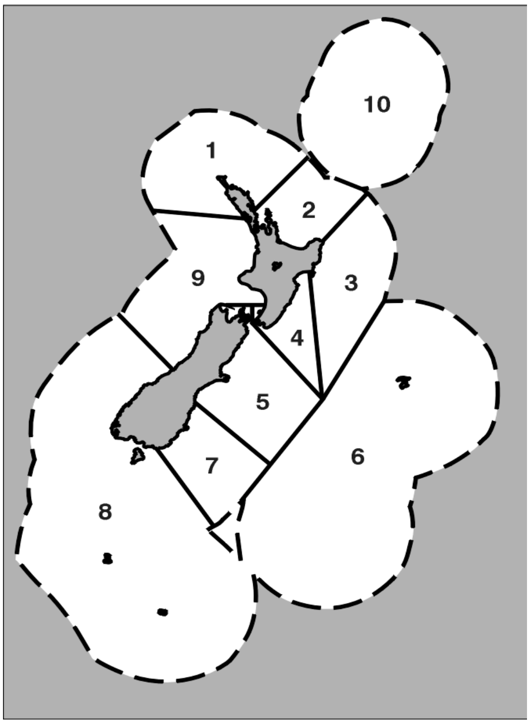
ROCK LOBSTER (CRA and PHC)

(*Jasus edwardsii*, *Sagmariasus verreauxi*)



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[1] (*Sagmariasus verreauxi*) is taken mainly in the north of the North Island.

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

[1]This species used to be known as *Jasus* (*Sagmariasus*) *verreauxi* (Holthuis 1991) - but almost always referred to as *J. verreauxi*. Recently, the subgeneric *Sagmariasus* was elevated to full generic status because of the many substantial differences between this species and all *Jasus* species, which among themselves vary little (Booth & Webber 2002).

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.

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 CRAs 1–5 and 7–9, each a separate Fishstock with a separate TACC. The sum of the TACCs for the NSI stock was set at 3200 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 is now 2323 t for the 2003–04 season (Table 1).

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 0.1 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 new requirement under the Fisheries Act 1996 and consequently TACs have been set since 1997–98 whenever adjustments have been made to the TACCs.

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 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 after 1993, although this pattern is changing again. 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.

Commercial fisheries

Table 1 provides a summary by fishing year of the reported commercial catches and TACCs by Fishstock (CRA). The Quota Management Reports (QMRs) 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, 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.

	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	225.0	379.4
1998–99	128.7	130.5	–	232.3	236.1	452.6	325.7	327.0	453.0
1999–00	125.7	130.5	–	235.1	236.1	452.6	326.1	327.0	453.0
2000–01	130.9	130.5	–	235.4	236.1	452.6	328.1	327.0	453.0
2001–02	130.6	130.5	–	225.0	236.1	452.6	289.9	327.0	453.0
2002-03	130.8	130.5		205.7	236.1	452.6	291.0	327.0	453.0

	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	576.0	771.0	349.5	350.0	467.0	322.4	360.0	370.0
2000–01	573.8	576.0	771.0	347.4	350.0	467.0	342.7	360.0	370.0
2001–02	574.1	576.0	771.0	349.1	350.0	467.0	328.7	360.0	370.0
2002–03	575.2	576.0	771.0	348.7	350.0	467.0	335.8	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	38.1	138.7	–	896.1	888.1	–
1994–95	20.3	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

	CRA 9			Total		
Fishing Year	Catch	TACC	TAC	Catch	TACC[1]	TAC[2]
1990–91	45.3	54.7	–	2 907.5	3 793.0	–
1991–92	47.5	50.2	–	3 020.9	3 503.0	–
1992–93	45.7	47.0	–	2 630.0	3 202.0	–
1993–94	45.5	47.0	–	2 746.3	2 912.1	–
1994–95	45.2	47.0	–	2 621.4	2 912.1	–
1995–96	45.4	47.0	–	2 548.5	2 912.1	–
1996–97	46.9	47.0	–	2 690.5	2 953.1	–
1997–98	46.7	47.0	–	2 584.1	2 844.2	1 312.0
1998–99	46.9	47.0	–	2 726.0	2 926.3	1 275.6
1999–00	47.0	47.0	–	2 748.6	2 848.6	3 442.6
2000–01	47.0	47.0	–	2 795.9	2 848.6	3 442.6
2001–02	46.8	47.0	–	2 593.2	2 683.6	3 277.6
2002–03	47.0	47.0		2 589.9	2 683.6	3 277.6

[1] TACC totals exclude CRA 10 (TACC=0.1 t); catch totals exclude CRA 10 and ET catches (outside EEZ).
[2] TAC totals include only QMAs where TACs have been set.

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 units 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. in prep.). 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 were corrected 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 this method ("Method C1", Bentley et al. in prep.) is biased because it drops trips with no landings, leading to estimates of CPUE which are too high. This bias is increasing because of the increasing trend in landings that are passed through holding pots. The current catch/effort data system operated by MFish allows landings from previous trips, held in holding pots, to be combined with landings from the active trip. This means that tracing capture from the fishing event to the landing event for the same lobster is not possible under the current system.

Therefore, the catch and effort data used in each of these analyses have been corrected using a new procedure. This 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. This new 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. (in prep.).

The CPUE estimates in Table 2 and Table 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 or sub-stock by fishing year.

Another potential problem with CPUE data as an abundance index has been identified by the Working Group. Fishers may sort their catch and discard any part 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 is increasing. The Working Group agreed to flag this issue for further investigation.

The 2003 Working Group report has continued the decision made in the previous Working Group report to report rock lobster catch and CPUE on the basis of the rock lobster fishing year only.

Table 2. Reported commercial landings (t) to 31 March 2003 and CPUE (kg per pot lift) for *Jasus edwardsii* NSI and CHI stocks, and NSN, NSC and NSS substocks, for the 1979–80 to 2002–03 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 2002–03 from QMR 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 2002–03 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									
	NSN (CRA 1 & 2)		NSC (CRA 3, 4 & 5)		NSS (CRA 7 & 8)		NSI (CRA 1–9)		CHI (CRA 6)	
			NSC		NSS		NSI		CHI	
Year	Landings	CPUE	Landings	CPUE	Landings	CPUE	Landings	CPUE	Landings	CPUE
1979–80	408	0.57	1386	0.85	2129	1.58	4012	1.06	400	2.33
1980–81	626	0.69	1719	0.88	1761	1.49	4203	1.02	356	2.18
1981–82	574	0.66	1664	0.85	1663	1.48	3973	0.99	465	2.19
1982–83	549	0.59	2213	0.91	1632	1.35	4453	0.96	472	1.78
1983–84	506	0.55	2303	0.84	1634	1.09	4514	0.87	548	1.73
1984–85	482	0.51	2294	0.76	1741	1.09	4598	0.82	492	1.35
1985–86	556	0.54	2227	0.71	2185	1.21	5048	0.83	604	1.41
1986–87	486	0.48	2144	0.72	1927	1.07	4650	0.79	580	1.66
1987–88	442	0.45	1781	0.57	1961	1.12	4277	0.72	448	1.48
1988–89	401	0.45	1399	0.51	1262	0.80	3087	0.58	450	1.40
1989–90	427	0.55	1457	0.53	1352	0.80	3262	0.62	318	1.34
1990–91	369	0.55	1156	0.46	968	0.75	2538	0.56	370	1.38
1991–92	358	0.49	1087	0.41	1140	0.82	2633	0.54	388	1.29
1992–93	301	0.44	946	0.40	1008	0.62	2300	0.48	329	1.14
1993–94	342	0.51	983	0.49	1034	0.87	2404	0.61	342	1.07
1994–95	343	0.61	945	0.59	976	0.79	2309	0.67	313	1.07
1995–96	339	0.77	942	0.73	907	0.76	2233	0.75	315	1.08
1996–97	343	0.87	997	0.88	925	0.74	2312	0.82	378	1.02
1997–98	364	0.86	1013	1.15	822	0.66	2246	0.87	339	0.88
1998–99	361	0.95	1117	1.22	867	0.71	2392	0.94	334	1.17
1999–00	361	0.82	1252	1.24	766	0.73	2426	0.96	322	1.19
2000–01	366	0.83	1249	1.21	791	0.81	2453	0.98	343	1.15
2001–02	356	0.71	1213	1.08	649	0.81	2264	0.91	329	1.15
2002–03	336	0.58	1215	1.01	656	0.94	2254	0.89	336	1.18

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 the NSI declined to 0.48 kg in 1992–93, reached a peak of 0.98 kg in 2000–01, and has been lower in the last 2 years(Table 2).

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. Recent trends in CPUE for CRA1 and CRA2 differ, with CRA1 maintaining higher catch rates since 2000–01 while CRA2 has declined since 1998–99 (Table 3). The combined NSN catch rate in 2002–03 was 0.58 kg per potlift.

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 per potlift to 0.7 kg (Table 2). Commercial catches then gradually decreased to below 1 000 t by the early 1990s and CPUE dropped 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 1.01 kg per potlift in 2002–03, which is higher than all catch rates prior to 1997–98. CPUE has increased steadily in CRA 5 since the 1995–96 fishing year. CPUE peaked in CRA 3 (1997–98) and in CRA 4 (1998–99) but has subsequently declined (Table 3).

