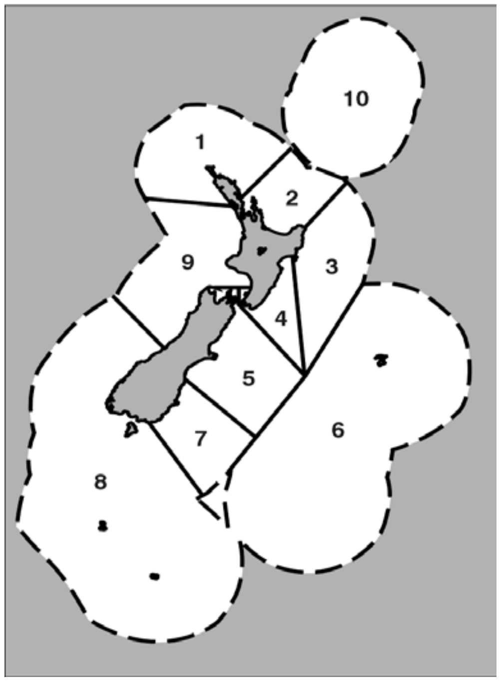
ROCK LOBSTER (CRA and PHC)

(*Jasus edwardsii*, *Sagmariasus verreauxi*)



1. FISHERY SUMMARY

Two species of rock lobsters are taken in New Zealand coastal waters. 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 fisheries were 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, rock lobster fishing 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, 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 (RLFAWG) 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 generally been carried out at the fishstock level, i.e. for CRA 1, CRA 2 &c.

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

The NSI stock is composed of the CRA QMAs 1–5 and 7–9, each being a separate Fishstock with a separate TACC. The sum of the TACCs for the NSI stock was set at 3 275 t for the year commencing 1 April 1990. This total was reduced in each year until 1993–94 to reach 2 382 t (taking into account some increases in individual ITQs resulting from appeals over catch histories by fishers). The total TACC for the NSI stock then fluctuated at a level of 2 300 to 2 400 t to the 2005–06 season, when the NSI TACC dropped to 2 229 t through a reduction to the CRA 3 TACC from 327 t to 190 t (Table 1). The CRA 3 TAC dropped at the same time from 453 t to 319 t. The total NSI TACC increased in 2006–07 to 2 407 t through increases to the CRA 7 and CRA 8 TACCs from the operation of the NSS Decision Rule in 2005. The CRA 4 stakeholders took voluntary reductions in their effective TACC by agreeing to a shelving of ACE (annual catch entitlement) in both 2007 and 2008. The TACs and TACCs for CRA 7 and CRA 8 were increased again on 1 April 2008 through the operation of a revised decision rule which was evaluated and approved in late 2007 and early 2008 (Table 1). The total New Zealand TACC for rock lobster in 2008-09 is 2 981 t, the highest it has been since 1992–93.

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

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

The MLS in the commercial fishery for red rock lobster is based on tail width (TW), except in the Otago fishery. For Otago (CRA 7), the MLS is a tail length (TL) of 127 mm, which applies to both sexes during the period 21 June to 19 November, the primary commercial season. The female MLS in all other rock lobster QMAs 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 TW for the June-August period.

Special conditions have applied to the Gisborne (CRA 3) fishery from April 1993. During June, July and August, commercial fishers are permitted to retain males at least 52 mm TW but females cannot be landed. These measures changed the commercial CRA 3 fishery to a mainly winter fishery for male lobsters from 1993 to 2002. The fishery was closed to all users from September to the end of November from 1993. This changed in 2000, when the beginning date for the closure was changed to 1 October. In 2002 the closed season was shortened further and CRA 3 now remains officially closed to commercial fishers only in May. Commercial fishers in 2008–09 have closed, by voluntary agreement, Statistical Areas 909 and 910 from 01 September to mid-January and Statistical Area 911 from mid-December to mid-January.

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

Commercial fisheries

Table 1 provides a summary by fishing year of the reported commercial catches, TACCs and TACs by Fishstock (CRA). The Quota Management Reports (QMRs) and their replacement Monthly Harvest Reports (MHRs; since 1 October 2001) provide the most accurate information on landings. Other sources of annual catch estimates include the Licensed Fish Receiver Returns (LFRRs) and the Catch, Effort, and Landing Returns (CELRs). In recent years, landings reported by LFRRs have been close to the QMR totals (Table 2 in Starr 2007).

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; N/A: catch not available (current fishing year)

	CRA 1			CRA 2			CRA 3		
Fishing Year	Catch	TACC	TAC	Catch	TACC	TAC	Catch	TACC	TAC
1990–91	131.1	160.1	–	237.6	249.5	–	324.1	437.1	–
1991–92	128.3	146.8	–	229.7	229.4	–	268.8	397.7	–
1992–93	110.5	137.4	–	190.3	214.6	–	191.5	327.5	–
1993–94	127.4	130.5	–	214.9	214.6	–	179.5	163.7	–
1994–95	130.0	130.5	–	212.8	214.6	–	160.7	163.7	–
1995–96	126.7	130.5	–	212.5	214.6	–	156.9	163.7	–
1996–97	129.4	130.5	–	213.2	214.6	–	203.5	204.7	–
1997–98	129.3	130.5	–	234.4	236.1	452.6	223.4	224.9	379.4
1998–99	128.7	131.1	–	232.3	236.1	452.6	325.7	327.0	453.0
1999–00	125.7	131.1	–	235.1	236.1	452.6	326.1	327.0	453.0
2000–01	130.9	131.1	–	235.4	236.1	452.6	328.1	327.0	453.0
2001–02	130.6	131.1	–	225.0	236.1	452.6	289.9	327.0	453.0
2002–03	130.8	131.1	–	205.7	236.1	452.6	291.3	327.0	453.0
2003–04	128.7	131.1	–	196.0	236.1	452.6	215.9	327.0	453.0
2004–05	130.8	131.1	–	197.3	236.1	452.6	162.0	327.0	453.0
2005–06	130.5	131.1	–	225.2	236.1	452.6	170.1	190.0	319.0
2006–07	130.8	131.1	–	226.7	236.1	452.6	178.7	190.0	319.0
2007–08	129.6	131.1	–	229.7	236.1	452.6	171.0	190.0	319.0
2008–09	N/A	131.1	–	N/A	236.1	452.6	N/A	190.0	319.0
	CRA 4			CRA 5			CRA 6		
Fishing Year	Catch	TACC	TAC	Catch	TACC	TAC	Catch	TACC	TAC
1990–91	523.2	576.3	–	308.6	465.2	–	369.7	518.2	–
1991–92	530.5	529.8	–	287.4	426.8	–	388.3	503.0	–
1992–93	495.7	495.7	–	258.8	336.9	–	329.4	503.0	–
1993–94	492.0	495.7	–	311.0	303.2	–	341.8	530.6	–
1994–95	490.4	495.7	–	293.9	303.2	–	312.5	530.6	–
1995–96	487.2	495.7	–	297.6	303.2	–	315.3	530.6	–
1996–97	493.6	495.7	–	300.3	303.2	–	378.3	530.6	–
1997–98	490.4	495.7	–	299.6	303.2	–	338.7	400.0	480.0
1998–99	493.3	495.7	–	298.2	303.2	–	334.2	360.0	370.0
1999–00	576.5	577.0	771.0	349.5	350.0	467.0	322.4	360.0	370.0
2000–01	573.8	577.0	771.0	347.4	350.0	467.0	342.7	360.0	370.0
2001–02	574.1	577.0	771.0	349.1	350.0	467.0	328.7	360.0	370.0
2002–03	575.7	577.0	771.0	348.7	350.0	467.0	336.3	360.0	370.0
2003–04	575.7	577.0	771.0	349.9	350.0	467.0	290.4	360.0	370.0
2004–05	569.9	577.0	771.0	345.1	350.0	467.0	323.0	360.0	370.0
2005–06	504.1	577.0	771.0	349.5	350.0	467.0	351.7	360.0	370.0
2006–07	444.6	577.0	771.0	349.8	350.0	467.0	352.1	360.0	370.0
2007–08	315.2	577.0	771.0	349.8	350.0	467.0	350.0	360.0	370.0
2008–09	N/A	577.0	771.0	N/A	350.0	467.0	N/A	360.0	370.0
	CRA 7			CRA 8					
Fishing Year	Catch	TACC	TAC	Catch	TACC	TAC			
1990–91	133.4	179.4	–	834.5	1152.4	–			
1991–92	177.7	164.7	–	962.7	1054.6	–			
1992–93	131.6	153.1	–	876.5	986.8	–			
1993–94	138.1	138.7	–	896.1	888.1	–			
1994–95	120.3	138.7	–	855.6	888.1	–			
1995–96	81.3	138.7	–	825.6	888.1	–			
1996–97	62.9	138.7	–	862.4	888.1	–			
1997–98	36.0	138.7	–	785.6	888.1	–			
1998–99	58.6	138.7	–	808.1	888.1	–			
1999–00	56.5	111.0	131.0	709.8	711.0	798.0			
2000–01	87.2	111.0	131.0	703.4	711.0	798.0			
2001–02	76.9	89.0	109.0	572.1	568.0	655.0			
2002–03	88.6	89.0	109.0	567.1	568.0	655.0			
2003–04	81.4	89.0	109.0	567.6	568.0	655.0			
2004–05	94.2	94.9	114.9	603.0	603.4	690.4			
2005–06	95.0	94.9	114.9	603.2	603.4	690.4			
2006–07	120.2	120.2	140.2	754.9	755.2	842.2			
2007–08	120.1	120.2	140.2	752.4	755.2	842.2			
2008–09	N/A	123.9	143.9	N/A	966.0	1053.0			

Table 1 (cont.): Reported commercial catch (t), TACC and TAC for CRA 9 and for all New Zealand. –:TAC not set for QMA; N/A: catch not available (current fishing year) [[1]all totals exclude CRA 10 and CRA EEZ]

	CRA 9			Total		
Fishing Year	Catch	TACC	TAC	Catch[1]	TACC[1]	TAC[1]
1990–91	45.3	54.7	–	2907.4	3793.0	–
1991–92	47.5	50.2	–	3020.9	3502.9	–
1992–93	45.7	47.0	–	2629.9	3201.9	–
1993–94	45.5	47.0	–	2746.2	2912.1	–
1994–95	45.2	47.0	–	2621.5	2912.1	–
1995–96	45.4	47.0	–	2548.6	2912.1	–
1996–97	46.9	47.0	–	2690.5	2953.1	–
1997–98	46.7	47.0	–	2584.2	2864.1	1312.0
1998–99	46.9	47.0	–	2726.0	2926.8	1275.6
1999–00	47.0	47.0	–	2748.5	2850.2	3442.6
2000–01	47.0	47.0	–	2795.9	2850.2	3442.6
2001–02	46.8	47.0	–	2593.0	2685.2	3277.6
2002–03	47.0	47.0	–	2591.1	2685.2	3277.6
2003–04	45.9	47.0	–	2451.5	2685.2	3277.6
2004–05	47.0	47.0	–	2472.3	2726.4	3318.8
2005–06	46.6	47.0	–	2475.8	2589.4	3184.8
2006–07	47.0	47.0	–	2604.8	2766.6	3362.0
2007–08	47.0	47.0	–	2464.8	2766.6	3362.0
2008–09	N/A	47.0	–	N/A	2981.0	3576.5

Problems with rock lobster commercial catch and effort data

There are two types of data on the Catch Effort Landing Return (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 QMAs 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 which was quickly remedied by providing additional instruction to fishers on how to properly complete the forms.

