females have no legal vulnerability in the autumn-winter, when all are assumed to be ovigerous. The annual rate of SL fishing mortality is calculated as the ratio of catch to the SL biomass, where catch includes both the legal catch and the portion of NSL catch taken from the SL biomass. SL biomass is defined as the weight of males and females in the size classes above the MLS limits, adjusted for their relative vulnerability as defined above. Handling mortality rate is assumed to be proportional to legal fishing mortality at 10% of all lobsters that are released.

c) **Fishery selectivity curves:** A three-parameter fishery selectivity function is assumed, with parameters describing increasing vulnerability from the initial size class to a maximum, followed by decreasing vulnerability. The three parameters describe the shapes of the ascending and descending limbs and the size at which vulnerability is maximum. Changes in regulations over time (for instance, changes in escape gap regulations) are modelled by estimating separate selectivity parameters appropriate to each period of the fishery. For the CRA 4 assessment, the shape of the right-hand part of the curve was assumed to be flat.

d) **Growth and maturity**. For each sex in each season, a growth transition matrix specifies the probability of an individual remaining in the same size class or growing into a different size class. Maturity for females is estimated as a two-parameter logistic curve from the maturity-at-size information in the size frequency data, but for the CRA 4 assessment there were few immature females in the data, reflecting a small size at maturity, and one maturity parameter was assumed.

ii) Model fitting

A total negative log likelihood function was minimised using AD Model Builder™. The model was fitted to standardised CPUE indices estimated by season from 1979–80 through to the autumn-winter of 2005–06 fishing years. The index for the most recent period (AW 2005) was estimated using a regression method which predicts the seasonal CPUE based on partial in-season data (up to July 2005) (working group paper RLWG2005/02). The model was also fitted to an additional seasonal catch rate index based on daily catch and effort data for the period 1963 to 1973 (Annala & King 1983). A lognormal error structure was assumed for abundance indices and a normal error structure for tag-recapture data and proportions-at-length.

The model was fitted to size data (proportions-at-length) taken from commercial pots, data obtained from research sampling conducted on commercial vessels. Voluntary logbooks were maintained by only one rock lobster fisherman in CRA 4 and were not considered sufficiently representative of the whole fishery to be included as input to the assessment. Estimates of the seasonal size frequency were summarised by area/month strata and weighted by the commercial catch taken in each stratum, the number of lobsters measured and the number of days sampled. A fundamental assumption is that the size frequency data are representative of the commercial lobster catch. Size proportions within each season are normalised to one across all three sex categories, providing the model with seasonal estimates of the relative proportion-at-size by sex.

Tag-recapture data come from all tagging projects conducted. Because the numbers of recoveries of small and large lobsters were limited, the CRA 4 tag data were augmented with an equal number of records from CRA 3 and CRA 5, after first establishing that the growth rates within the sizes of overlap in the data were similar.

A summary of data used, data sources and the applicable years is provided in Table 14. For this assessment it was observed that few tag-recapture data involved larger lobsters.

Table 14. Data types and sources for the 2005 assessment for CRA 4. Year codes apply to the first 9 months of each fishing year, *viz.* 1998-99 is called 1998. MFish: NZ Ministry of Fisheries; NZ RLIC: Rock Lobster Industry Council. –: not applicable

Data type	**Data source**	**Begin year**	**End year**	**Number**
Historical catch rate	Annala & King (1983)	1963	1973	21
CPUE	FSU & CELR	1979	2005 (AW)	53
Observer proportions-at-size	MFish and NZ RLIC	1986	2003	33
Tag recovery data	NZ RLIC & MFish	1998	2004	2146
Historical MLS regulations	Annala (1983), MFish	1945	2004	–
Escape gap regulation changes	Annala (1983), MFish	1945	2004	–

The parameters estimated and the priors used are provided in Table 15. Fixed parameters and their values are given in Table 16.

CPUE, the historical catch rate, the proportions-at-length and tagging data were weighted directly by a relative weighting factor, and the assessment attempted to obtain standard deviations of standardised residuals for each data set that were close to one.

Table 15. Parameters estimated and priors used in basecase assessments for CRA 4. Prior type abbreviations: U- uniform; N – normal; L – lognormal.