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 since 1988–89, but has been increasing since 1997–98 (Table 2). Catches and CPUE have been particularly low in CRA 7 compared with those in other areas (Table 3), but CPUE has risen in the last 3 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 increased to 1.11 kg per potlift in 2002–03 (Table 3).

Jasus edwardsii, CHI stock

CPUE in this fishery was higher than in the other New Zealand CRA areas up to the mid 1990s (Table 2). However, CPUE declined consistently after 1979 to levels similar to those in other CRAs. Landings were around 400 to 500 t per fishing year in the 1980s but fell below 400 t per year in the 1990s. The lowest catch was just over 300 t in 1994–95, but both CPUE and catches have risen since then (Table 2). The reasons for the decline and subsequent increase in catch and in CPUE are unknown. Size frequencies of 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 eight 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(a)i in text for explanation).

	1995–96	1996–97	1997–98	1998–99	1999–2000	2000–01	2001–02	2002–03
CRA 1	0.94	0.94	0.88	1.04	1.09	1.17	1.30	1.20
CRA 2	0.69	0.83	0.85	0.91	0.71	0.71	0.56	0.44
CRA 3	1.30	1.76	2.18	1.63	1.56	1.19	0.95	0.73
CRA 4	0.86	1.02	1.24	1.31	1.26	1.26	1.06	1.09
CRA 5	0.49	0.56	0.79	0.89	0.99	1.16	1.27	1.26
CRA 6	1.08	1.02	0.88	1.17	1.19	1.15	1.15	1.18
CRA 7	0.31	0.25	0.23	0.30	0.22	0.35	0.46	0.52
CRA 8	0.90	0.87	0.72	0.79	0.84	0.98	0.92	1.11
CRA 9	0.98	0.98	0.79	0.92	0.87	0.93	0.82	1.11

Sagmariasus verreauxi, PHC stock

Reported catches of this species to the QMS have halved since 1998–99 (Table 4). Reasons for these declining and low level of landings relative to the TACC (40 t) are unknown.

Table 4. Reported landings of *Sagmariasus verreauxi*. Landings from 2001–03 are from the Blue Book.

Year	Landings (t)
1998–99	16.2
1999–00	12.6
2000–01	10.4
2001–02	7.8
2002–03	8.3

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

Table 4 shows the CPUE (kg/potlift) for the last five years within each CRA area for each statistical area reported on CELR forms (Figure 1). The values of CPUE and the trends in the fisheries vary greatly both within and between CRA areas.

Table 5. Estimated CPUE (kg/potlift) for each statistical area for the five 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(a)i in text for explanation). – value withheld because fewer than three vessels were fishing.

CRA	Statistical Area	98/99	99/00	00/01	01 /02	02/03
1	901	–	2.85	2.82	2.92	2.05
	902	1.18	1.13	1.22	2.77	3.05
	903	0.80	0.48	0.71	0.77	0.72
	904	0.54	0.34	0.40	0.50	0.36
	939	1.08	1.16	0.89	0.86	0.96
2	905	0.96	0.74	0.72	0.59	0.44
	906	0.83	0.67	0.65	0.47	0.36
	907	2.19	1.18	0.89	0.64	0.49
	908	0.61	0.47	0.70	0.67	0.53
3	909	1.94	1.69	1.45	1.00	0.81
	910	1.57	1.50	0.93	0.71	0.54
	911	1.61	1.61	1.61	1.22	0.93
4	912	1.72	1.38	1.16	0.93	1.08
	913	2.51	1.79	1.91	1.17	1.18
	914	1.02	1.05	1.13	1.08	1.02
	915	0.72	1.23	1.10	1.11	1.20
	934	–	0.84	0.96	0.82	–
5	916	1.11	2.07	3.45	2.84	2.25
	917	0.75	0.76	0.83	0.83	0.92
	918	0.88	0.87	1.40	1.64	1.31
	919	–	–	–	–	–
	932	–	–	–	–	–
	933	1.04	0.91	0.97	1.05	0.88

CRA	Statistical Area	98/99	99/00	00/01	01/ 02	02/03
6	940	0.91	0.97	0.92	0.98	1.12
	941	1.05	0.93	0.91	0.86	1.00
	942	1.53	1.70	1.54	1.47	1.34
	943	1.24	0.83	0.83	1.15	1.21
7	920	0.25	0.20	0.27	0.45	0.45
	921	0.38	0.31	0.49	0.50	1.07
8	922	–	–	–	–	–
	923	0.73	0.75	1.20	1.43	–
	924	0.71	0.88	1.27	1.33	1.35
	925	0.88	0.82	1.56	0.61	1.56
	926	1.01	1.14	1.27	1.03	1.29
	927	0.86	0.89	0.82	0.79	0.93
	928	0.61	0.52	0.55	0.64	0.74
9	929	0.63	–	0.72	–	–
	930	0.74	0.74	0.74	0.54	–
	931	1.22	0.99	–	1.86	–
	935	0.98	1.01	0.74	0.66	1.21
	936	–	–	0.47	–	–
	937	–	–	–	0.93	–
	938	–	–	–	–	–

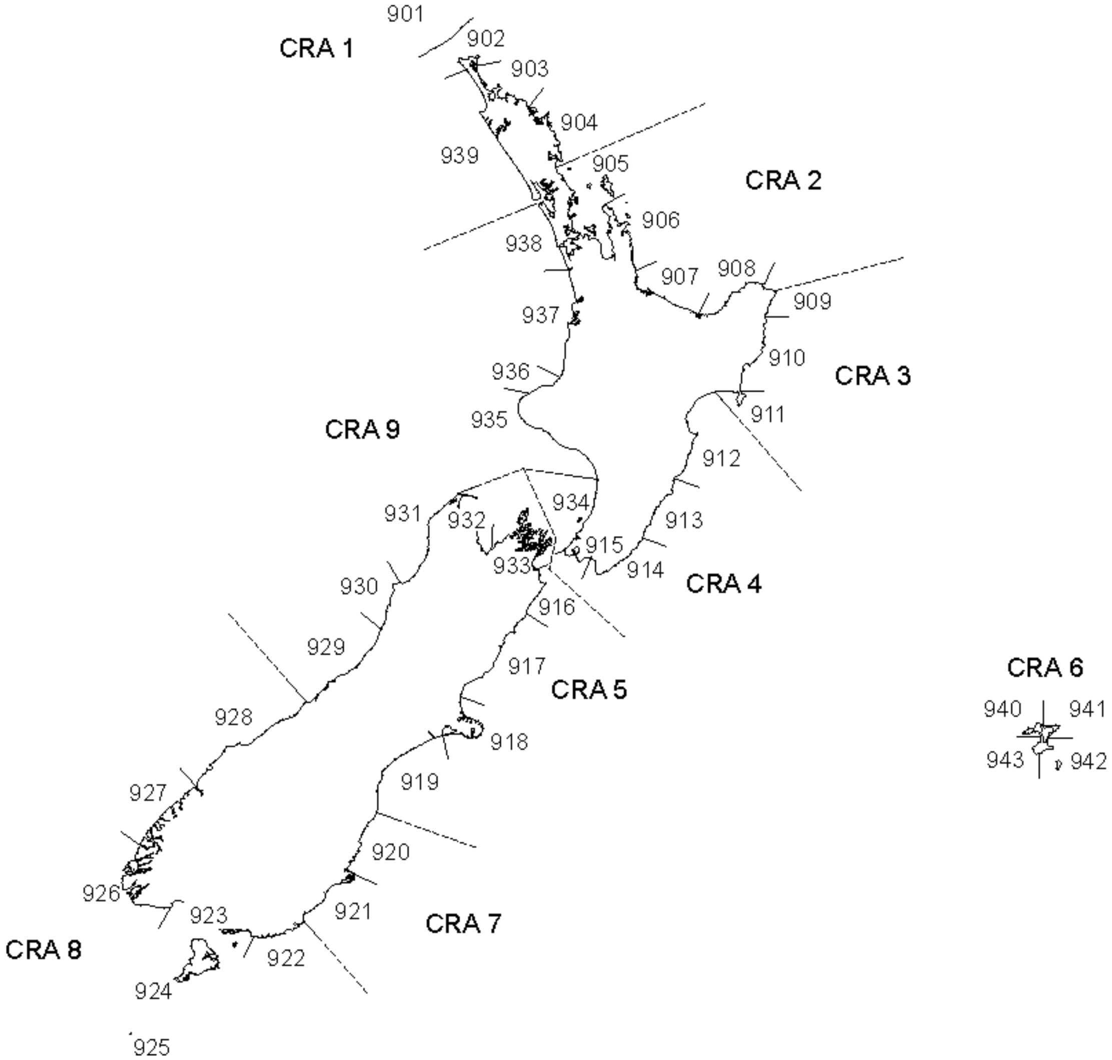


Figure 1. Statistical areas for rock lobster as reported on CELR forms.

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). The results from the 1996 National Diary Survey were reported by Bradford 1998 (Table 7). 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 for CRA 4 and CRA 5 (Table 8).