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 reported 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 catches 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, catches 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 reported area distribution of the estimated catches. The revised method assumes that landings from holding pots tend to even out at the month level. However, in some areas there are vessel/month combinations with no landings, indicating that the problem has not been completely solved by this approach. In these instances, the method is modified by dropping all data for the vessel in the month with zero landings and the following month; it is 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 arithmetic CPUE estimates in Tables 2 and 3 have been subjected to the same error screening as those used for standardised CPUE analysis. For arithmetic estimates, 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 RLFAWG 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, if fishermen do not report the catch they could legally have retained. The practice has become more prevalent in recent years, especially in areas where rock lobster abundance has increased. The RLFAWG agreed to identify this issue for further investigation.

Jasus edwardsii, NSI stock

NSI landings were relatively stable from about 1960 until the late 1980s, when they 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 2008 and CPUE (kg/potlift) for *Jasus edwardsii* NSI and CHI stocks, and NSN, NSC and NSS substocks, for the 1979–80 to 2007–08 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 2007–08 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 2007–08 from the CELR data held by the Ministry of Fisheries corrected for actual landings. *See* Booth et al. (1994) for a discussion of problems with the QMS-held FSU data.

	NSI Substocks						NSI Total		CHI	
Fishing	NSN (CRA1 & 2)		NSC (CRA3, 4 & 5)		NSS (CRA7 & 8)		CRA 1–5 & CRA 7–9		CRA6	
Year	Landings	CPUE	Landings	CPUE	Landings	CPUE	Landings	CPUE	Landings	CPUE
1979–80	408	0.57	1 386	0.85	2 129	1.58	4 012	1.06	400	2.33
1980–81	626	0.69	1 719	0.88	1 761	1.49	4 203	1.02	356	2.18
1981–82	574	0.66	1 664	0.85	1 663	1.48	3 973	0.99	465	2.19
1982–83	549	0.59	2 213	0.91	1 632	1.35	4 453	0.96	472	1.78
1983–84	506	0.55	2 303	0.85	1 634	1.09	4 514	0.87	548	1.73
1984–85	482	0.51	2 294	0.76	1 741	1.09	4 598	0.82	492	1.35
1985–86	556	0.54	2 227	0.71	2 185	1.21	5 048	0.83	604	1.41
1986–87	486	0.48	2 144	0.72	1 927	1.07	4 650	0.79	580	1.66
1987–88	442	0.45	1 781	0.57	1 961	1.12	4 277	0.72	448	1.48
1988–89	401	0.45	1 399	0.51	1 262	0.80	3 087	0.58	450	1.40
1989–90	427	0.55	1 457	0.53	1 352	0.81	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	0.95	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	1 142	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	323	1.23
2005–06	356	0.60	1 024	0.90	698	1.62	2 124	0.97	352	1.36
2006–07	358	0.70	973	0.76	875	2.07	2 253	1.00	352	1.45
2007–08	359	0.72	836	0.76	873	2.19	2 115	1.04	350	1.53

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. CPUE levels in CRA 1 and CRA 2 differ: CRA 1 maintained higher catch rates since the late 1990s while CRA 2 declined to less than 0.5 kg/potlift in 2002–03 and has since remained near that level (Table 3). The combined NSN catch rate has increased from 0.6 to 0.72 kg per potlift in 2007–08.

Jasus edwardsii, NSC substock

Landings in the NSC substock were very high to the mid 1980s, exceeding 2 000 t for five fishing years in succession. During that time, CPUE dropped from 0.9 kg/potlift to 0.7 kg/potlift (Table 2). Commercial catches then gradually decreased to below 1 000 t and CPUE dropped to below 0.5 kg per potlift by the early 1990s. From 1993–94, CPUE increased to a peak of 1.24 kg/potlift in 1999–00 (Table 2). CPUE dropped to near 1.0 kg per potlift in 2002–03, and dropped to 0.76 kg/potlift in 2006–07 and 2007–08. This is still higher than the levels observed from 1987–88 to 1995–96. Trends in CPUE have differed between the three component QMAs in the NSC, with CRA 3 CPUE peaking in 1997–98, CRA 4 in 1998–99, and CRA 5 in 2003–04 (Table 3).

Jasus edwardsii, NSS substock

Catches and CPUE were high for this substock: greater than 1 500 t per fishing year, with CPUE well over 1.0 kg per potlift throughout most of the 1980s. However, both measures gradually declined during that period, dropping below 1 000 t and below 1.0 kg per potlift by the early- to mid-1990s (Table 2). CPUE has been increasing since 1997–98 and is now above 2.0 kg per potlift for the two most recent fishing years (Table 2). Catches are relatively low in CRA 7 compared with those in other areas, but CPUE has been rising in both QMAs, with CPUE currently at the highest level in both QMAs since recording began (Table 3).

Jasus edwardsii, Westland/Taranaki (CRA 9)

Catch per pot lift fluctuated near 0.9 kg per potlift between 1998–99 and 2001–02, then increased to above 2 kg per potlift in 2004–05 and 2005–06, and has since decreased to just below 2 kg per potlift (Table 3).

Jasus edwardsii, CHI stock

CPUE in the CHI fishery was higher than in the other New Zealand CRA areas in the 1980s (Table 2). However, CPUE since the mid-1980s has declined to levels similar to those in other CRA QMAs (Table 3). CPUE dropped to 1.1 kg/potlift in 2003–04, and since increased to over 1.5 kg/potlift in 2007–08. 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 arithmetic CPUE (kg/potlift) for each CRA quota management area for the ten 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).

										Fishing year
QMA	**1998–99**	**1999–2000**	**2000–01**	**2001–02**	**2002–03**	**2003–04**	**2004–05**	**2005–06**	**2006–07**	**2007–08**
CRA 1	1.04	1.09	1.17	1.30	1.20	1.22	1.24	1.14	1.32	1.64
CRA 2	0.93	0.73	0.73	0.56	0.44	0.43	0.45	0.47	0.55	0.54
CRA 3	1.63	1.56	1.19	0.95	0.73	0.63	0.52	0.62	0.58	0.60
CRA 4	1.31	1.27	1.26	1.06	1.09	1.14	1.00	0.88	0.66	0.60
CRA 5	0.89	1.00	1.16	1.27	1.27	1.42	1.27	1.18	1.18	1.19
CRA 6	1.17	1.19	1.15	1.15	1.16	1.10	1.23	1.36	1.45	1.53
CRA 7	0.30	0.22	0.35	0.46	0.52	0.58	0.75	1.12	1.59	1.31
CRA 8	0.79	0.84	0.98	0.92	1.11	1.67	1.58	1.75	2.19	2.47
CRA 9	0.92	0.88	0.93	0.82	1.11	1.63	2.14	2.22	1.94	1.85

Sagmariasus verreauxi, PHC stock

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

Table 4. Reported landings of *Sagmariasus verreauxi* from 1990–91 to 2006–07. Data from QMR or MHR (after 1 Oct 2001). N/A: not available

Year	Landings (t)	Year	Landings (t)
1990–91	7.4	1999–00	12.6
1991–92	23.6	2000–01	9.8
1992–93	11.1	2001–02	7.8
1993–94	5.7	2002–03	8.6
1994–95	7.9	2003–04	16.4
1995–96	23.8	2004–05	20.8
1996–97	16.9	2005–06	25.0
1997–98	16.2	2006–07	25.4
1998–99	16.2	2007–08	N/A

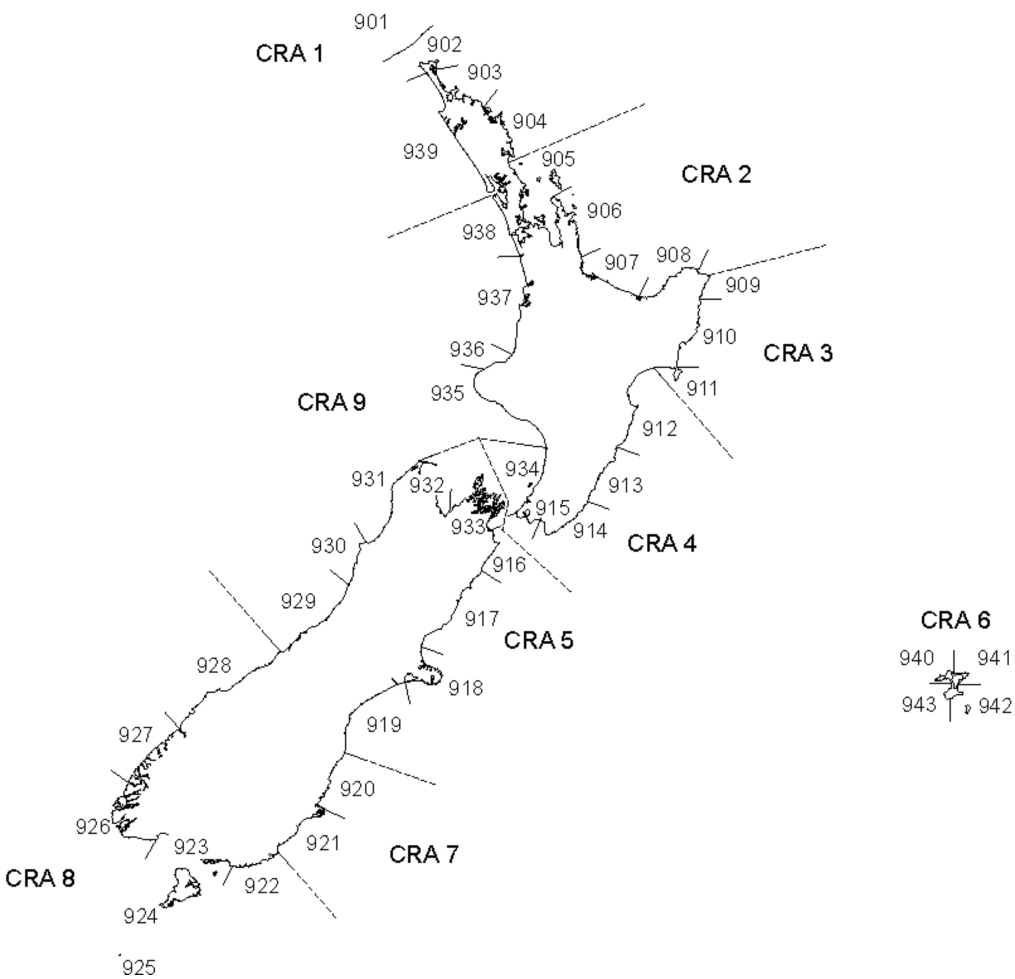


Figure 1. Rock lobster statistical areas as reported on CELR forms.