	Prior Type	**Lower bound**	**Upper bound**	**Mean**	**CV**
Log R_0 (ln mean recruitment)	U	1	25	–	–
M (natural mortality)	L	0.01	0.35	0.12	0.4
Recruitment deviations	N [1]	-2.3	2.3	0	0.4
LogqI	U	-25	0	–	–
LogqCR	U	-25	2	–	–
Increment at TW=50 (male & female)	U	1	8	–	–
Difference between increments at TW=80, TW=50	U	0.001	30	–	–
Shape of length-growth increment relation	U	0.1	20	–	–
Relative sex/season vulnerability: [2]	U	0	1	–	–
Shape of ascending limb of vulnerability ogive	U	1	50	–	–

[1] Normal in logspace = lognormal (bounds equivalent to – 10 to 10).
[2] Relative vulnerability of males in autumn-winter was fixed at one.

Table 16. Fixed values used in basecase assessment for CRA 4.

Quantity	**CRA 4**
Common error component (sigma tilde)	0.1108
(TW at 95% probability female maturity) – (TW at 50% probability female maturity)	20 mm
Shape parameter for biomass-CPUE relation	1
Minimum std dev of growth increment	1 mm
Std dev of observation error of increment	2.68 mm
Growth CV (male and female)	0.5
Shape of descending limb of vulnerability ogive	200
Std dev of historical catch per day	0.30
Maximum exploitation rate per season	90%

Handling mortality	10%
Process error for CPUE	0.25
Process error for historical catch rate	0.3
Year of selectivity change	1993
Current male size limit	54
Current female size limit	60
First year for recruitment deviations	1945
Last year for recruitment deviations	2003
Relative weight for length frequencies	1.25
Relative weight for CPUE	0.317
Relative weight for CR	0.5
Relative weight for tag-recapture data	0.5
Sex-season with maximum vulnerability	male (AW)

iii) Model projections

Bayesian estimation procedures were used to estimate uncertainty in model estimates of current biomass and in future projections. This procedure was conducted in the following steps:

a) Model parameters were estimated by AD Model Builder™ using maximum likelihood and the prior probabilities. These point estimates represent the mode of the joint posterior distributions of the parameters, and are called the MPD estimates;

b) Samples from the joint posterior distribution of parameters were generated using a Markov chain – Monte Carlo procedure (MCMC) and the Hastings-Metropolis algorithm;

c) For each sample of the posterior, 3-year projections (encompassing the 2006–07 to 2009–10 fishing years) were generated by assuming the catches indicated in Table 17. Future annual recruitment was randomly sampled with replacement from the model's estimated recruitments from the period 1994–2003;

d) A marginal posterior distribution was found for each quantity of interest by integrating the product of the likelihood and the priors over all model parameters; the posterior distribution was described by the mean, median, and 5th and 95th percentiles.

At the request of the RLWG, projections were made with both our "best estimate" of future catch - comprising the TACC plus the current estimates of non-commercial catch and with the allowances specified in the TAC (Table 17). For both sets of projections, the current split of AW and SS was used.

Table 17. Catches (t) used in the 3-year projections for CRA 4. Two sets of projected catches were used: one based on the TACC and the current "best" estimates of recreational, customary and illegal catches; the other based on the allowances in the TAC. The "reported illegal" catches are subtracted from the legal commercial catch.

	Size-limited (SL)			Not size-limited (NSL)			
Catch category	**Commercial**	**Recreational**	**catch Total**	**Reported illegal**	**Unreported illegal**	**Customary**	**catch Total**
"Best" estimate of catch	571	47	618	5	35	20	60
TAC allowances	567	85	652	10	64	35	109

iv) Performance indicators

The assessment used several performance indicators based on biomass and exploitation rate, all using beginning season biomass legally available and vulnerable to the fishery (e.g. above MLS and non-berried females) in the autumn-winter season (vulnerable biomass). The minimum biomass indicator, B_{min}, varies between MCMC draws, so it is not possible to define a single year as the expected minimum biomass. Current biomass, $B_{current}$, is taken from the autumn-winter season of 2006 because the assessment extends to the end of 2005 (see above). Projected biomass, B_{proj}, is taken from the autumn-winter season of 2009. A list of the projection performance indicators is provided in Table 18.