Estimates from the 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 2 sensitivity tests to the basecase runs for CRA 4 and CRA 5.

For the basecase assessments it was assumed that recreational catch in each year from 1979 onwards is proportional to abundance of the stock. The estimates from 1994 and 1996 were averaged (Table 8) and assumed to represent recreational catch at that time. For 1979 onwards, recreational catch was assumed to be proportional to the standardised CPUE, using the relation between catch and CPUE seen in 1994 and 1996. As in previous assessments, it was assumed that the 1945 catch was 20% of the 1979 catch. The 2002 estimates from the procedure described above were used in projections (Table 17).

Two alternatives were explored in sensitivity trials:

i) the 1979 recreational catch level was calculated from the estimated recreational catch number in 1996 times a scalar, 2.78 (Dave Gilbert, pers. comm.). Then 20% of the 1979 recreational catch level was assumed for the 1945 recreational catch, increasing linearly from 1945 to 1979, then remaining constant at the 1979 level until the present (and in projections).

ii) the 1979 recreational catch of the basecase catch series was doubled. Then 20% of the 1979 recreational catch level was assumed for the 1945 recreational catch, increasing linearly from 1945 to 1979. From 1979, the recreational catch follows the CPUE trend as the basecase recreational catch series does. The 2002 estimates from this procedure above were used in projections.

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

Table 8. Estimates of annual recreational catch from the two years of surveys, mean weight from the catch sampling and voluntary logbook programs, and resulting estimates of recreational catch for CRA 4 and CRA 5 used in the 2003 assessment.

	Catch numbers CRA 4	Catch numbers CRA 5	Mean weight (kg) CRA 4	Mean weight (kg) CRA 5	Catch weight (kg) CRA 4	Catch weight (kg) CRA 5
1994	65 000	67 000	0.51	0.563	33 150	37 721
1996	118 000	41000	0.51	0.563	60 218	23 094
1994-96 mean	91500	54 000	0.51	0.563	46 665	30 402

Maori customary fisheries

The Ministry of Fisheries provided estimates of the Maori customary catches 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 CRA 4 and CRA 5 stock assessments each used an estimate of Maori customary catch of 10 t.

Illegal catches

For the years 1945–1978, illegal catch is from the average ratio of export discrepancies to the reported catch observed for the period 1974 to 1980. The Ministry of Fisheries provided estimates in 1997 of the illegal catches by Fishstock applicable to the 1996–97 fishing year.

For years 1979 onwards, Ministry of Fisheries Compliance staff have supplied estimated illegal catches at various times (Table 9). These estimates are used to estimate annual catches, with interpolation in years for which no estimates were provided.

Compliance also estimated the percentage of this illegal catch which had been reported against quota for the 1997–98 fishing year (see Annala & Sullivan 1999). They estimated that 6.7% of the illegal catch in CRA 4 was reported against quota and 5.6% in CRA 5. This breakdown was used to estimate the catches that respect or do not respect the legal size limit and berried female restrictions.

Table 9. Compliance estimates of illegal catches (t) for the 2003 assessment for CRA 4 and CRA 5. For the years not listed after 1979, the assessment interpolated annual estimates linearly.

Year	CRA 4	CRA 5
1979	19.89	20.74
1987	96.84	101.00
1990	160	178
1992	30	180
1994	70	70
1995	64	70
1996	75	37
2000	64	40
2002	60	52

The Working Group members have very 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%.

BIOLOGY

Rock lobsters are thought to be 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 in autumn, and the egg hatches in spring into the short-lived naupliosoma stage. Most of the phyllosoma development takes place in oceanic waters tens to hundreds of kilometres offshore over a period of 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 stock assessment are shown in Table 10.

Table 10. 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

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 address 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). This was re-written completely in 1999 and further refined in each subsequent assessment. Growth-at-size is represented stochastically by growth transition matrices for each sex. The growth increments of lobsters are assumed to be normally distributed with a mean and variance determined from model parameters. Each row in these transition matrices represents a starting size category and each cell in the row is the probability that a lobster will move into that specific size bin.

In 2003, the underlying growth model is based on two parameters for each sex, describing the expected growth increments of lobsters of 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 proves to be over-parameterised when these are estimated, so in the assessments they are 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, in autumn. Growth rates are estimated within the assessment model, so that the model estimates of growth are affected by all the data used in the model including the size frequency and CPUE data, as well as the tagging data.

(b) Settlement indices

Annual levels of puerulus settlement have been measured for periods ranging from 9 to 22 years at 6 sites from Gisborne to Otago, on the northeast of Stewart Island, and at Chalky Inlet in Fiordland. A new site was recently established at Jackson's Bay on the west coast of the South Island.

The settlement data for NSC to the end of 2002 (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 since then declined markedly (except for a moderate year in 1998), in 1999 reaching the lowest seen. From 2000 there has been a recovery in settlement levels, with 2001 and 2002 near the long-term average. Dive observations carried out in Wellington showed high abundance of juveniles following the high settlement of pueruli in the early 1990s (Booth et al. 2000). Recruitment to the fishery of lobsters from the high 1991 to 1993 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 recruitment are widespread. This is also the case in other rock lobster fisheries such as Western Australia.

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 Halfmoon Bay) starting in, and continuing from, the year 2000. For the west coast (Chalky Inlet), settlement since sampling began in 1987 has been high compared with the east coast of NSS, but variable from year to year.

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. in press).

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 substock 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 appears to be genetically subdivided from populations of the same species in Australia.

DECISION RULES AND MANAGEMENT PROCEDURE

The decision rules and management procedure for 2003 have been evaluated on the basis of CPUE summarised by fishing year (1 April to 31 March). The information used in the 2003 evaluations is based on catch and effort data in the updated CRACE database. It is believed that these data should represent a reasonably complete dataset for the 2002–03 fishing year.

The data used in all the CPUE evaluations for the NSN and NSC decision rules and the NSS management procedure have been extracted from the CRACE database using procedures described in Bentley et al. (in prep.). All error checks have been set to “Level 1” which effectively screen out all major data errors.

The change in methodology for estimating CPUE (section 1 a) i)) has little effect on the operation of the NSN and NSC decision rules because they are defined in relative terms. However, keeping lobsters in holding pots and the associated positive bias have profound implications for the operation of the NSS decision rule because the rebuilding trajectory and the observed CPUE are defined in absolute units for this rule. Because this bias does not extend back into the old FSU data, the target CPUE is not affected. This means that the current decision rule must be modified either by adjusting the slope to maintain the existing target rebuilding year or by extending the rebuild period to maintain the existing slope.

To perform the 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 have been restricted to the appropriate QMAs for each analysis. The NSN and NSC analyses base the comparison on the exponent of year coefficients as calculated by the regression with the natural logarithm of (catch/potlifts) and using 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 analysis (using CRA 8 data only) 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 and the procedure allows the calculation of standard errors for each 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. As the canonical process scales the standardised series to a geometric mean of one, multiplying the resulting standardised series by the geometric mean of the arithmetic indices will scale the standardised indices to CPUE levels which are consistent with those observed by fishermen. The arithmetic index is the summed mean of the total catch and effort for each fishing year:
$\left(\beta_{year} = \sum catch_{year} \Big/ \sum potlifts_{year}\right)$. The Working Group notes that the arithmetic mean CPUE is potentially misleading because it is more affected by extreme outliers in the distribution than the mean obtained in the standardisation procedure.

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 for a 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 would be considered “significantly different” from the 1992–93 year index if the standard error bars of the two years did not overlap.

Table 11. Decision rule indices for 1992–93 and 2002–03 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	2002–03 Index	2002–03 Lower	2002–03 Upper	Result
NSN	0.974	0.943	1.007	1.253	1.207	1.301	*
NSC	0.393	0.386	0.401	1.196	1.167	1.226	*

NSN

The standardised CPUE for the NSN substock increased steadily between the 1992–93 and 1998–99 fishing years (Figure 2 and Table 11). There have been four consecutive years of decrease since 1998–99. However, the standardised index for 2002–03 is still above the low levels registered in the late 1980s and the early 1990s. Figure 3 compares the standardised index with the simple arithmetic mean which shows similar trends well above the period of low abundance in the late 1980s and early 1990s.

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 and Table 11). Again as for the NSN substock, there have been four consecutive years of decrease since 1998–99. However, the degree of decline for the NSC substock (about 25%) is less than the comparable decline for the NSN substock (about 35%). As for the NSN substock, the standardised index for 2002–03 is still above the lowest level registered in 1992–93. Figure 5 compares the standardised index with the simple arithmetic mean which shows a similar trend well 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.