Jasus edwardsii CPUE by statistical area

Table 5 shows the CPUE 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 within and between CRA areas.

Table 5. **Arithmetic 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	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08	CRA	Stat Area	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08
1	901	2.05	–	3.48	3.21	2.88	3.29	6	940	0.99	0.76	0.89	0.91	1.03	1.15
1	902	3.04	3.29	2.01	2.19	–	1.97	6	941	1.31	1.40	1.58	1.72	1.93	2.04
1	903	0.72	0.79	1.14	0.81	1.17	1.12	6	942	1.18	0.99	1.04	1.51	1.95	1.41
1	904	0.36	0.36	0.58	–	–	0.56	6	943	1.15	1.18	0.99	1.04	1.51	1.95
1	939	1.12	1.15	1.14	1.30	1.25	1.38	7	920	0.45	0.45	0.55	0.83	1.27	1.14
2	905	0.48	0.56	0.61	0.51	0.61	0.57	7	921	1.07	1.88	1.61	1.81	2.12	1.81
2	906	0.36	0.36	0.40	0.49	0.53	0.57	8	922	–	–	–	–	–	–
2	907	0.49	0.46	0.47	0.47	0.56	0.60	8	923	–	2.75	2.46	4.27	2.02	3.82
2	908	0.53	0.46	0.44	0.43	0.55	0.43	8	924	1.34	2.34	1.93	3.08	3.90	2.79
3	909	0.81	0.88	0.82	0.82	0.99	1.02	8	925	–	1.57	1.15	–	–	2.87
3	910	0.55	0.60	0.55	0.59	0.48	0.60	8	926	1.29	1.92	1.74	1.93	2.41	1.99
3	911	0.93	0.60	0.43	0.61	0.62	0.52	8	927	0.93	1.56	1.43	1.21	1.56	2.21
4	912	1.08	1.10	0.77	0.60	0.58	0.66	8	928	0.75	0.94	1.15	1.52	2.13	3.99
4	913	1.18	1.36	1.20	0.94	0.76	0.71	9	929	–	–	–	–	–	–
4	914	1.02	1.08	1.06	0.94	0.57	0.47	9	930	–	1.79	–	–	2.94	–
4	915	1.21	0.90	0.70	0.81	0.76	0.79	9	931	0.88	0.86	0.87	0.70	0.68	0.68
4	934	1.21	2.21	2.30	2.15	1.69	1.76	9	935	–	–	–	1.58	–	–
5	916	2.25	2.36	2.21	1.90	1.68	1.73	9	936	–	–	–	–	–	–
5	917	0.96	1.18	1.00	0.98	1.09	1.19	9	937	0.96	0.81	0.69	0.57	0.78	1.08
5	918	1.31	1.38	1.37	1.72	–	–	9	938	–	–	–	–	–	–
5	919	0.45	0.45	0.55	0.83	1.27	1.14								
5	932	–	–	–	–	–	–								
5	933	–	–	–	–	1.55	0.81								

Recreational fisheries

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

Table 6. **All available estimates of recreational rock lobster harvest (in numbers and in tonnes by QMA, where available) from regional telephone and diary surveys in 1992, 1993, 1994, 1996, 2000 and 2001 (Bradford 1997, 1998; Teirney et al. 1997). Data were provided by the chairman of the Recreational Fisheries Fishery Assessment Working Group (Peter Todd, MFish; *pers. comm.*)**

QMA/FMA	Number	c.v. (%)	Nominal point estimate (t)
Recreational Harvest South Region 1 Sept 1991 to 30 Nov 1992			
CRA5	65,000	31	40
CRA7	8,000	29	7
CRA8	29,000	28	21
Recreational Harvest Central Region 1992–93			
CRA1	1,000		
CRA2	4,000		
CRA3	8,000		
CRA4	65,000	21	40
CRA5	11,000	32	10
CRA8	1,000		
Northern Region Survey 1993–94			
CRA1	56,000	29	38
CRA2	133,000	29	82
CRA9	6,000		
1996 Survey			
CRA1	74,000	18	51
CRA2	223,000	10	138
CRA3	27,000		
CRA4	118,000	14	73

QMA/FMA	Number	c.v. (%)	Nominal point estimate (t)
CRA5	41,000	16	35
CRA7	3,000		
CRA8	22,000	20	16
CRA9	26,000		
2000 Survey			
CRA1	107,000	59	102.3
CRA2	324,000	26	235.9
CRA3	270,000	40	212.4
CRA4	371,000	24	310.9
CRA5	151,000	34	122.3
CRA7	1,000	63	1.3
CRA8	13,000	33	23.3
CRA9	65,000	64	52.8
2001 Roll Over Survey			
CRA1	161,000	68	153.5
CRA2	331,000	27	241.4
CRA3	215,000	48	168.7
CRA4	419,000	22	350.5
CRA5	226,000	22	182.4
CRA7	10,000	67	9.4
CRA8	29,000	43	50.9
CRA9	34,000	68	27.7

In previous assessments, the RLFAWG has not accepted results from the 1999–2000 national survey and the subsequent “roll-over” survey (Table 6), both of which tended to have higher catch estimates in most of the CRA QMAs when compared to the earlier surveys. For 2008, the RLFAWG agreed to use a fixed estimate of recreational catch of 20 000 kg in the CRA 3 assessment, reasoning that this total is greater than the 1996 estimate when converted into weight and with the Section 111 landings added (see below; Table 7). As has been the practice in previous assessments, catch in weight was estimated using the mean weight for lobsters taken from the commercial sampling data for the relevant year or years, calculated using the recreational MLS (Table 7). The RLFAWG has little confidence in these estimates of recreational catch.

Table 7. Information used to estimate recreational catch for CRA 3.

	CRA 3
Available catch estimates (in numbers of lobsters)	
1992	8000
1996	27000
2000	270000
2001	215000
Calculation of recreational catch by weight	
1996 numbers	27000
1996 SS mean weight (kg)	0.533
1996 estimated catch (kg)	14390
2000/2001 average numbers	242500
2000/2001 SS mean weight (kg)	0.543
2000/2001 estimated average catch (kg)	131754
Section 111 reported landings	
Maximum reported landings (kg)	1167
Total estimated recreational catch	**20000**

Recreational landings made by commercial vessels under the provisions of Section 111 of the Fisheries Act 1996 were not added to the survey recreational catch estimates. These were identified as greenweight landings which used the destination code “F” in the MFish landing data. The maximum annual value in this category between 1989–90 and 2007–08 was 1 167 kg for CRA 3.

The RLFAWG agreed in 2008 to use a single recreational catch value of 20 t for all years used in the assessment.

Mäori customary fisheries

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

MFish provided collated returns for harvest taken under customary authorisations for CRA 3 (Table 8). These values should be considered minimum estimates of the actual catch as they include only catches that were authorised and then subsequently indicated as being taken. When these catch reports in numbers of lobsters were converted to weight, the annual estimates for CRA 3 were less than 10 t (Table 8).

The RLFAWG agreed in 2008 to use a single customary catch value of 20 t for all years used in the assessment. The RLFAWG has little confidence in these estimates.

Table 8. Estimates (kg) of CRA 3 catch based on lobster permits issued under Section 27A of the Amateur Fishing Regulations plus the CRA 3 catch under the kaimoana Regulations. A mean weight of 0.40 kg/lobster was used to convert from numbers to weight. This is the mean weight from all 2003 to 2007 samples (both sexes combined across all size categories). Source: letter from Alicia McKinnon (MFish) to P.A. Breen, 23 September 2008.

Year	Section 27A	Kaimoana	Total
2003–04	7136	0	7136
2004–05	5530	56	5586
2005–06	5212	80	5293
2006–07	3992	365	4357
2007–08	4893	4671	9564

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 3 (1.16) was applied as a constant multiplier to the reported legal catch in each of the years without export information. Illegal catch for the years 1974 to 1980 is taken from unpublished estimates of discrepancies between reported catch totals and total exported weight (McKoy pers. comm.).

Ministry of Fisheries Compliance staff have supplied illegal catch estimates for CRA 3 over a number of years, with the last available estimate for 2003–04 (Table 9). Values for years without estimates were obtained by interpolation. The 2003–04 estimate is considered by MFish to be the most credible estimate for current illegal catch in CRA 3[1].

Table 9. Estimates of illegal catches (t) for CRA 3 used in the 2004 and 2008 assessments. The estimates by category from 1994–95 onwards were provided by Aoife Martin (MFish Compliance, letter to P.A. Breen 17 August 2004). Estimates for 1990–91 and 1992–93 are historical estimates provided by MFish Compliance. Grey shaded cells were used to estimate proportion (0.045) of illegal catch eventually reported through legal channels.

	Illegal Recreational Take	Illegal Customary Take	Illegal Commercial Take	Poaching	Total
1990–91	–	–	–	–	288
1992–93	–	–	–	–	250
1994–95	24	13	5	–	42
1995–96	–	–	–	63	63
1996–97	–	–	20	64	84
1997–98	–	–	4	60	64
1998–99	7.5	9	4	70	90.5
1999–00	8	–	–	128	136
2000–01	5	–	3	70	78
2001–02	5	–	–	70	75
2002–03	5	–	–	70	75
2003–04	5	–	0	84.5	89.5[1]
2004–05	–	–	–	–	89.5[1]
2005–06	–	–	–	–	89.5[1]
2006–07	–	–	–	–	89.5[1]
2007–08	–	–	–	–	89.5

[1] (letter from Alicia McKinnon (MFish) to P.A.Breen, 23 September 2008)

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 shaded in Table 9 were assumed to be estimates of the commercial catches that eventually were reported through legal channels (missing values were assigned a value of 0.0). This proportion was applied to all illegal catch estimates from 1990–91 and subtracted from the legal commercial catch for the same years.

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

Other sources of mortality

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

2. BIOLOGY

They cannot be aged, at least easily or in high numbers, but 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. In CRA 3, 50% maturity appears to be realised near 40 mm TW. Most females in the south and southeast of the South Island do not breed before reaching MLS.