Table 18: Performance indicators for the 2004 CRA 4 stock assessment projections

B_{ref}	mean of AW vulnerable biomass from 1979–88
B_{min}	nadir of AW vulnerable biomass
$B_{current}$	2006 AW vulnerable biomass
$U_{current}$	AW exploitation rate on the SL biomass in 2005
B_{proj}	2009 AW biomass
U_{proj}	AW exploitation rate on the SL biomass in 2008
$B_{current}/B_{ref}$	ratio: current biomass to reference biomass
$B_{current}/B_{min}$	ratio: current biomass to minimum biomass
B_{proj}/B_{ref}	ratio: projected biomass to reference biomass
$B_{proj}/B_{current}$	ratio: projected biomass to current biomass
B_{proj}/B_{min}	ratio: projected biomass to minimum biomass
$U_{proj}/U_{current}$	ratio: projected exploitation rate to current exploitation rate
$P\left(B_{proj} < B_{current}\right)$	probability projected biomass is less than current biomass
$P\left(B_{proj} < B_{ref}\right)$	probability projected biomass is less than reference biomass
$P\left(B_{proj} < B_{min}\right)$	probability projected biomass is less than minimum biomass

(b) Stock assessment results - *Jasus edwardsii*, CRA 4

The base case assessment chosen for CRA 4 (Tables 15 and 16) resulted from extensive exploration of about 200 alternative runs. Initially, the various datasets were given natural weightings by trying to obtain standard deviations of normalised residuals (sdnr) from all data sets that were close to 1. However, in most cases this resulted in poor fits to the CPUE data; also some key parameters were estimated at their bounds and the maximum exploitation bound was reached. By upweighting the CPUE data, better fits to the recent CPUE were obtained. However, these model runs were not robust to small changes in model structure assumptions and both the length frequency data and the tag data showed a greater than expected number of very large residuals. Satisfactory runs were found by downweighting the length frequency and tag data and fixing the common error component (instead of fitting this value) so that the model was able to fit the data more freely. The chosen basecase gave a value of approximately 1 for the sdnr for CPUE, decreased the number of large residuals in the length frequency and tag data and the maximum exploitation rate stayed below 0.9. The WG noted that there was more uncertainty with this assessment than indicated by the basecase outputs because of the sensitivity shown to the data weighting.

Base case results suggested that the index biomass decreased to stable but low levels throughout the 1980s and early 1990s (Figure 8). This period coincided with the largest catches from the QMA in the mid-1980s. However, catches and apparent productivity had declined by the early 1990s. The biomass then increased strongly to a peak in 1998 and has since declined. Exploitation rate peaked in the 1990 spring-summer season, but the base case and most of the sensitivity runs did not reach the exploitation rate upper bound (Table 16). Recent exploitation rates appear to be around 20-30% of the vulnerable biomass (Table 19).

Three MCMC sensitivity trials were made, including a) a “domed” trial where the right-hand limb of the selectivity function was estimated, allowing it to descend to obtain a better fit to the data; b) a trial where a non-linear fit was allowed to the CPUE data; and c) a trial where the non-commercial catches were arbitrarily doubled. Three retrospective MCMC sensitivity trials were also done, stepping backward one year at a time from 2004 to 2002 and refitting the model to the remaining data. These sensitivities investigated the major uncertainties in the basecase assessment.

Table 19. Summary statistics for performance indicators from posterior distributions from the CRA 4 basecase assessment. Biomass indicators are shown in tonnes.

Indicator	5%	Median	95%
B_{ref}	393	478	580
B_{min}	278	360	455
$B_{current}$	677	855	1068
$U_{current}$	21%	25%	30%
B_{proj}	426	808	1331
U_{proj}	18%	27%	45%
$B_{current}/B_{ref}$	1.50	1.78	2.12
$B_{current}/B_{min}$	1.94	2.37	2.95
B_{proj}/B_{ref}	0.92	1.68	2.73
$B_{proj}/B_{current}$	0.57	0.94	1.39
B_{proj}/B_{min}	1.23	2.24	3.67
$U_{proj}/U_{current}$	0.76	1.11	1.67
$P\left(B_{proj} < B_{current}\right)$	60%		
$P\left(B_{proj} < B_{ref}\right)$	7%		
$P\left(B_{proj} < B_{min}\right)$	2%		

None of the three sensitivity trials resulted in any major differences in stock status, with the non-linear CPUE trial being the most similar to the basecase. The “domed” sensitivity was slightly more optimistic and the “double non-commercial catch” trials was slightly more pessimistic than the basecase, but neither trial provided results which were qualitatively different from those shown in Table 19. The retrospective sensitivities were robust to the removal of the data, with little change in the results over the period investigated.