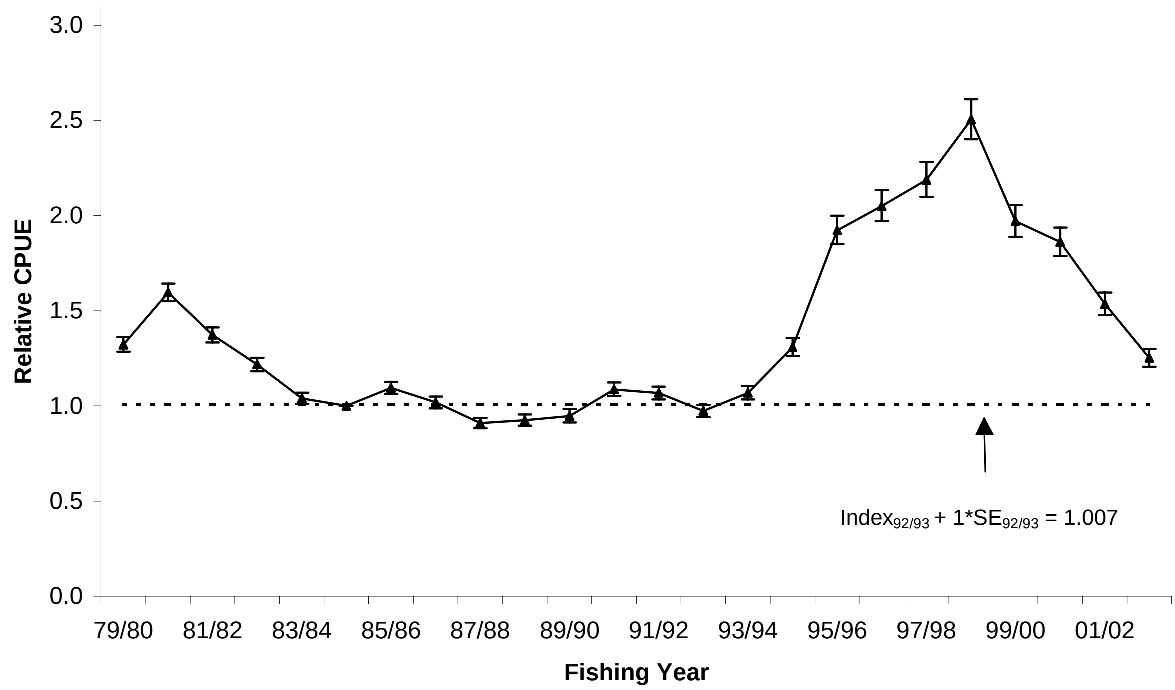


Figure 2. Values of the year index from the standardised CPUE analysis for the NSN substock showing plus and minus one standard error for each year. Horizontal line shows the upper bound of the 1992–93 standardised index which is the threshold for triggering this decision rule. Each year index is relative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

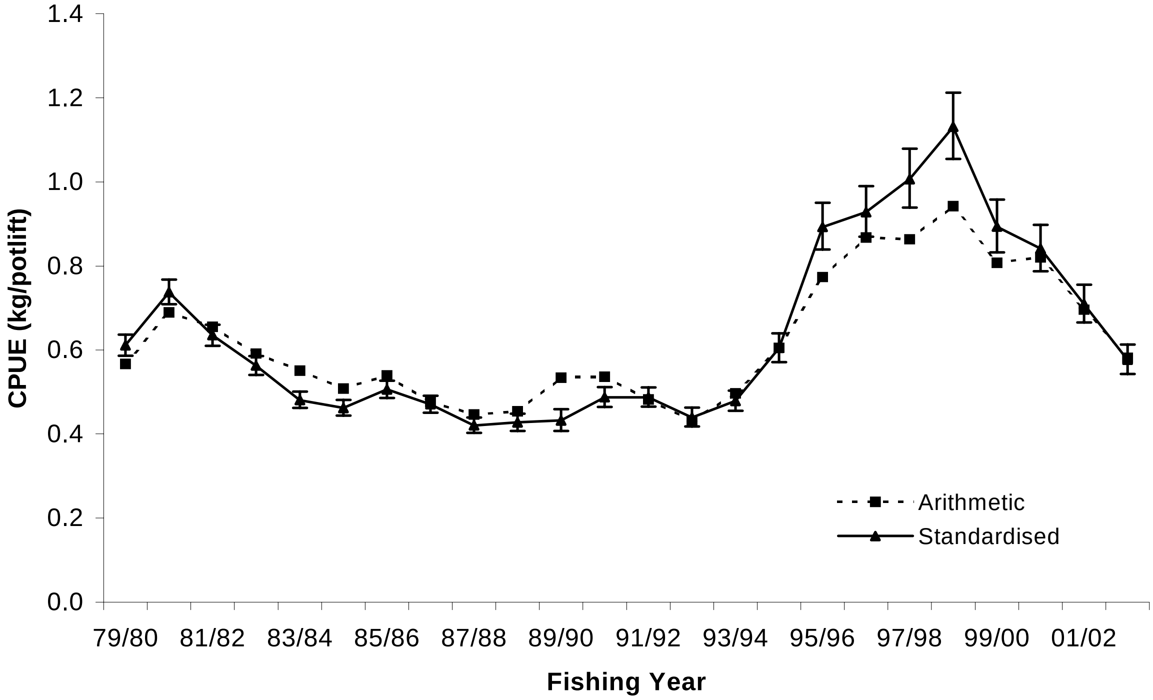


Figure 3. Values for the NSN standardised annual CPUE indices compared to the mean arithmetic annual CPUE (sum of annual catch divided by sum of potlifts). The standardised series is scaled to the geometric mean of the arithmetic annual CPUE (kg/potlift).

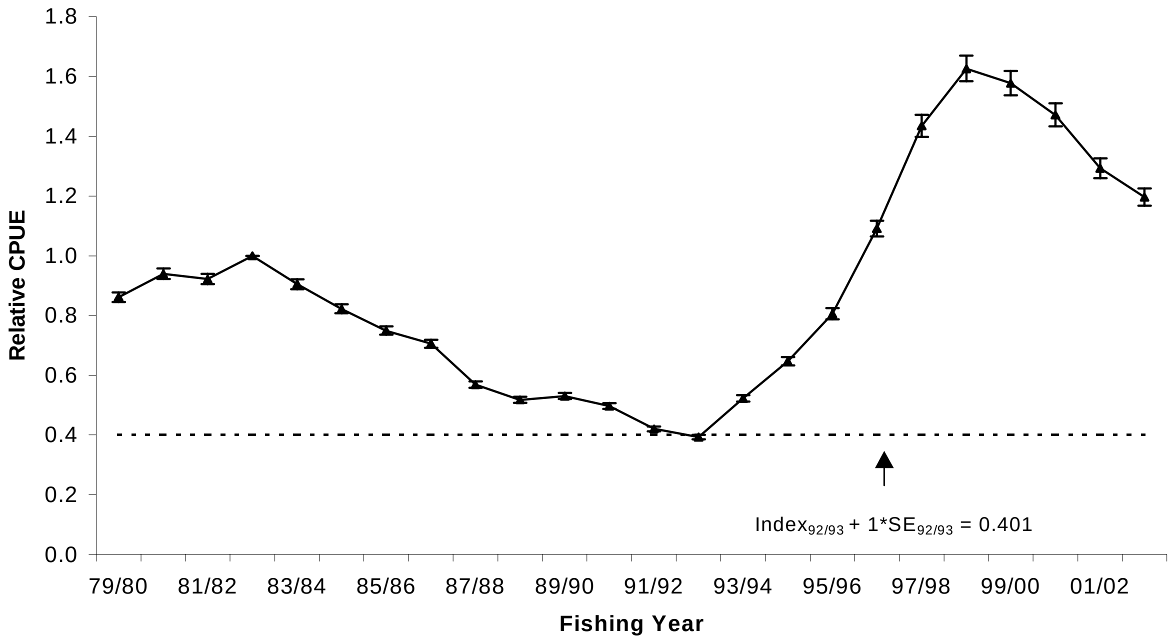


Figure 4. Values of the year index from the standardised CPUE analysis for the NSC substock showing plus and minus one standard error for each year. Horizontal line shows the upper bound of the 1992–93 standardised index which is the threshold for triggering this decision rule. Each year index is relative to the 1982–83 fishing year (the year with the lowest standard error). Input catch data used in this analysis were corrected for differences between estimated and landed catches.