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.

Long-distance migrations of rock lobsters have been observed 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 3 stock assessment are shown in Table 10.

Table 10. Values used for some biological parameters.

1. Natural mortality (*M*) [1]

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

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

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

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

[2] Fecundity has not been 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

The primary source of information for growth is tag-recapture data. Lobsters have been caught, measured, tagged and released, then recaptured and re-measured at some later time (and in some instances re-released and re-recaptured later
Since 1998, the length-based model has been used to estimate the expected increment-at-size, which is represented stochastically by growth transition matrices for each sex. Growth increments-at-size are assumed to be normally distributed with means and variances determined from the growth model. The transition matrices contain the probabilities that a lobster will move into specific size bins given its initial size.

The growth model contains parameters for expected increment at 50 mm and 80 mm TW, a shape parameter (1 = linear), the c.v. of the increment for each sex, the minimum standard deviation and the observation error. This model is over-parameterised if all parameters are estimated, so the last two parameters are usually fixed.

Since 2006, the growth model applied to the tag-recapture data has been a continuous model – giving a predicted growth increment for any time at liberty greater than 30 days – whereas the older versions assumed specific moulting periods between which growth did not occur. For the current model, tag-recapture records from lobsters at liberty for fewer than 30 days are excluded. Some other basic data grooming is performed, but the robust likelihood fitting model precludes the need for extensive grooming of outliers. Growth parameters are estimated simultaneously with other parameters of the assessment model in an integrated way, so that growth estimates might be affected by the size frequency and CPUE data as well as the tag-recapture data.

For CRA 3, data are available from 1975–1981 and 1995–2006. Equivalent data are also available from a PhD project (Freeman 2008) from areas outside the Te Tapuwae o Rongokako marine reserve near Gisborne, and these data were used, with permission, in the stock assessment. For the 2008 assessment, it was discovered that growth rates based on the 1995–2006 data were significantly lower than those based on the 1975–1981 data. There is no obvious reason for the change in growth rates and an analysis of the CRA 5 tag recaptures did not show this decrease. Growth estimation in the 2008 assessment treated the older and newer data as two discrete data sets, and estimated growth for these periods separately as described below.

(b) Settlement indices

Annual levels of puerulus settlement have been estimated since 1979 or later at sites in Gisborne, Castlepoint, Napier, Wellington, Kaikoura, Moeraki, Halfmoon Bay, Chalky Inlet and Jackson Head.

The standardised settlement data for Gisborne to the end of 2007 show a strong settlement pulse in 1992–94, then lower settlement from 1995–2002, with very low settlement in 1999, and strongly varying settlement after 2002. Settlement is correlated among sites. Table 11 provides the Gisborne standardised settlement indices that were evaluated in the CRA 3 stock assessment in 2008.

Table 11. Puerulus settlement indices for CRA 3. Source: A. McKenzie, NIWA.

Year	Arithmetic	Standardised	Upper Bound	Lower Bound	Standard Error
1991	1.88	1.44	2.73	0.76	0.33
1992	3.18	2.04	3.01	1.38	0.20
1993	2.42	1.52	2.24	1.04	0.20
1994	2.90	2.83	4.00	2.00	0.18
1995	1.00	1.07	1.55	0.74	0.19
1996	0.77	0.99	1.46	0.67	0.20
1997	0.98	1.05	1.52	0.72	0.19
1998	1.30	1.43	2.03	1.00	0.18
1999	0.09	0.10	0.19	0.05	0.36
2000	0.84	0.93	1.35	0.64	0.19
2001	1.10	1.24	1.78	0.87	0.18
2002	0.96	1.09	1.58	0.76	0.19

Year	Arithmetic	Standardised	Upper Bound	Lower Bound	Standard Error
2003	1.70	2.14	3.03	1.51	0.18
2004	0.69	0.75	1.11	0.51	0.20
2005	2.23	2.44	3.42	1.73	0.17
2006	0.35	0.37	0.58	0.23	0.23
2007	0.34	0.29	0.52	0.16	0.30

3. STOCKS AND AREAS

There is no evidence for genetic subdivision of lobster stocks within New Zealand based on biochemical genetic and mtDNA studies. The observed long-distance migrations in some areas and the long larval life probably result in genetic homogeneity among areas. Gene flow at some level probably 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 prevalence of antennal banding, size at onset of maturity in females, migratory behaviour, 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 be genetically subdivided from populations of the same species in Australia.

4. DECISION RULES AND MANAGEMENT PROCEDURE

This section presents evaluations of the NSN and NSC rock lobster decision rules and the CRA 7 and CRA 8 management procedures for the 2009–10 fishing year, based on CPUE data extracted in September and November 2008.

Data preparation procedures

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

The NSN and NSC decision rules use annual standardised CPUE indices based on the fishing year. The CRA 7 and CRA 8 management procedures both use the most recent annual standardised CPUE estimates from CRA 7 or CRA 8 respectively. The year used as the basis for this straddles the fishing year. It comprises the most recent AW season and the preceding SS season (whereas the fishing year comprises the SS season and the preceding AW season).

The analysis follows the suggestion of Francis (1999) and calculates “canonical” coefficients and standard errors for each year, allowing the calculation of standard errors for every coefficient, including the base year coefficient. A further refinement is to scale each standardised index by the geometric mean of the simple arithmetic CPUE indices (the summed catch divided by summed effort for each fishing year). The geometric mean CPUE is preferred to the arithmetic mean because it is less affected by outliers than the arithmetic mean. This procedure scales the standardised indices to CPUE levels consistent with those observed by fishermen.

Decision Rule for NSN and NSC

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

Table 12. Decision rule indices for 1992–93 and 2007–08 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	2007–08 Index	2007–08 Lower	2007–08 Upper	Result
NSN	0.970	0.936	1.004	1.739	1.667	1.814	*
NSC	0.395	0.387	0.403	0.819	0.797	0.841	*

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 reversed and the standardised indices since 2004–05 show increases relative to 2003–04. The increase in the NSN series relative to the 2003–04 fishing year extends to both components of the NSN (CRA 1 and CRA 2). Figure 3 shows that the standardised index and the simple arithmetic mean show similar trends and that both are above the low abundance observed in the late 1980s and early 1990s.

Under the NSN decision rule, the 2007-08 CPUE is significantly above the 1992-93 CPUE (Table 12).

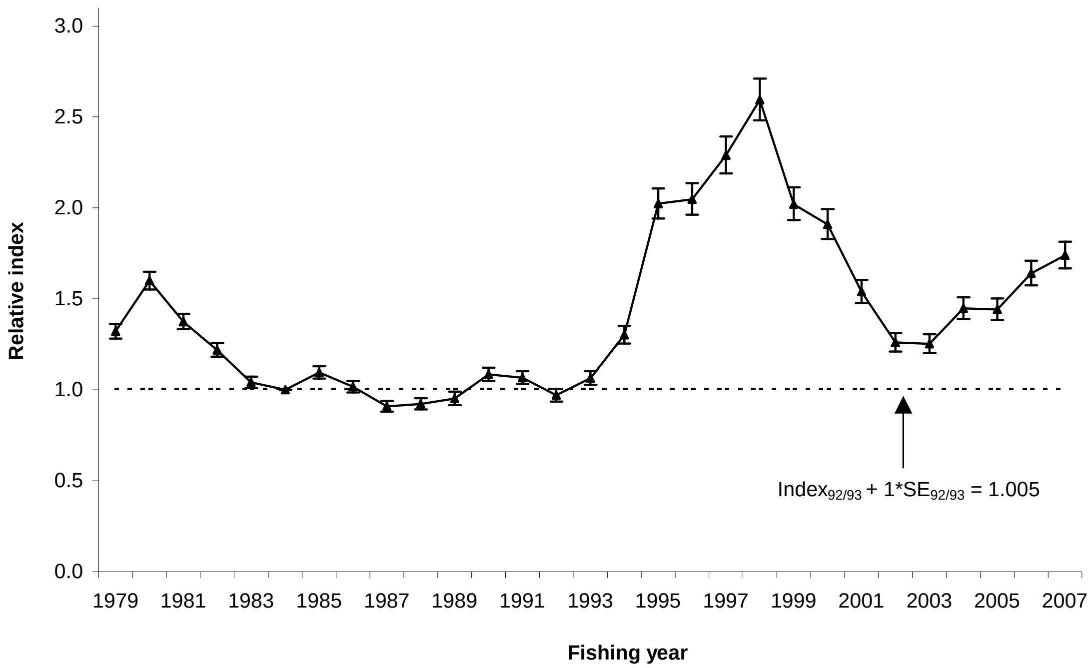


Figure 2. Values of the year index from the standardised CPUE analysis for the NSN substock showing plus and minus one standard error for each year. Horizontal line shows the upper bound of the 1992–93 standardised index which is the threshold for triggering this decision rule. Each year index is relative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

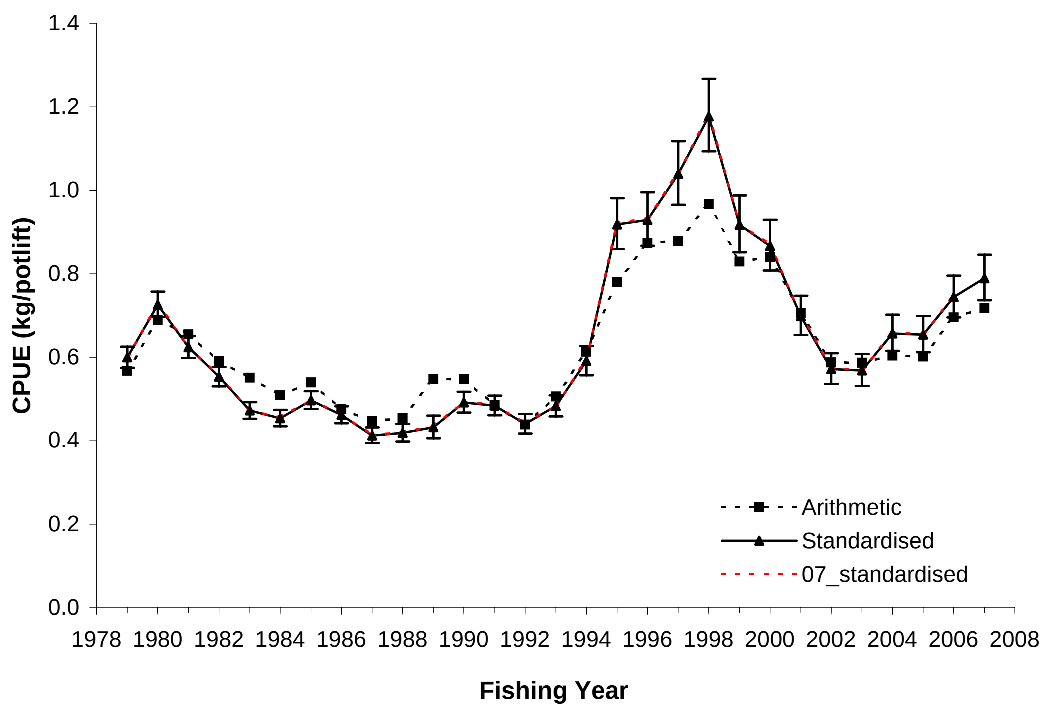


Figure 3. Values for the NSN standardised annual CPUE indices compared with the mean arithmetic annual CPUE (sum of annual catch divided by sum of potlifts). The standardised series is scaled to the geometric mean of the arithmetic annual CPUE (kg/potlift). Also shown is the equivalent standardised series calculated in September 2007.