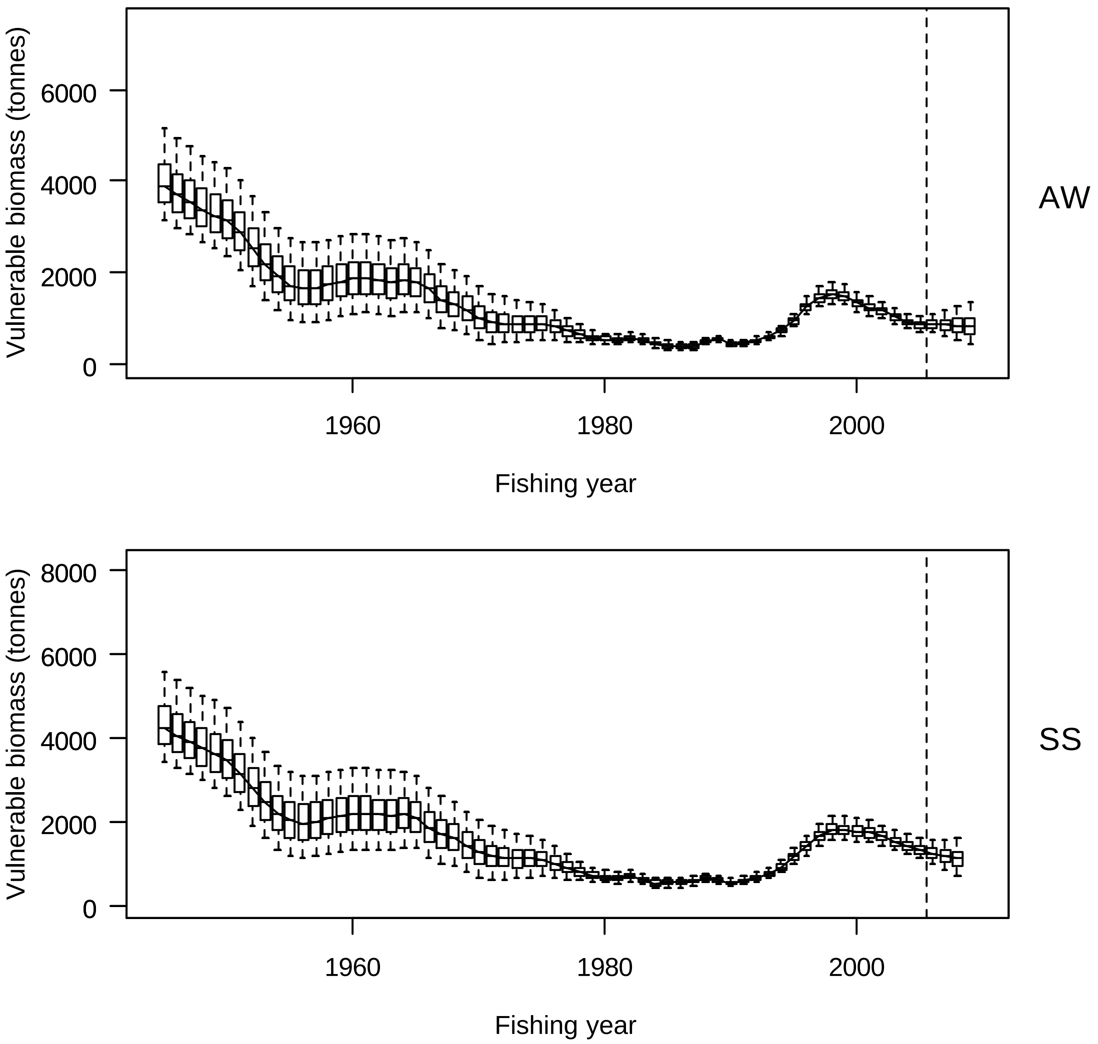


Figure 8. Posterior trajectories of vulnerable biomass, for the AW (top) and SS (bottom) seasons, from the CRA 4 base case MCMC simulations. For each year the horizontal line represents the median, the box spans the 25th and 75th percentiles and the dashed whiskers span the 5th and 95th percentiles. The vertical dashed line shows the beginning of the projection period.