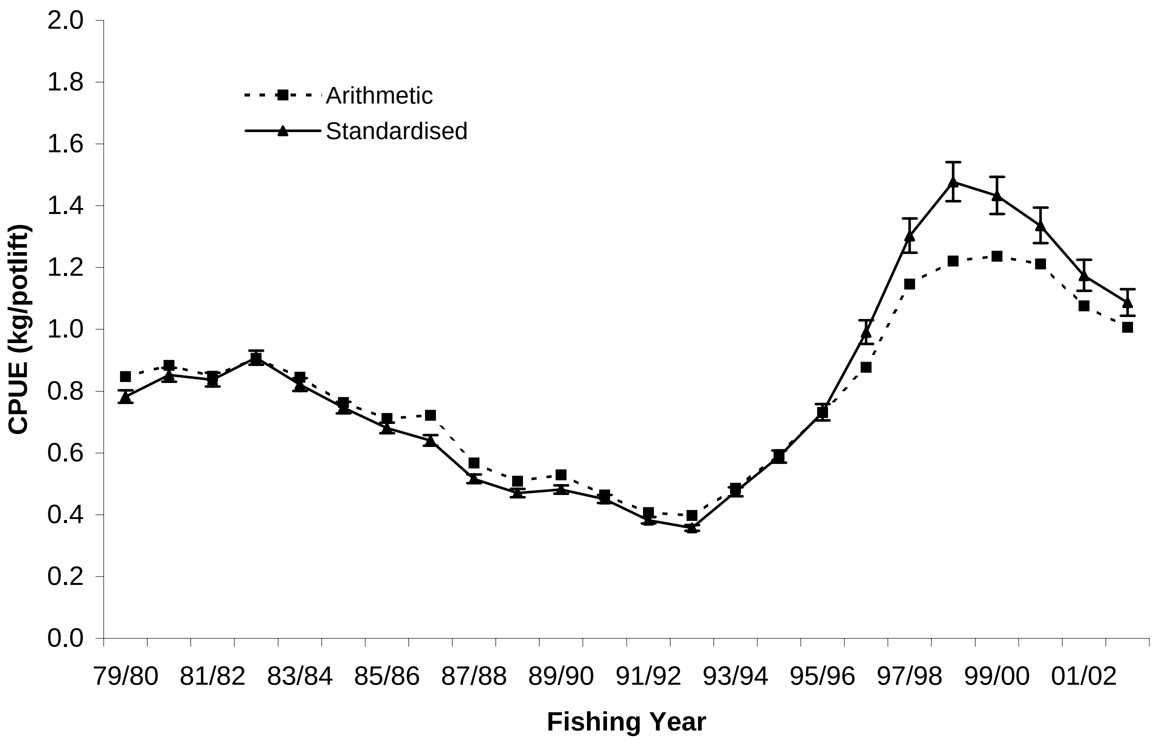


Figure 5. Values for the NSC standardised annual CPUE indices compared to the mean arithmetic annual CPUE (sum of annual catch divided by sum of potlifts). The standardised series is scaled to the geometric mean of the arithmetic annual CPUE (kg/potlift).

Management Procedure for NSS

A new management procedure was proposed by the National Rock Lobster Management Group and accepted by the Minister of Fisheries in 2002. The evaluation of this procedure is documented in Bentley et al. (2003). A number of different stock and recruitment hypotheses were considered across a series of management strategies relative to the two NSS QMAs using a family of "harvest control rules" generated by a range of parameters which drive a generic procedure to set the final TAC. The selected harvest control rule replaces a previous NSS management procedure, which was instituted in 1996 and which resulted in TAC and TACC decreases in 1999 and 2001. As was the 1996 management procedure, the new management procedure is a rebuilding rule designed to achieve a specific target CPUE within a specified number of years. The implementation of this rule for the 2003–04 fishing year resulted in no change to either of the NSS TACs (Annala et al. 2002).

The new management procedure currently applies to the entire NSS substock but is based entirely upon 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.

A harvest control rule automatically controls the functioning of the management procedure. This rule evaluates how well the observed CRA 8 CPUE tracks the rebuilding trajectory (= "status" indicator) and whether the CPUE trend is increasing more quickly or more slowly compared to the increasing target trajectory (= "gradient" indicator). The parameters of the harvest control rule represent a compromise between the maximisation of fishery harvest goals and the minimisation of 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).

Revised target biomass level

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) 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 for the 1979–80 to the 1981–82 fishing years. 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 which is nearly twice the recent level should serve as a reasonable and achievable reference biomass target. The target trajectory was made linear between the 1997 CPUE (0.94 kg/potlift, the lowest recorded) and the target value for 2011.

The problems stemming from the use of holding pots (see section 1 a) i)) have made this NSS rebuilding trajectory invalid, because the 1997 CPUE, used as a starting point, is positively biased. The revised value is 0.729, substantially lower than the original value of 0.94. Thus the trajectory must be revised. The target value is almost unchanged.

Two options are available for adjusting the existing trajectory; to keep the existing slope of the rebuilding trajectory by moving back the year that the target is achieved; or alternatively to keep the existing target year by increasing the slope of the rebuilding trajectory. The NRLMG recommended to the Minister of Fisheries that the first option (constant slope, delayed rebuilding) be employed and this was agreed in October 2003.

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:

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

where I_t^{obs} and I_t^{pred} are the observed and predicted 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*:

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

Then 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 $(R_t) > Maximum$

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 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

Implementation of NSS harvest control rule for 2003

A plot of the observed standardised CPUE indices compared with the agreed CRA 8 rebuilding trajectory is provided in Figure 6. 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 0.040 (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 0.093. When these two indicators are combined using the weighting parameter *W* (Table 12), the resulting value $\left(A_t^*\right)$ is 0.072 (Table 13). This value is scaled by the scaling parameter *S* (Table 12) to create a response $\left(R_t\right)$ of 0.054 (Table 13). This value is greater than the agreed minimum change value for the management procedure (0.05; Table 12), so the value of Z_t is set to 1.054 (Table 13) which enables the CRA 7 and CRA 8 TACs to be increased by 5.4% from April 2004.

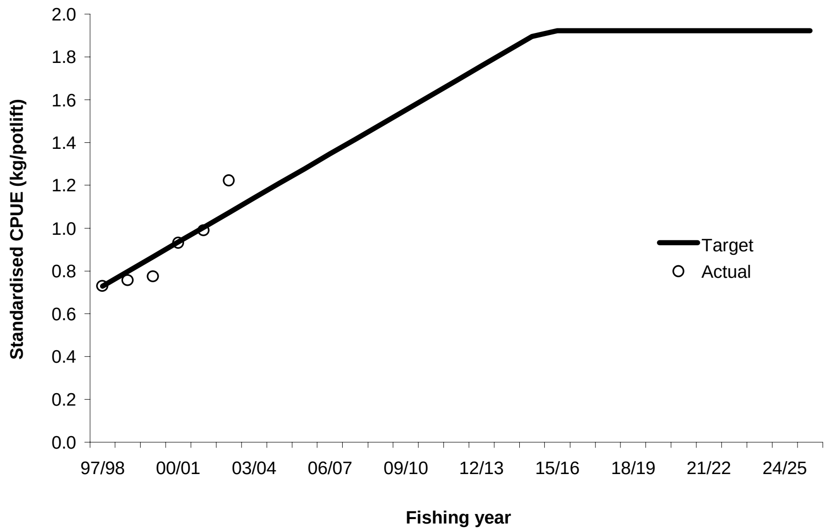


Figure 6. Operation of the new NSS harvest control rule for 2003. The target biomass trajectory for CRA 8 is generated by plotting a straight line from the observed starting value in the 1997–98 fishing year to the mean 1979–80 to 1981–82 CPUE which is to be achieved in 2015–16. Observed CPUE is generated 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 13. Implementation of NSS decision rule for 2003.

	Target Rebuild CPUE	Observed Standardised CPUE	Status Indicator	Gradient Indicator	A_t^*	R_t	Z_t
2000–01	0.935	0.930	-0.005	0.122			
2001–02	1.003	0.990	-0.014	-0.009			
2002–03	1.072	1.221	0.139	0.165			
Mean			0.040	0.093	0.072	0.054	1.054

STOCK ASSESSMENT

This section reports new assessments for *J. edwardsii* for CRA 4 and CRA 5 from the NSC substock.

Revised size-based model

Model structure

The size-based model used in 2002, which was fully described by Starr et al. (2003), was revised and improved for the 2003 assessment. The model is fitted to three series of catch rate indices from different periods, and to size frequency and tagging data.

An important structural feature of the model is the division of the year into two seasons (autumn-winter (AW): April to September, and spring-summer (SS): October to March). This captures several biological processes: a) season- and sex-specific moult patterns; b) possible differential vulnerability of both sexes between each other and between the two seasons; and c) a reduction in the vulnerability of mature females in the autumn-winter season because of their egg-bearing status. The seasonal structure is important to incorporate because several fisheries have changed from predominantly spring/summer fisheries to autumn/winter fisheries which catch mostly male lobsters.

Significant catches occurred in the early part of the time series for CRA 4 and CRA 5. Different MLS regulations existed at this time and pots were not required to have escape gaps. We therefore incorporated historical information for CRA 4 and CRA 5: a time series of sex-specific MLS regulations, time series of catch per day estimates for the 1960s and early 1970s, and some early size frequency data, including market sampling data. These data and their sources are listed in Table 14.

Major changes made to the 2003 model were: fitting to pre-recruit indices; estimation of recruitment deviations for all years through 1999; the generalised form of the growth model with shape parameter; direct estimation of catchability rather than calculating it; the use of true lognormal likelihood including the constants; addition of a switch assigning maximum seasonal vulnerability to any sex/season combination; and addition of a surplus production calculation.

The initial population in 1945 is assumed to be in equilibrium with average 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 autumn-winter season. The proportion of individuals entering each size class is modelled as a normal distribution with a mean size (32 mm) and standard deviation (2 mm), and is truncated at the smallest size class (30 mm). The magnitude of recruitment in a specific year is determined by the parameter for base recruitment and (except for the early years) a parameter representing the deviation from base recruitment. The vector of recruitment deviations is assumed to be normally distributed with a mean of zero. The years for which recruitment deviations were estimated were 1945 to 1999.

b) **Mortality**. Natural, fishing and handling mortalities are applied to each sex category (male, immature female and mature female) in each size class. Natural mortality is estimated, but is assumed to be constant and independent of sex and length. Fishing mortality is determined from observed catch and model biomass, modified by legal sizes, sex-specific vulnerabilities and selectivity curves.