NSC

As in the NSN substock, standardised CPUE for the NSC substock increased steadily between the 1992–93 and 1998–99 fishing years (Figure 4). Since then, there has been a continuous drop in CPUE to a level 50% below the 1998–99 peak. This decline has occurred in all three components of the NSC (CRA 3, CRA 4 and CRA 5), although CRA 4 is the only QMA showing a declining trend for the entire period to 2007–08. Both CRA 3 and CRA 5 have stopped declining, with CRA 3 having a flat trend since 2004–05 and CRA 5 flattening in 2007–08. CRA 5 only began its decline from a peak in 2003–04 while CRA 3 and CRA 4 started declining sooner. As was noted for the NSN substock, the standardised index for 2007–08 remains above the lowest level which was observed in 1992–93.

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

Under the decision rule, the 2007-08 CPUE is significantly above the 1992-93 CPUE (Table 12).

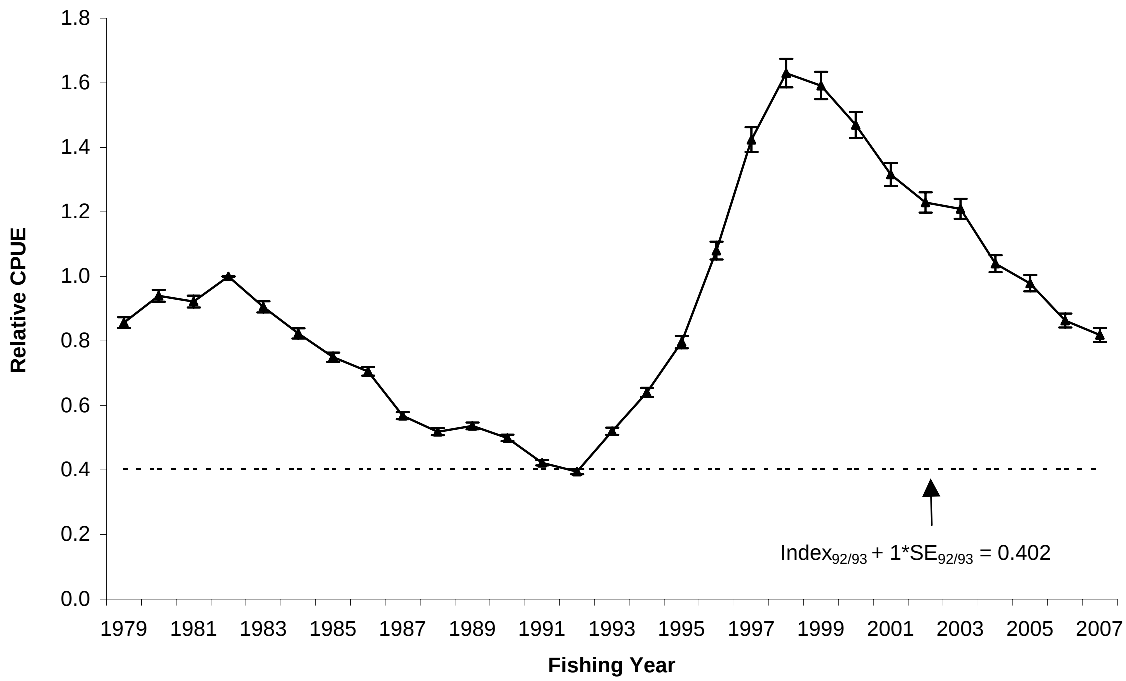


Figure 4. Values of the year index from the standardised CPUE analysis for the NSC substock showing plus and minus one standard error for each year. Horizontal line shows the upper bound of the 1992–93 standardised index which is the threshold for triggering this decision rule. Each year index is relative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

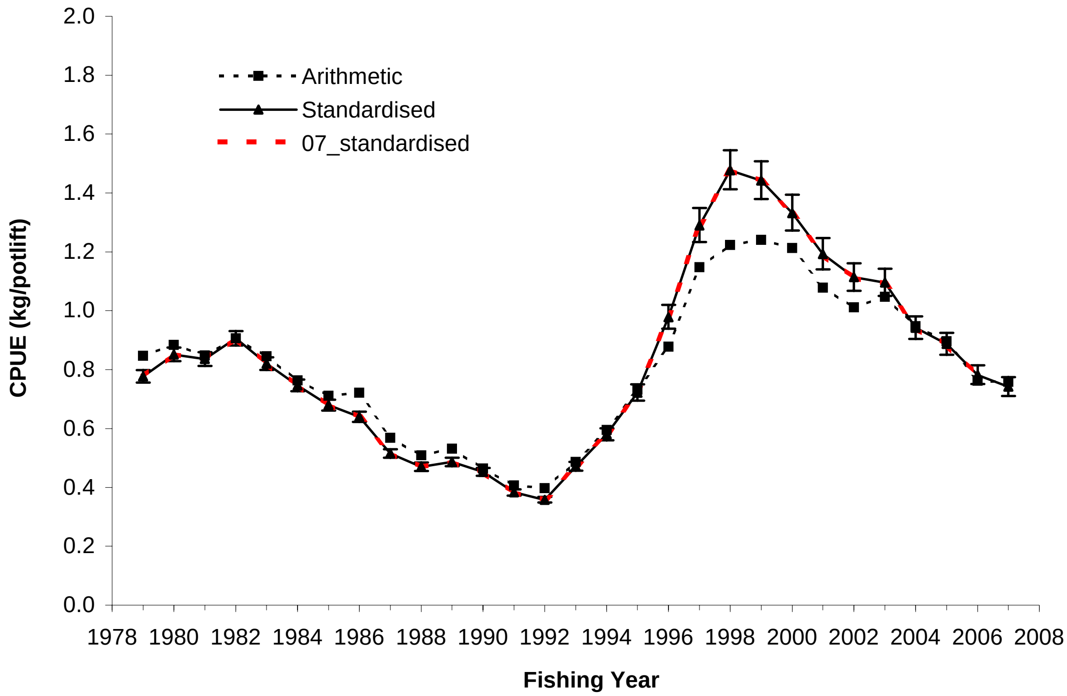


Figure 5. Values for the NSC standardised annual CPUE indices compared with the mean arithmetic annual CPUE (sum of annual catch divided by sum of potlifts). The standardised series is scaled to the geometric mean of the arithmetic annual CPUE (kg/potlift). Also shown is the equivalent standardised series calculated in September 2007.

Management Procedures for CRA 7 and CRA 8

Since 1996 both CRA 7 and CRA 8 areas have been managed using decision rules based on the observed CPUE in the fishery. The management procedure have been revised over the years, most recently in 2007 when a separate management procedure was accepted by the Minister for each of CRA 7 and CRA 8 for
the 2008–09 fishing year.

Both management procedures use the most recent standardised CPUE estimate as input. However, this analysis differs from those published in Starr (2007) as they encompass a non-standard fishing year, extending from 1 October to 30 September, thus bringing in 6 months of the active fishing year into the calculation. By using only the most recent CPUE observation, the new management procedure contrasts with the previous NSS procedure that used the most recent three years of estimates. Both new management procedures produce a TAC value in every year which also contrasts with the NSS procedure that incorporated a "latent year", whereby TAC changes could not be made in two consecutive years.

The CRA 7 management procedure is shown in Figure 6. The rule gives TAC as a simple function of CPUE. The rule is

$$TAC_{y+1} = 100 I_y$$

where TAC_{y+1} is the rule's specified TAC for the next year and I_y is standardised CPUE from the most recent 12 months, 1 October to 30 September (not the fishing year as shown in Table 3).

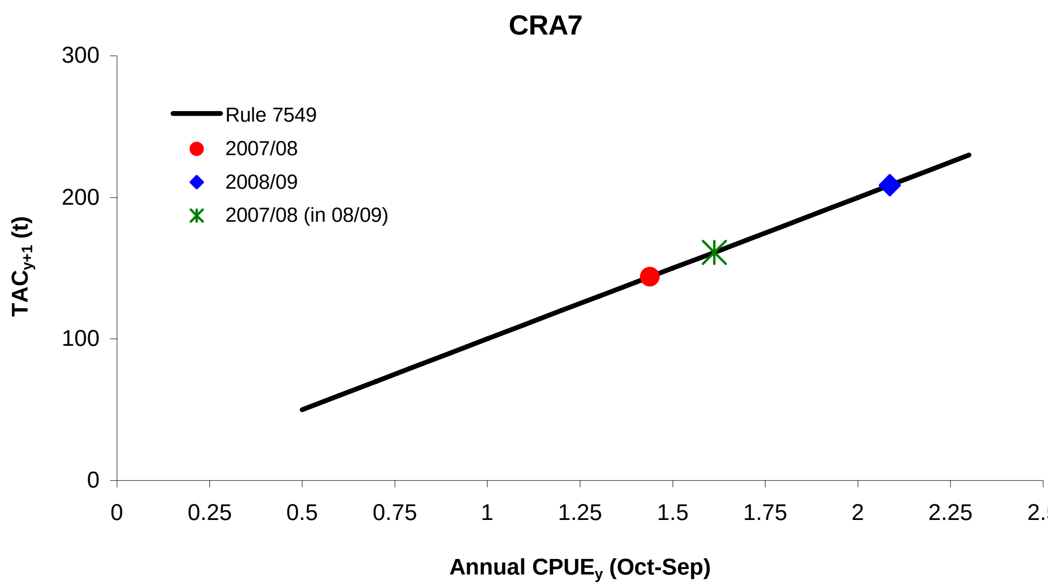


Figure 6: Graphical representation of the CRA 7 management procedure, showing TAC in the next year as a function of CPUE in the current year, showing the 2008–09 CPUE value (2.09 kg/pot lift). Also shown are the 2007–08 CPUE values, one calculated in December 2007 and the most recent from the end of October 2008.