The assessment results (Table 19) are based on the posterior distributions of indicators. These were obtained from the MCMC simulations – a single chain of 4 million was made and 2000 samples were taken. They suggest that the current vulnerable biomass is currently two to three times B_{min} (0.05 and 0.95 quantiles were 94% to 195% greater than B_{min}) and 78% greater than B_{ref} (50% to 112% greater). Using the "best" estimate of current catches and using historical recruitments sampled from 1994–2003, the median expectation is that biomass will decrease by 6% over three years, but with wide bounds (-43% to +39% of current biomass). The probability of a decrease was 60%, however, the probability of going below the reference biomass is low (7%) as is the probability of going below the minimum biomass (2%).

The projections based on the sensitivity trials were also very similar to the basecase, with the "double non-commercial catch" trial giving the same probabilities of decline and exceeding the reference biomass levels as shown in Table 19. The "domed" projections were slightly more optimistic, with only a 50% probability of decline and almost no chance of exceeding the reference biomass levels.

The projections rely on an assumption that recruitment would be similar, on average, to that in the 1994–2003 period and with variability as seen in those ten years.

6. YIELD ESTIMATES

(a) Estimation of Maximum Constant Yield (MCY)

i) *Jasus edwardsii*, all stocks

MCY was not estimated.

ii) *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.

(b) Estimation of Current Annual Yield (CAY)

i) *Jasus edwardsii*, all stocks

CAY was not estimated for any stock.

ii) *Sagmariasus verreauxi*, PHC stock

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

7. STATUS OF THE STOCKS

(a) *Jasus edwardsii*, NSN substock

i) CRA 1

The stock assessment of CRA 1 was not updated in 2005. 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 assumpion 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.

ii) CRA 2

The stock assessment of CRA 2 was not updated in 2005. 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.

(b) *Jasus edwardsii*, NSC substock

i) CRA 3

The stock assessment of CRA 3 was not updated in 2005. 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.

ii) CRA 4

The stock assessment of CRA 4 was updated in 2005. The 2005 model results suggests 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.

iii) CRA 5

The stock assessment of CRA 5 was updated in 2003. 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.

(c) *Jasus edwardsii*, NSS substock

There was no new assessment of the NSS stock in 2005. However, a revised management procedure was accepted by the Minister of Fisheries in July 2002 and was adjusted in October 2003 to accommodate biases in the CPUE series used to evaluate the procedure. This procedure is used to determine any annual changes to the existing TACC (see Section 4 above). The outcome of the management procedure in 2005 was to trigger a 22% increase to the TACs for CRA 7 and CRA 8 which is scheduled to be implemented at the beginning of the 2006–07 fishing year.

(d) *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 2004–05 fishing year (322 t) were within the range of estimates for *MSY* (300–380 t), and were 15% less than the previous year's landings. The current TAC (370 t) lies within the range of the estimated *MSY*.

(e) *Sagmariasus verreauxi*, PHC stock

The status of this stock is unknown.

Summary of yield estimates (t), TACCs and TACs (t), and reported 2004-05 commercial landings. The yield estimates for CRA 6 are the range of yield estimates from a simple production model. (-, not available).

Fishstock	QMA	Yield estimate	2004-05 TACC	2004-05 Commercial landings	2005-06 TACC	2005-06 TAC
CRA 1	Northland	–	131.1	130.8	131.1	
CRA 2	Bay of Plenty	–	236.1	197.3	236.1	452.6
CRA 3	Gisborne	–	327.0	162.0	190.0	319.0
CRA 4	Wairarapa–Hawke Bay	–	577.0	569.9	577.0	771.0
CRA 5	Canterbury–Marlborough	–	350.0	344.9	350.0	467.0
CRA 6	Chatham Islands	300–380	360.0	321.7	360.0	370.0
CRA 7	Otago	–	94.9	94.2	94.9	114.9
CRA 8	Southern	–	603.4	602.5	603.4	690.4
CRA 9	Westland–Taranaki	–	47.0	47.0	47.0	
CRA 10	Kermadec	–	0.1	0.0	0.1	
Total			2726.5	2470.2	2589.5	
PHC 1	All QMAs	18	40.3		40.3	

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