   Fisheries that respect size limits (SL fisheries – legal commercial and recreational) are differentiated from those which do not (NSL fisheries – part of the illegal fishery plus the Maori traditional fishery). It is assumed that size limits and the prohibition of taking of berried females apply only to the SL fisheries. Otherwise, the selectivity and vulnerability functions are the same for the SL and NSL fisheries. Relative vulnerability is calculated by assuming that the males in the spring-summer season have the highest vulnerability and that the vulnerability of all other sex categories by season are equal to or less than the spring-summer males. 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) can be modelled by estimating separate selectivity parameters appropriate to each period of the fishery).

d) **Growth and maturity**. For each size class and sex category in a season, a transition matrix specifies the probability of an individual remaining in the same size class or growing into each of the other size classes. Maturity for females is estimated as a two-parameter logistic curve from the maturity-at-size information in the size frequency data.

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 the 1979–80 to 2002–03 fishing years. 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) and a pre-recruit index series from the catch sampling. A lognormal error structure was assumed for abundance indices and a normal error structure was assumed for tag-recapture data and proportions-at-length.

The model was fitted to size data (proportions-at-length) taken from commercial pots. These data were available either from research sampling conducted on commercial vessels or from voluntary logbooks maintained by rock lobster fishers. Estimates of the seasonal size frequency were obtained by collating data that had been 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. Size data from each source (research sampling or voluntary logbooks) were fitted separately. A fundamental assumption is that the size frequency data are representative of the commercial lobster catch. The size proportions within each season summed to one across all three sex categories: males, immature females, and mature females. This provides the model with seasonal estimates of the relative proportion by sex category in the catch.

Market sampling data were also used in the fitting procedure. These data are available only as carapace lengths from males and females, without maturity information. The carapace lengths were converted to tail width, and the model made predictions for the size classes beginning at one size class above the MLS.

A summary of the data used in each assessment, the data sources and the applicable years is provided in Table 14.

Table 14. Data types and sources for the 2002 assessment s for CRA 4 and CRA 5. Year codes apply to the first 9 months of each fishing year, *viz* 1998–99 is called 1998. NA – not applicable or not used; MFish - NZ Ministry of Fisheries; RLIC – Rock Lobster Industry Council.

Data type	Data source	Begin year	End year
Historical catch rate	Annala & King (1983)	1963	1973
CPUE	FSU & CELR	1979	2002
Pre-recruit index	MFish and RLIC	1993	2002
Historical proportions-at-size	Various	1974	1984
Observer proportions-at-size	MFish	1986	2002
Logbook proportions-at-size	RLIC	1994	2002
Current tag recovery data	RLIC & MFish	1996	2002
Historical MLS regulations	Annala (1983), MFish	1945	2002
Escape gap regulation changes	Annala (1983), MFish	1945	2002

The parameters estimated in each model and the priors used are provided in Table 15. Fixed parameters and their values are given in Table 16. CPUE, the historical catch rate, pre-recruit data, the proportions-at-length and tagging data were weighted directly by a relative weighting factor. For CRA 5 we varied the weights to obtain standard deviations of standardised residuals for each data set that were close to one. For CRA 4 it was necessary to increase the weight further on historical catch rate to obtain a credible fit.

Table 15. Parameters estimated and priors used in basecase assessments for CRA 4 and CRA 5. Prior type abbreviations: U– uniform; N – normal; L – lognormal.

	Prior Type	Bounds	Mean	CV
Log R_0 (ln mean recruitment)	U	1–50	–	–
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	1-25	–	–
LogqCR	U	1-25	–	–
LogqPRI	U	1-25	–	–
Increment at TW=50 (male & female)	U	1–8	–	–
Increment at TW=80 (male & female)	U	-10–3	–	–
CV of growth increment (male & female)	U	0.01-2.0	–	–
TW at 50% probability female maturity	U	30–80	–	–
(TW at 95% probability female maturity) – (TW at 50% probability female maturity)[2]	U	0–60	–	–
Relative vulnerability: males autumn-winter [3]	U	0-1	–	–
Relative vulnerability: males spring-summer	U	0-1	–	–
Relative vulnerability: immature and mature females spring-summer	U	0-1	–	–
Relative vulnerability: mature females autumn-winter	U	0-1	–	–
Shape of ascending limb of vulnerability ogive	U	1–50	–	–
Size at maximum selectivity males	N	10-80	54	2.0
Size at maximum selectivity females	N	10-80	60	2.0

[1] Normal in logspace = lognormal (bounds equivalent to – 10 to 10).
[2] CRA 5 only.
[3] Relative vulnerability of immature females in autumn-winter was fixed at one.

Table 16. Fixed values used in basecase assessment for CRA 4 and CRA 5.

	CRA 4	CRA 5
Std dev of observation error of increment	1	1
Std dev of historical catch per day	0.30	0.30
Std dev of pre-recruit index	0.30	0.30
Maximum exploitation rate	90%	90%
Handling mortality	10%	10%
Process error for CPUE	0.25	0.25
Year of selectivity change	1993	1993
Current male size limit	54	54
Current female size limit	60	60
First year for recruitment deviations	1945	1945
Last year for recruitment deviations	1999	1999
Relative weight for length frequencies	25	29
Relative weight for CPUE	0.733	1.52
Relative weight for CR	2.0	2.4
Relative weight for PRI	0.1	0.18
Relative weight for tag-recapture data	0.2	0.28
Projected SL catch (t)	644	447
Projected NSL catch (t)	70	62

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 the Markov chain – Monte Carlo procedure (McMC) using the Hastings-Metropolis algorithm;

c) For each sample of the posterior, 5-year projections (encompassing the 2003–04 to 2007–08 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 1989–1998;

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.

Table 17. Catches (t) used in the five-year projections. Projected catches are based on the current TACC for CRA 4 and CRA 5, and the current estimates of recreational, customary and illegal catches.

Population Modelled	Commercial	Recreational	Reported illegal	Unreported illegal	Customary
CRA 4	577	71	4	56	10
CRA 5	350	99	3	49	10

Performance indicators

The 2001 Plenary agreed to use a number of performance indicators as measures of the status and risk for CRA 3. Subsequent assessments have continued this agreement. The Working Group did not consider that virgin biomass or B_{MSY} were appropriate reference points, given the difficulty of accurately estimating these quantities. Therefore the assessment used performance indicators based on biomass levels for the ten years 1979 to 1988. This is the earliest period for which we have CPUE data, and base case fits for both CRA 4 and CRA 5 suggest that biomass was relatively stable during this period. In 2001 the Plenary agreed that this was an appropriate reference biomass level. Biomass in both stocks increased in the mid 1990s to higher levels than this reference level.

1. $BVULN_{03}/BVULN_{79\text{-}88}$
2. $BVULN_{08}/BVULN_{03}$
3. $BVULN_{08}/BVULN_{79\text{-}88}$
4. $UNSL_{02,AW}$
5. $USL_{02,AW}$
6. $UNSL_{07,AW}$
7. $USL_{07,AW}$

The vulnerable biomass in the assessment model is determined by four factors:
- MLS for male and female lobsters
- Length-based selectivity function
- Relative seasonal vulnerability of males and mature and immature females (parameters of the model)
- Berried state for mature females

Current vulnerable biomass, $BVULN_{03}$, is defined as the start-of-season vulnerable biomass on 1 April 2003, the beginning of the autumn-winter season for the 2003-04 fishing year. Similarly, projected vulnerable biomass $BVULN_{08}$ is defined as the start-of-season vulnerable biomass on 1 April 2008, the beginning of the autumn-winter season for the 2008–2009 fishing year. Vulnerable biomass was also calculated for the reference period: $BVULN_{79\text{-}88}$ is defined as the mean of beginning AW vulnerable biomass from 1979 through 1988.

$USL_{02,AW}$ is the exploitation rate for catch taken from the SL vulnerable biomass in the autumn-winter season of 2002–03, and $USL_{07,AW}$ is the exploitation rate for catch taken from the SL vulnerable biomass in the autumn-winter season of 2007–08, the last year of projections. $UNSL_{02,AW}$ and $UNSL_{07,AW}$ are similarly defined except that they describe the exploitation rate for catch taken from the NSL vulnerable biomass.

Stock assessment results using the revised size-based model

The following section presents the new stock assessments for CRA 4 and CRA 5.

***Jasus edwardsii*, CRA 4**

The base case assessment for CRA 4 was obtained by making the standard deviations of normalised residuals (sdnr) from all data sets close to 1 by adjusting the relative weights for each data set. It was not possible to reduce the sdnr to 1 for historical catch rate and still retain good minimisation. The fit to the data was acceptable except for the pre-recruit index, which had to be downweighted to maintain good minimisation.

Base case results suggested that vulnerable biomass decreased to a low in 1991, then increased strongly in the late 1990s and then declined after 1998. Exploitation rate peaked in the late 1980s to early 1990s at the model's maximum of 90% for the spring-summer fishery, and recent exploitation rate is near 60% for the catch limited by size limit and berried female restrictions in the autumn-winter.