The CRA 8 management procedure is shown in Figure 7. This rule gives a TAC which is not a simple linear function of CPUE: instead, TAC is constant over a wide range of CPUE; it decreases at a faster rate than CPUE when CPUE is below a threshold and it increases slowly when CPUE is above a threshold. The plateau affords stability of TACC that was a high desideratum of the CRA 8 commercial industry.

Formally, this rule is given by:

$$TAC_{y+1} = \begin{cases} \max\left(0, \left(1053 - 1.2\left(1.9 - I_y\right)\dfrac{1053}{1.9}\right)\right), & I_y < 1.9, \\ 1053, & 1.9 \le I_y \le 3.2, \\ 1053 + 0.16\left(I_y - 3.2\right)\dfrac{1053}{1.9}, & I_y > 3.2. \end{cases}$$

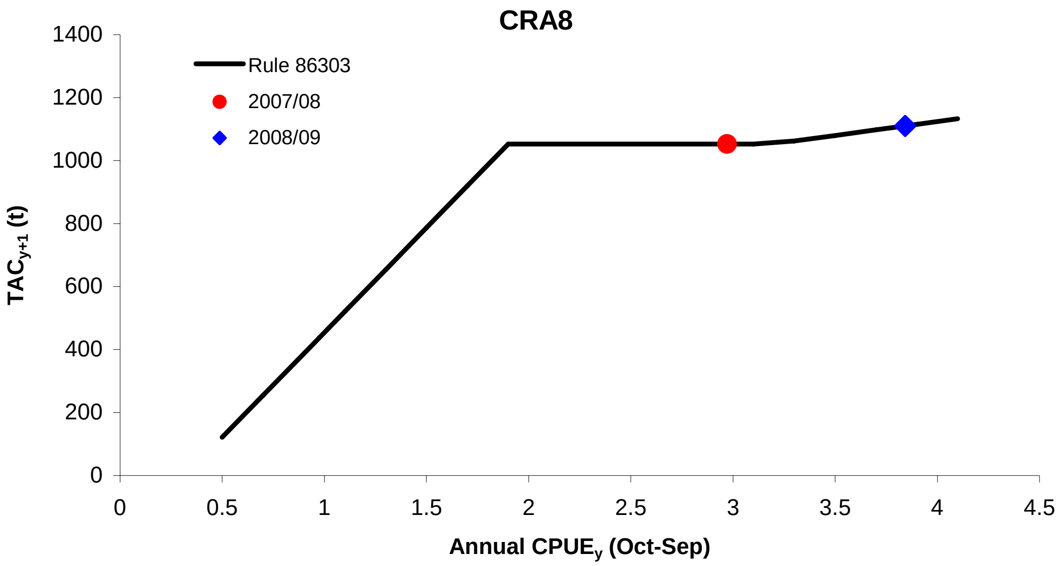


Figure 7: Graphical representation of the CRA 8 management procedure, showing TAC in the next year as a function of CPUE in the current year, showing the 2007–08 and 2008–09 CPUE values

Implementation of CRA 7 and CRA 8 harvest control rules for 2008

The most recent annual standardised CPUE estimate for CRA 7 is 2.09 kg/pot for the period 1 October 2007 to 30 September 2008. Under the CRA 7 management procedure, this gives a TAC of 209 t. The current TAC for CRA 7 is 143.9 t.

The most recent annual standardised CPUE estimate for CRA 8 is 3.84 kg/pot for the period 1 October 2007 to 30 September 2008. Under the CRA 8 management procedure, this gives a TAC of 1110 t. The current TAC for CRA 8 is 1053 t.

5. STOCK ASSESSMENT

A new multi-stock length-based model (MSLM) (Haist et al. 2009) was developed in 2006 as an extension to the length-based model previously used for rock lobster stock assessments. MSLM changed the growth model used to make predicted increments in tag-recapture data, and extended the model in several ways:

- MSLM allows several regions to be modelled simultaneously: separate parameters can be estimated for each region or common parameters can be estimated and shared by the regions;
- dynamics allow for movement among regions;
- fishing mortality dynamics can be finite (as in the older model) or instantaneous;
- density-dependent growth can be modelled;
- the time step can be variable;
- a stock-recruit relation can be modelled;
- the fishery selectivity sub-model has two options;
- likelihoods have a variety of options.

This model was used as a single-stock model for the 2008 assessment of CRA 3. In a simple preliminary trial, the new model was able to reasonably match the MPD results from the 2004 CRA 3 assessment when fitted to the same data.

Catch histories for CRA 3 were agreed by the RLFAWG. Other input data to the model included:

- tag-recapture data from 1975–1981 and from 1995–2006,
- standardised CPUE from 1979–2007,
- historical catch rate data from 1963–1973; and
- length frequency data from commercial catches (log book and catch sampling data) from 1989 to 2007.

Because the predicted growth rates were different for the 1975–1981 and 1995–2006 datasets, the RLFAWG agreed that it would inappropriate to fit the model to the combined tag-recapture dataset (as had been done in the 2004 CRA 3 assessment). Two approaches were used instead. First, the model was altered to permit of fitting to the two tag-recapture datasets separately. This alteration was not a formal generalised change to MSLM, but rather was a one-off change to produce a specialised CRA 3 assessment model. In this version, the growth transition matrix for years up to and including 1981 was based on the 1975–1981 tagging dataset (plus whatever contribution was made by other data sets). The growth transition matrix for years from 1995 onwards was based on the 1995–2006 tagging dataset (plus whatever contribution was made by other datasets). The growth transition matrix for the intervening years, 1982–1994, was based on an interpolation of the growth transition matrices estimated for the earlier and later periods. The sensitivity of the model predictions to the specified transition years was also examined.

In this version of the model, the size classes represented by the model were specified differently to deal with a technical problem introduced by the new growth rate handling. The midpoint of the first size bin in the model was increased from 31 mm to 45 mm, and the recruiting cohort mean size was increased to midpoint 47 mm from 33 mm. This was done to avoid growth model misspecification in the small size classes for which there are no observations.

In the second approach, the model was fitted to data from 1983 onwards, using only the 1995–2006 tag-recapture data. This approach was rejected by the RLFAWG, based on the diagnostics of the model and the value of some of the parameters in the results, and will not be described further.

The start date for the accepted model was 1945, with an annual time step through 1973 and then switching to a seasonal model from 1974 onward: autumn/winter (AW), extending from April to September, and spring/summer (SS), extending from October to March. The last fishing year in the minimisations was 2007, and projections were made through 2012 (five years). Two selectivity epochs were modelled, with the change made in 1993 to capture regulation shifts for the pot escape gaps. Recruitment deviations were estimated from 1945 through 2004. Maximum vulnerability was assumed to be for males in the SS season. A marine reserve was modelled, beginning in 1999 and alienating 10% of the habitat. The model was fit to CPUE, the historical catch rate series, length frequency (LF) data and the two tag-recapture datasets. No pre-recruit index was fit, and the puerulus settlement index was fit in a separate randomisation trial.

A log-normal prior was specified for *M*, with mean 0.12 and c.v. of 0.4. A normal prior was specified for the recruitment deviations in log space, with mean 0 and standard deviation 0.4. Priors for all other parameters were specified as uniform distributions with wide bounds.

Other model options used in the reference case were:

- the dynamics option was set to instantaneous;
- selectivity was set to the double normal form used in previous assessments;
- movements were turned off;
- the relation between CPUE and biomass was fixed to linear;
- maturity parameters were fixed at values estimated outside the model;
- the growth c.v. was fixed to 0.5 to stabilise the analysis;
- the right-hand limb of the selectivity curve was fixed to 200 as in previous assessments;
- dataset weights were adjusted to attempt to obtain standard deviations of normalised residuals of 1.0 or medians of absolute residuals of 0.67.

The RLFAWG considered results from the mode of the joint posterior distribution (MPD) results and the results of 13 sets of MPD sensitivity trials:

- altering the specification of the growth transition period,
- varying the transition period between tag data sets,
- using finite dynamics instead of instantaneous,
- varying start year and initial exploitation rate,
- estimating the relation between CPUE and biomass,
- estimating the CV of predicted growth increments,
- estimating maturity parameters,
- fixing the size at maximum selectivity for females to 60,
- fixing M to 0.12 (the mean of the prior),
- removing data sets one at a time
- estimating the right-hand limb of selectivity for both sexes and epochs,
- ignoring the marine reserve,
- fitting to puerulus settlement data and
- adding uncertainty to NSL catches as requested by the WG

Most base case results showed limited sensitivity to these trials, with some notable exceptions being the removal of CPUE data or, to a lesser extent, removal of tag-recapture data. The indicator ratios were reasonably stable, but some sensitivity was observed to model starts after 1945 with different assumed values for initial exploitation rate. Overall, it was not possible to draw strong conclusions from the sensitivity trials, given that the median and mean of the assessment posterior distributions moved a considerable distance from the MPD estimates.

The assessment itself was based on Markov chain – Monte Carlo (McMC) simulation results. We started the simulation at the base case MPD, and made a chain of three million, with samples saved every 1000 samples, for a sample size of 3000. From the joint posterior distribution of parameter estimates, forward projections were made through 2012. In these projections, catches were assumed to remain constant at their 2007 values, except that the TACC of 190 t was used for commercial catch (which is about 20 t greater than the 2007 commercial catch). The 2007 commercial catch seasonal split was used. Recruitment was re-sampled from 1995-2004, and the estimates for 2005–2007 were overwritten. These projections are sensitive to the period chosen from which to re-sample recruitment, because recruitment trends are different over different periods. The most recent ten years' estimates are considered the best information about likely future recruitments in the short term.

The RLFAWG agreed on a set of indicators. Some of these were based on beginning of season AW vulnerable biomass: the biomass legally and functionally available to the fishery, taking MLS, female maturity, selectivity-at-size and seasonal vulnerability into account. The limit indicator *Bmin* was defined as the nadir of the vulnerable biomass trajectory (using current MLS), 1945-2007. Current biomass, *B2008*, was taken as vulnerable biomass in AW 2008, and projected biomass, *B2012*, was taken from AW 2012.

A biomass indicator associated with *MSY* or maximum yield, *Bmsy*, was calculated by doing deterministic forward projections for 50 years, using the mean of estimated recruitments from 1979-2004. This period was chosen to represent the recruitments that were estimated from adequate data, and represents the best available information about likely long-term average recruitment. These *MSY* and *Bmsy* calculations are sensitive to the period chosen to represent the mean recruitment, which varies substantially over the range of the period available, causing variation in estimated *Bmsy*. It was agreed to hold the non size-limited (NSL) catches (customary and illegal) constant at their assumed 2007 values and to vary the SL fishery mortality rate *F* to maximise the annual size-limited (SL) catch, and to record the associated AW biomass.