A series of sensitivity trials on the MPD estimates, exploring the effects of various modelling choices, suggested that the results were generally robust to these trials. When the shapes of the biomass-CPUE and growth relations were estimated together, the model showed a better fit, but indicators were little changed. Little effect was seen when the assumed value of maximum exploitation rate was reduced to 70%. Projection results were sensitive to fitting alternative higher non-commercial catch vectors, but current stock status was similar. A set of retrospective analyses on the MPD fits showed generally good behaviour, suggesting that recent data have the effect of producing more optimistic model estimates; removing recent data leads to less optimistic fits. This effect is mild.

The assessment results (Table 1) are based on the posterior distributions of indicators. These were obtained from MCMC simulations – a single chain of 10 million was made and 5000 samples were taken. Results suggest that vulnerable biomass is currently about 32% higher (0.05 and 0.95 quantiles 16% to 48%) than in the 1979–88 reference period. At the 2002–03 level of catch and using recruitments sampled from 1989–98, the median expectation is that biomass will decrease by about 30% over five years, but with considerable uncertainty (30% to 190% of current biomass). Vulnerable biomass decreased in 69% of projections.

The projections rely on an assumption that recruitment would be similar, on average, to that in the period 1989–98 and with variability as seen in those ten years. No sensitivity tests were conducted using alternative recruitment assumptions such as the puerulus settlement data. 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 and 2002 near the long-term average.

Table 18. Summary statistics for performance indicators from posterior distributions from CRA 4. Biomass indicators are shown in t.

	Basecase			
	0.05	**Median**	**Mean**	**0.95**
$BALL_{79-88}$	7210	7550	7851	9095
$BRECT_{79-88}$	413	462	477	574
$BVULN_{79-88}$	522	559	565	626
$BALL_{03}$	5273	7019	7217	9803
$BRECT_{03}$	1444	1565	1566	1695
$BVULN_{03}$	659	742	744	836
$BALL_{08}$	4390	7133	7345	11065
$BRECT_{08}$	534	1052	1216	2396
$BVULN_{08}$	217	521	646	1457
$UNSL_{02}$ (%)	2.4%	2.7%	2.7%	3.0%
USL_{02} (%)	55.1%	62.0%	62.1%	69.8%
$UNSL_{07}$ (%)	1.8%	3.3%	3.5%	5.8%
USL_{07} (%)	36.1%	91.8%	78.9%	99.2%
$BVULN_{03}/BVULN_{79-88}$ (%)	116.1%	131.7%	131.9%	148.2%
$BVULN_{08}/BVULN_{03}$ (%)	29.5%	70.8%	86.6%	191.5%
$BVULN_{08}/BVULN_{79-88}$ (%)	38.5%	92.8%	114.4%	256.4%
$P(BVULN_{08}<BVULN_{03})$	0.688			

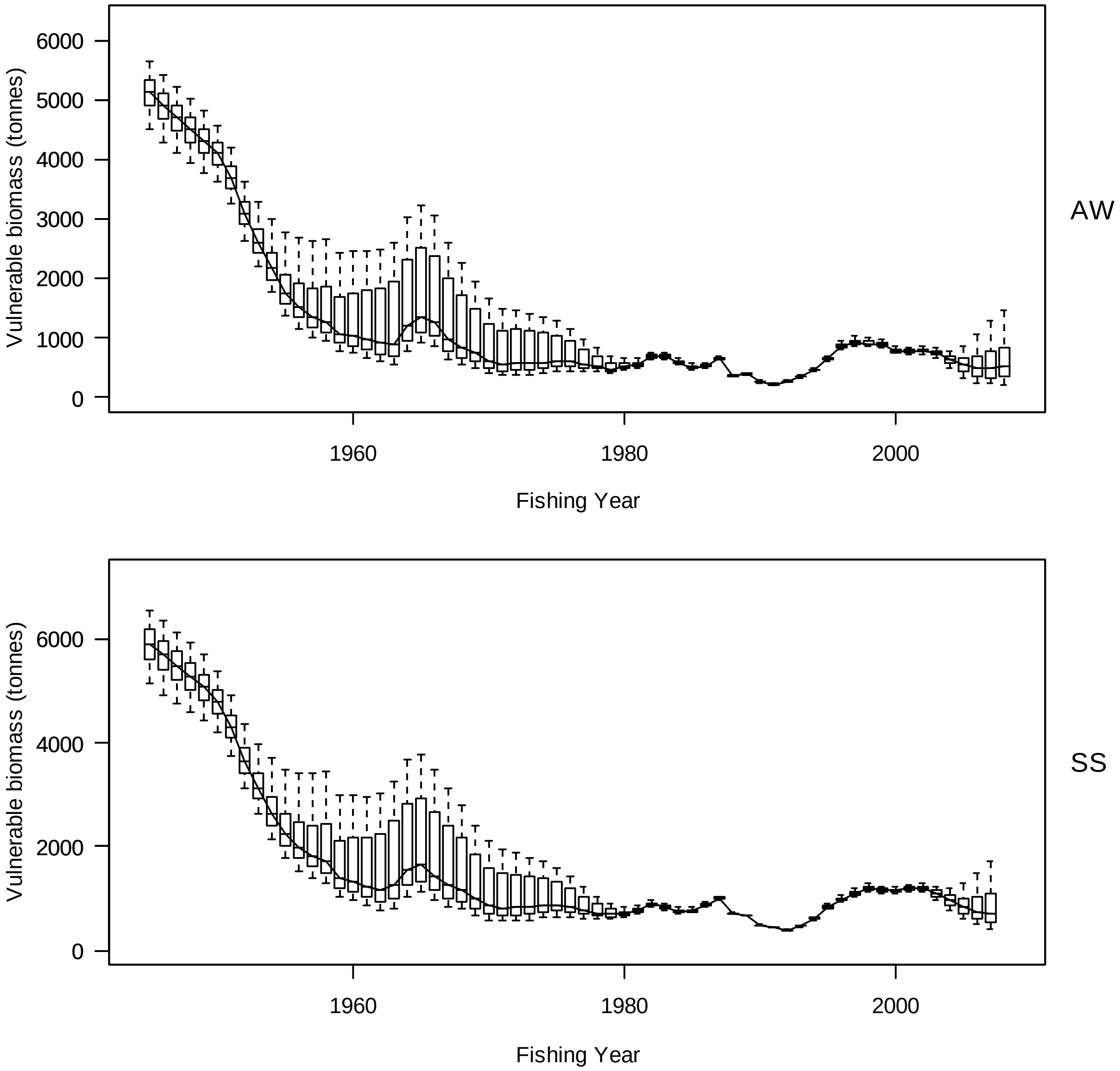


Figure 7. CRA 4: posterior trajectories of vulnerable biomass, for the AW (top) and SS (bottom) seasons, from the CRA 4 base case MCMC simulations. For each year the horizontal line represents the median, the box spans the 25th and 75th percentiles and the dashed whiskers span the 5th and 95th percentiles.

Jasus edwardsii, CRA 5

The base case assessment for CRA 5 was obtained by first making the standard deviations of standardised residuals from all data sets close to 1 by adjusting the relative weights for each data set. However, an initial McMC trial using a fit which had standard deviations of normalised residuals (sdnrs) close to 1 had a poor trace. This was solved by reducing slightly the weight on the CPUE and CR data sets which produced an McMC with a better trace and sdnrs close to 1.

Base case results suggested that biomass decreased to a low point in the late 1980s, remained low through 1995, then increased (Figure 7). Seasonal exploitation rate peaked in 1985 at over 80% for the spring-summer fishery, and is currently near 30% for the catch limited by size limit and berried female restrictions in the autumn-winter and much lower (about 10%) in the spring-summer fishery.

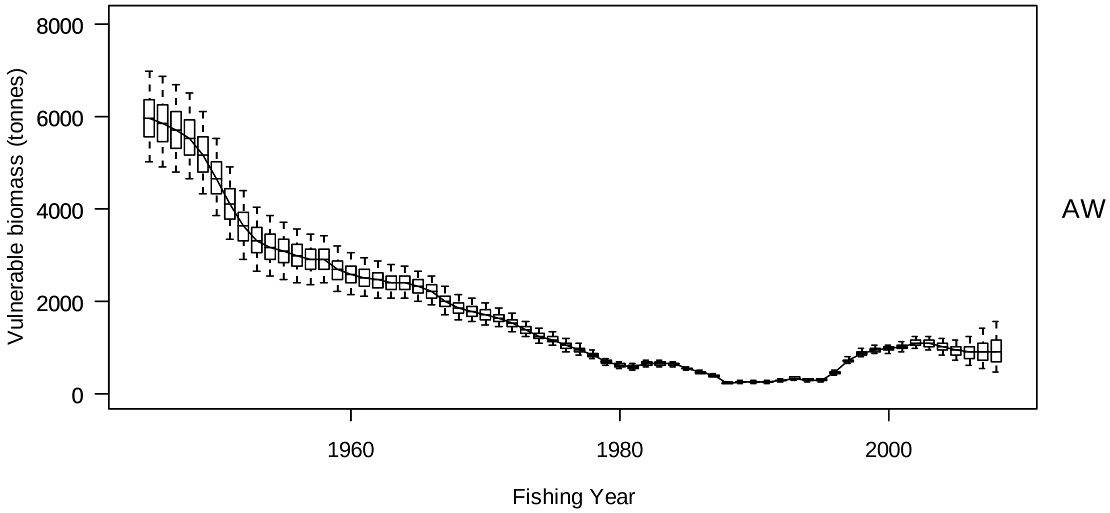
A series of sensitivity trials on the MPD estimate suggested that the results were generally robust to these trials. Sensitivities with alternative non-commercial catch estimates showed that projected biomass was more affected by differences in their trend, rather than their magnitude. A set of retrospective analyses on the MPD fits did not change estimates of biomass or exploitation rate a great deal.

The assessment results (Table 18) are based on the posterior distributions of indicators. These were obtained from MCMC simulations – a single chain of 2 million was made and 10 000 samples were taken. The first 1000 were discarded to improve the diagnostics, which were accepted by the Working Group. Results suggest that the 2003 vulnerable biomass is currently about 198% (0.05 and 0.95 quantiles 77% to 121%) of the vulnerable biomass during the 1979-88 reference period Figure 8). At the 2002–03 levels of catch and using recruitments sampled from 1989-98, the probability of the vulnerable biomass in 2008 being lower than the vulnerable biomass in 2003 is 0.69. However, the decrease is not expected to be large. The median expectation is that biomass will decrease to 84% of 2002-03 biomass over five years, but with considerable uncertainty (44% to 139% of current biomass).

The projections rely on an assumption that recruitment would be similar, on average, to that in the period 1989–98 and with variability as seen in those ten years. No sensitivity tests were conducted using alternative recruitment assumptions such as the puerulus settlement data. 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 and 2002 near the long-term average.

Table 19. Summary statistics for performance indicators from posterior distributions from CRA 5. Biomass indicators are shown in t.

				Basecase
	0.05	**Median**	**Mean**	**0.95**
$BALL_{79\text{-}88}$	3744	3918	3929	4151
$BRECT_{79\text{-}88}$	708	776	778	855
$BVULN_{79\text{-}88}$	517	555	557	606
$BALL_{03}$	4475	5281	5341	6394
$BRECT_{03}$	2314	2555	2562	2827
$BVULN_{03}$	966	1102	1106	1261
$BALL_{08}$	3928	5610	5676	7659
$BRECT_{08}$	1516	2364	2424	3494
$BVULN_{08}$	472	930	969	1586
$UNSL_{03}$ (%)	1.5%	1.7%	1.7%	2.0%
USL_{03} (%)	25.7%	29.4%	29.5%	33.5%
$UNSL_{07}$ (%)	1.3%	1.8%	1.9%	2.5%
USL_{07} (%)	22.7%	35.6%	37.3%	57.8%
$BVULN_{03}/BVULN_{79\text{-}88}$ (%)	176.9%	197.9%	198.5%	221.1%
$BVULN_{08}/BVULN_{03}$ (%)	44.5%	84.3%	87.2%	139.4%
$BVULN_{08}/BVULN_{79\text{-}88}$ (%)	85.5%	167.4%	173.7%	282.8%
$P(BVULN_{08}<BVULN_{03})$	0.692			



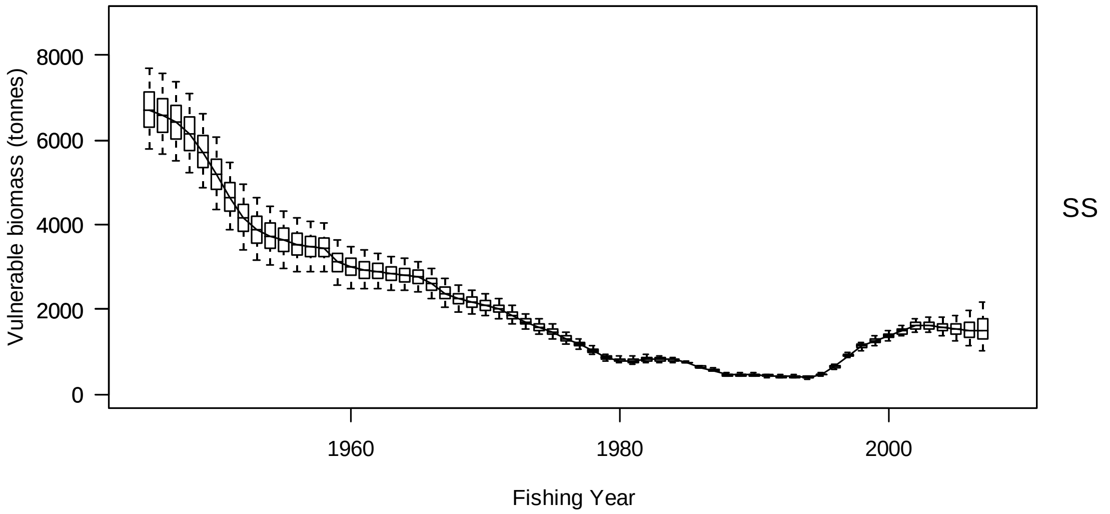


Figure 8. CRA 5: posterior trajectories of vulnerable biomass, for the AW (top) and SS (bottom) seasons, from the CRA 5 base case MCMC simulations. For each year the horizontal line represents the median, the box spans the 25th and 75th percentiles and the dashed whiskers span the 5th and 95th percentiles.

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.

STATUS OF THE STOCKS

***Jasus edwardsii*, NSN substock**

CRA 1

The stock assessment of CRA 1 was not updated in 2003. 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 present levels (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 2003. 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 2003. The revised length-based model was applied to this stock in 2001. The assessment suggested a stock that increased sharply from 1993 to 1997 and had since decreased in vulnerable biomass. The 2000–01 vulnerable biomass was high (mean = 238%) compared with a reference period (1974–79), the earliest period where there are good data available to estimate biomass.

CPUE rose steadily after a package of measures was implemented in 1993. It peaked in the 1997–98 season and has declined (0.721 kg/potlift in 2002–03). The model had no trouble fitting the increase, which was caused by a mixture of good recruitment, decreased removals, altered MLS and fishing patterns. The decline is difficult to fit with the model's assumptions, suggesting a problem with those assumptions, with the data, or possibly by an additional population process not captured in the modelling.

The base case assessment showed a median expectation that the stock would increase slightly in five years at the 2000–01 levels of catch, but the 5th and 95th percentiles of future stock level were 44% and 188% of the 2000 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, are 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 – it was assumed that recruitment would be similar, on average, to that in the period 1988–97 and 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. A sensitivity trial fitted the model to settlement data and used recent settlement indices to predict future recruitment. This trial showed a median expectation that the vulnerable biomass would decrease to about half the 2000–01 level by 2006, with 5th and 95th percentiles of 17% and 93%. If settlement at Castlepoint is a reliable index of future recruitment to the population in CRA 3, then the results suggested that continuing stock decreases were likely at the 2000–01 levels of catch.

CRA 4

The stock assessment of CRA 4 was updated in 2003. The 2003 model results suggest that 2002–03 stock abundance is higher than in the 1979–88 reference period. Exploitation rate peaked in the late 1980s to early 1990s at the model's maximum of 90% for the spring-summer fishery, and recent exploitation rate is near 60% for the catch limited by size limit and berried female restrictions in the autumn-winter under the 2002–03 levels of catch assumed in the model. Those levels of catch would produce a median 30% reduction in model biomass over five years to a level slightly below reference levels. Projections are sensitive to the assumed level of non-commercial catch.

These projections show 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 2002–03 levels used in the assessment, 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. In particular, the effect of alternative higher non-commercial catch histories in the model resulted in similar current stock status, but more pessimistic projections.

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 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**

There was no new assessment of the NSS stock in 2003. 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(b) above)." The outcome of the harvest control rule used to operate the management procedure would be to trigger a 5.4% increase in the 2003–04 TACs for CRA 7 and CRA 8.

***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 1998/1999 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 2002–03 fishing year (336 t) were within the range of estimates for *MSY* (300–380 t). The current TAC (370 t) also 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 2001-02 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	2002–03 TACC	2002–03 Commercial landings	2003–04 TACC	2003–04 TAC
CRA 1	Northland	–	130.5	130.8	130.5	
CRA 2	Bay of Plenty	–	236.1	205.7	236.1	452.6
CRA 3	Gisborne	–	327.0	291.0	327.0	453.0
CRA 4	Wairarapa–Hawke's Bay	–	576.0	575.1	576.0	771.0
CRA 5	Canterbury–Marlborough	–	350.0	348.7	350.0	467.0
CRA 6	Chatham Islands	300–380	360.0	335.8	360.0	370.0
CRA 7	Otago	–	89.0	88.6	89.0	109.0
CRA 8	Southern	–	568.8	567.1	568.8	655.0
CRA 9	Westland–Taranaki	–	47.0	46.8	47.0	
CRA 10	Kermadec	–	0.1	0.0	0.1	
Total			2684.5	2589.6	2684.5	
PHC 1	All QMAs	18	40.3		40.3	

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