MSY was the maximum yield (the sum of AW and SS "size-limited" [SL] catches) found by searching across a range of multipliers (from 0.1 to 2.5) on the AW and SS *F* values that were estimated for

2007 for the SL catch for each of the 3000 samples from the joint posterior distribution. The model used a Newton-Raphson algorithm to find the NSL fishery mortality rates. The AW vulnerable biomass associated with the *MSY* was taken to be *Bmsy*. If the *MSY* were still increasing with the highest *F* multiplier, the *MSY* and *Bmsy* obtained with that multiplier were used. The multiplier, *Fmult*, was also reported as an indicator. The *MSY* and *Bmsy* calculations were based on the growth parameters estimated from the second (1996–2006) tag dataset.

We also used as indicators the exploitation rate associated with the SL catch from 2007 and 2012: *USL2007* and *USL2012* respectively. At the request of the National Rock Lobster Management Group we also compared projected CPUE with an arbitrary target of 0.75 kg/potlift.

The assessment was based on the medians of posterior distributions of these indicators, the posterior distributions of ratios of these indicators, and probabilities that various propositions were true in the posterior distributions.

The primary diagnostics used to evaluate the convergence of the McMC were the appearance of the traces, running quantiles and moving means. The trace for *M* was not as well mixed as one could hope to see and showed some drift throughout the run, with higher values towards the end. The running quantile plots for many estimated parameters also showed a drift through the run, suggesting poor convergence, and a trend to move well away from the MPD estimate. Diagnostic plots of the indicators, however, tended to be more acceptable than those of the parameters.

The posterior trajectory of vulnerable biomass by season from 1976 (Figure 8) shows a nadir near 1989, a strong increase in the 1990s followed by a sharp decrease, and variable projections with an decreasing median. The trajectory of biomass from 1945 to 1960 is difficult to explain as there were only low catches throughout this period; the model output shows low recruitments estimated for these years.

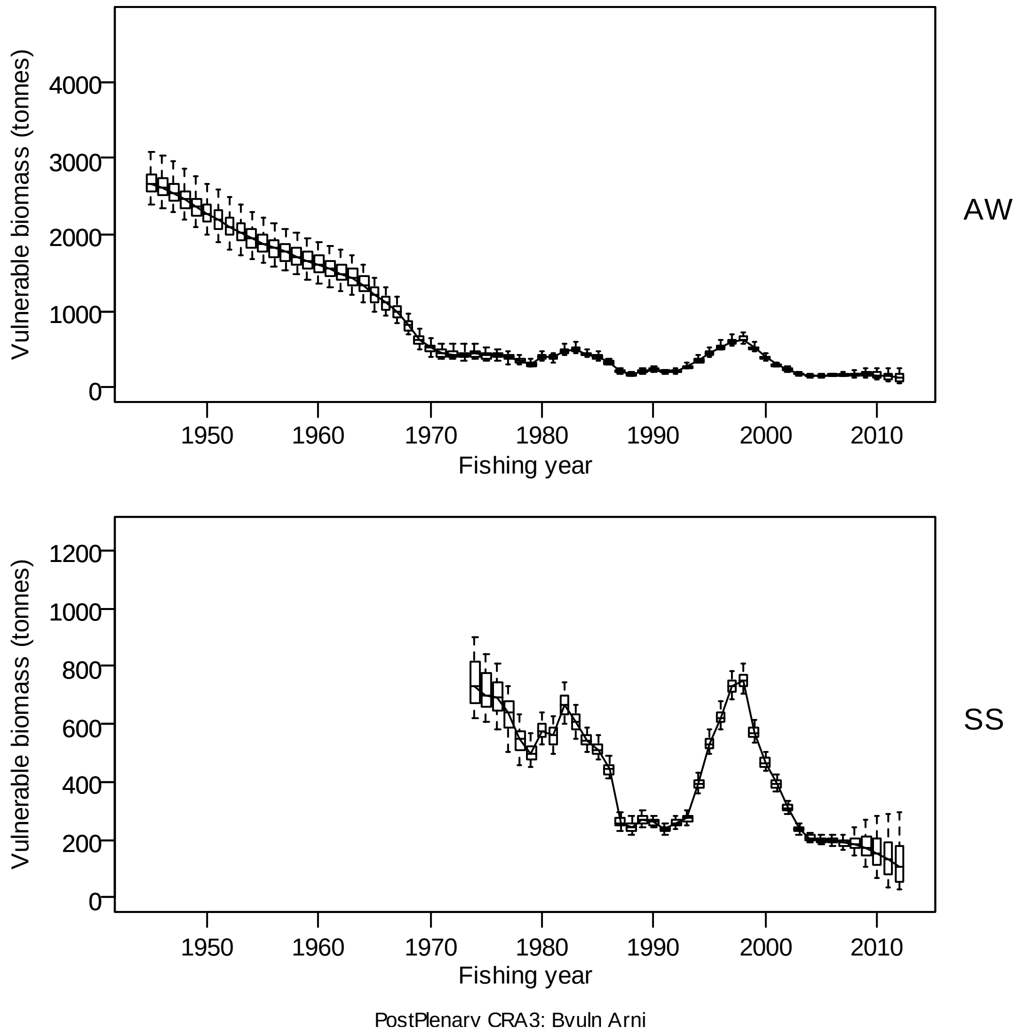


Figure 8: The posterior trajectory of vulnerable biomass, by season, from the CRA 3 base case McMC simulations, including the projections from 2008-12. For each year the horizontal line represents the median, the box spans the 25th and 75th percentiles and the dashed whiskers span the 5th and 95th percentiles. Values in the AW panel before 1974 reference a complete year rather than the AW season.

The assessment results are summarised in Table 13. *Bmsy* and *MSY* from the base case were calculated with growth estimates based on the later and slower growth dataset. Current biomass (2008) was above *Bmin* in 83% of runs, and the median result was 11% above *Bmin*. Current biomass was above *Bmsy* in less than 1% of runs, and the median result was half *Bmsy*. Current exploitation rate was about 55%.

Biomass increased in only 25% of projections, and the median decrease was 25%. Projected biomass had a median of 124 t, but uncertainty around this was high, with a 5% to 95% range of 65 to 256 t. *B2012* was above *Bmin* in 36% of runs, and the median result was 83% of *Bmin*. *B2012* was greater than *Bmsy* in less than 1% of runs, and the median was 37% of *Bmsy*.

Projected CPUE had a median of 0.5 kg/potlift, and only 20% of runs exceeded 0.75 kg/potlift. The mean *F* multiplier associated with *MSY* was about 75% of current *F*.

These results suggest a stock that is near *Bmin* and well below *Bmsy*. Under current catches and recent recruitments the model predicted a 75% probability of biomass decrease over four years.

Table 13: Quantities of interest to the assessment from the model base case McMCs. *USL* is the exploitation rate that produces the size-limited catch. All biomass values are in tonnes and represent the beginning of season AW vulnerable biomass.

	indicator	type	value	5%	95%
biomass	*Bmin*	median	149.1	134.4	172.2
	B2008	median	167.1	135.1	218.7
	B2012	median	123.7	64.9	255.6
	Bmsy	median	330.4	301.2	378.1
CPUE	*CPUEcurr*	median	0.662	0.547	0.835
	CPUE2012	median	0.492	0.260	0.989
	CPUEmsy	median	1.314	1.178	1.476
yield	*MSY*	median	300.4	291.2	310.2
biomass ratios	*B2008/Bmin*	median	1.114	0.936	1.400
	B2008/Bmsy	median	0.505	0.406	0.643
	B2012/B2008	median	0.746	0.424	1.347
	B2012/Bmin	median	0.831	0.445	1.662
	B2012/Bmsy	median	0.372	0.195	0.759
fishing mortality	*USL2007*	median	0.550	0.461	0.621
	USL2012	median	0.811	0.392	1.546
	USL2012/USL2007	median	1.478	0.733	2.761
	Fmult	mean	0.727		
probabilities	P(*2008>Bmin*)	mean	82.5%		
	P(*B2008>Bmsy*)	mean	0.0%		
	P(*B2012>B2008*)	mean	24.5%		
	P(*B2012>Bmin*)	mean	36.5%		
	P(*B2012>Bmsy*)	mean	0.5%		
	P(*CPUE2012*>0.75)	mean	19.0%		
	P(*USL2012>USL2007*)	mean	78.9%		

Projections were made with alternative levels of SL catch (commercial plus recreational) with the NSL catch (illegal and customary) held constant. These were 5-year projections made in the same way as the base case projections described above, and were made at the request of the Plenary for the guidance of the NRLMG, stakeholders and MFish.

Table 14: results of 5-year projections with alternative SL catch levels.

SL catch (t)	**206.0**	**185.4**	**164.8**	**144.2**	**123.6**	**82.4**	**41.2**	**0.01**
% of current catch	**100%**	**90%**	**80%**	**70%**	**60%**	**40%**	**20%**	**0%**
B2012	123.7	160.9	195.3	229.0	262.0	328.6	396.6	463.6
B2012/Bmin	0.831	1.073	1.307	1.532	1.754	2.199	2.645	3.090
B2012/B2008	0.746	0.948	1.151	1.346	1.548	1.942	2.340	2.740
B2012/Bmsy	0.372	0.481	0.586	0.688	0.788	0.989	1.191	1.394
CPUE2012	0.492	0.639	0.775	0.910	1.041	1.303	1.566	1.832
P(*B2012>Bmin*)	36.5%	57.0%	77.4%	92.4%	98.2%	100.0%	100.0%	100.0%
P(*B2012>B2008*)	24.5%	44.4%	67.6%	88.7%	97.7%	100.0%	100.0%	100.0%
P(*B2012>Bmsy*)	0.5%	1.4%	4.0%	9.0%	18.5%	47.8%	83.6%	98.3%
P(*CPUE2012>0.75*)	19.0%	34.6%	53.7%	73.5%	89.1%	99.1%	100.0%	100.0%

6. YIELD ESTIMATES

Estimation of Maximum Constant Yield (MCY)

***Jasus edwardsii*, all stocks**

MCY was not estimated.

***Sagmariasus verreauxi*, PHC stock**

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

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

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

Estimation of Current Annual Yield (CAY)

***Jasus edwardsii*, all stocks**

CAY was not estimated for any stock.

***Sagmariasus verreauxi*, PHC stock**

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

7. STATUS OF THE STOCKS

Jasus edwardsii, NSN substock

CRA 1
The stock assessment of CRA 1 was not updated in 2008. The 2002 model results suggested 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 appeared to be sustainable, because model projections at the end of the 5-year projection period had 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 were made under the assumption of constant catches fixed at levels used in the assessment (commercial 129.2 t, amateur 47.2 t; customary 10 t; unreported illegal 72 t.), an increase in 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 2001 and projected stock status.

CRA 2
The stock assessment of CRA 2 was not updated in 2008. 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 2001 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 had a median expected biomass near the 2001–02 biomass. However, in this stock, the projections should be considered less reliable than for CRA 1, because the uncertainty of future recruitment has more short-term effect 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 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 updated in 2008, using a purpose-built modification of the new multi-stock, length-based Bayesian model. Model results suggest that stock abundance at the start of 2008–09 was probably above the minimum biomass estimated over the course of the fishery (*Bmin)*. A *Bmsy* reference point was calculated for the first time but the utility of this reference point requires further discussion and investigation. Current biomass was estimated to be roughly half *Bmsy*, suggested a depleted stock compared with the estimated *Bmsy*. Current fishing mortality is approximately 27% higher than *Fmsy*. Projections made for five years with the 2007 levels of catch (but using the TACC for projected commercial catch) produced a median 25% decrease in model biomass.

Model results were reasonably robust to the range of assumptions examined in the MPD sensitivity trials. In particular, altering assumptions with respect to non-commercial catch histories in the model resulted in similar current stock status. However, it was not possible to draw strong conclusions from the sensitivity trials, given that the median and mean of the assessment posterior distributions moved a considerable distance from the MPD estimates.

The quality of the Markov chain – Monte Carlo simulations was not high. The running quantile plots for many estimated parameters showed a drift through the run, suggesting poor convergence, and a trend to move well away from the MPD estimate. Diagnostic plots of the indicators, however, tended to be more acceptable than those of the parameters.

CRA 4

The stock assessment of CRA 4 was not updated in 2008. The 2005 model results suggest that stock abundance in 2005–06 was higher than in the 1979–88 reference period. Exploitation rate peaked in the late 1980s to early 1990s in the spring-summer fishery, and recent exploitation rate was between 20% and 30% of the size-limited catch. 2006 levels of catch produced a median 6% reduction in model biomass over three years to a level that usually remained higher than the reference levels.

Model results were 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 showed 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 base case was chosen after extensive exploration of model runs that showed sensitivity to data weighting assumptions. This suggested that other credible model structures may exist.

CRA 5

The stock assessment of CRA 5 was not updated in 2008. The 2003 model results suggested that 2002–03 vulnerable biomass was 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 showed a median biomass smaller than the 2002–03 biomass, but still well above the reference levels. The 2002–03 vulnerable biomass was estimated to be greater than at any time in the last 20 years and the decrease was expected to be modest.

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

Model results seemed robust to the range of assumptions examined in the sensitivity trials, and also showed reasonable retrospective performance. The effect of higher alternative non-commercial catch histories in the model resulted in similar 2002 stock status but quite different projected stock status.

***Jasus edwardsii*, NSS substock**

In 2006, CRA 7 and CRA 8 were modelled simultaneously as separate stocks within a new multi-stock model. The assessment was not finalised in the time available; however, both stocks showed increasing CPUE to levels not seen since the 1980s. CPUE in CRA8 in 2006 was well above the target set for the rebuilt stock (1.9 kg per potlift). This indicated that it was time to develop a management strategy designed to maintain stock biomass, and this was done in 2007.

The 2007 management procedure for CRA 7 triggered a 3.7 t increase in the TAC for CRA 7, which was implemented at the beginning of the 2008–09 fishing year. The 2007 management procedure for CRA 8 triggered a 211 t increase in the TAC for CRA 8, which was implemented at the beginning of the 2008–09 fishing year. In 2008 these management procedures indicate further increases in the TAC. For CRA 7, implementation of the harvest control rule for the 2009-10 fishing year would see the TAC increase from 143.9 to 209 t, while in CRA 8 the TAC would increase from 1053 to 1110 t.

***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, although the shortfall was only 10 t in 2007-08. CPUE showed a declining trend from 1979/1980 to 1997/1998 but increased to 2004 and has been stable since then. These observations suggest a roughly stable standing stock after an initial fishing down period. However, size frequency distributions in the lobster catch had not changed when they were examined in the mid 1990s, 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 2007–08 fishing year (350 t) were within the range of estimates for MCY (300–380 t), and close to the current TACC (360 t). The current TAC (370 t) lies within the range of the estimated MCY.

***Sagmariasus verreauxi*, PHC stock**

The status of this stock is unknown.

Summary of yield estimates (t), TACCs and TACs (t), and reported 2007-08 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	2007–08 TACC	2007–08 Landings	2008–09 TACC	2008–09 TAC

CRA 1	Northland	–	131.1	129.6	131.1	–
CRA 2	Bay of Plenty	–	236.1	229.7	236.1	452.6
CRA 3	Gisborne	–	190.0	171.0	190.0	319.0
CRA 4	Wairarapa–Hawke Bay	–	577.0	315.2	577.0	771.0
CRA 5	Canterbury–Marlborough	–	350.0	349.8	350.0	467.0
CRA 6	Chatham Islands	300–380	360.0	350.0	360.0	370.0
CRA 7	Otago	–	120.2	120.1	123.9	143.9
CRA 8	Southern	–	755.2	752.4	966.0	1 053.0
CRA 9	Westland–Taranaki	–	47.0	47.0	47.0	–
CRA 10	Kermadec	–	0.0	0.0	0.0	–
Total			2 766.6	2 464.8	2 981.0	3 576.5
PHC 1	All QMAs	18	40.3		40.3	

8. REFERENCES

Annala, J.H. 1983: New Zealand rock lobsters: biology and fisheries. *Fisheries Research Division Occasional Publication 42*. 35 p.

Annala, J.H. & King, M.R. 1983: The 1963–73 New Zealand rock lobster landings by statistical area. *Fisheries Research Division Occasional Publication, Data Series 11*. 20 p.

Bentley, N., Breen, P.A. & Starr, P.J. 2003. Design and evaluation of a revised management decision rule for red rock lobster fisheries (*Jasus edwardsi*i) in CRA 7 and CRA 8. *New Zealand Fishery Assessment Report 2003/30*. 44 p.

Bentley, N. & Starr, P.J. 2001: An evaluation of the stock structure of New Zealand rock lobster. *New Zealand Fisheries Assessment Report 2001/48*. 22 p.

Bentley, N., Starr, P.J., Walker, N. & Breen, P.A. 2005: Catch and effort data for New Zealand rock lobster stock fisheries. *New Zealand Fisheries Assessment Report 2005/49*. 49 p.

Booth, J.D. & Breen, P.A. 1992: Stock structure in the New Zealand red rock lobster, *Jasus edwardsii*. New Zealand Fisheries Assessment Research Document 92/20. 35 p.

Booth, J.D., McKenzie, A., Forman, J.S. & Stotter, D.R. 2007: Settlement indices for 2003 for the red rock lobster (*Jasus edwardsii*), and investigations into correlations between settlement and subsequent stock abundance. *New Zealand Fisheries Assessment Report 2007/42*. 48 p.

Booth, J.D., Robinson, M. & Starr, P.J. 1994: Recent research into New Zealand rock lobsters, and a review of recent rock lobster catch and effort data. New Zealand Fisheries Assessment Research Document 94/7. 56 p.

Bradford, E. 1997: Estimated recreational catches from Ministry of Fisheries North region marine recreational fishing surveys, 1993–94. New Zealand Fisheries Assessment Research Document 97/7. 16 p.

Bradford, E. 1998: Harvest estimates from the 1996 national marine recreational fishing surveys. New Zealand Fisheries Assessment Research Document 98/16. 27 p.

Breen, P.A., Starr, P.J. & Kim, S.W. 2005: A medium-term research plan for red rock lobsters (*Jasus edwardsii*). *New Zealand Fisheries Assessment Report 2005/54*. 52 p.

Breen, P.A., Kim, S.W., Haist, V. & Starr, P.J. 2006: The 2005 stock assessment of red rock lobsters (*Jasus edwardsii*) in CRA 4. *New Zealand Fisheries Assessment Report 2006/17*. 133 p.

Breen, P.A., Kendrick, T.H., Starr, P.J. & Maunder, M. 1994: Results of the implementation of the Rock Lobster Decision Rule in 1994. New Zealand Fisheries Assessment Research Working Group Report 94/3. 17 p.

Chiswell, S.M., Wilkin, J., Booth, J.D. & Stanton, B. 2003: Trans-Tasman Sea larval transport: is Australia a source for New Zealand rock lobsters? *Marine Ecology Progress Series.*247: 173-182.

Francis, R.I.C.C. 1999: Moving towards B_{MSY}. New Zealand Fisheries Assessment Research Document 1999/2. 23 p.

Freeman, D.J. 2008: The ecology of spiny lobsters (*Jasus edwardsii*) on fished and unfished reefs. PhD thesis, University of Auckland. 306 p.

Haist, V., P.A. Breen, S.W. Kim & P.J. Starr. 2005: Stock assessment of red rock lobsters (*Jasus edwardsii*) in CRA 3 in 2004. *New Zealand Fisheries Assessment Report 2005/38*. 126 p.

Haist, V., Breen, P.A. & Starr, P.J. 2009: A new multi-stock length-based assessment model for New Zealand rock lobsters (*Jasus edwardsii*) *New Zealand Journal of Marine and Freshwater Research* (in press).

Kim, S.W., N. Bentley, P.J. Starr & P.A. Breen. 2004: Assessment of red rock lobsters (*Jasus edwardsii*) in CRA 4 and CRA 5 in 2003. *New Zealand Fisheries Assessment Report 2004/8.* 165 p.

Maunder, M.N. & Starr, P.J. 1995: Rock lobster standardised CPUE analysis. New Zealand Fisheries Assessment Research Document 95/11. 28 p.

Starr, P.J.. 2007: Rock lobster catch and effort data: summaries and CPUE standardisations, 1979–80 to 2005–06. *New Zealand Fisheries Assessment Report 2007/31.* 69 p.

Starr, P.J., Bentley, N., Breen, P.A. & Kim, S.W. 2003: Assessment of red rock lobsters (*Jasus edwardsii*) in CRA 1 and CRA 2 in 2002. *New Zealand Fisheries Assessment Report 2003/41*. 119 p.

Teirney, L.D., Kilner, A.R., Millar, R.B., Bradford, E. & Bell, J.D. 1997: Estimation of recreational harvests from 1991–92 to 1993–94. New Zealand Fisheries Assessment Research Document 97/15. 43 p.

Vignaux, M., & Kendrick, T.H. 1998: CPUE analyses for rock lobster substocks and QMAs to 1997. New Zealand Fisheries Assessment Research Document 98/19. 24 p.