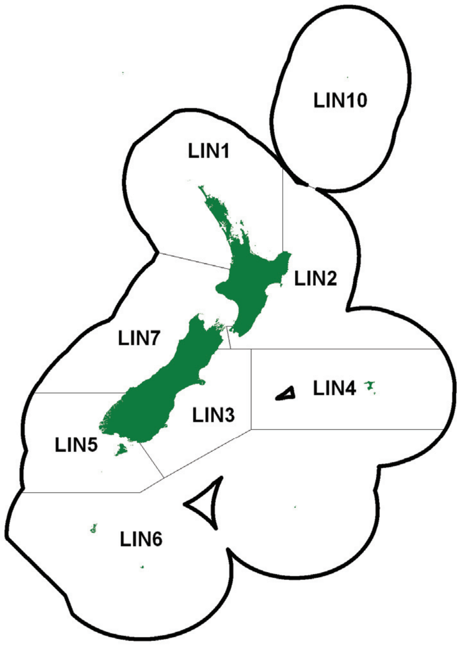
LING

(*Genypterus blacodes*)
Hoka



1. FISHERY SUMMARY

1.1 Commercial fisheries

Ling are widely distributed through the middle depths (200–800 m) of the New Zealand EEZ, particularly to the south of latitude 40° S. From 1975 to 1980 there was a substantial longline fishery on the Chatham Rise (and to a lesser extent in other areas), carried out by Japanese and Korean longliners. Since 1980 ling have been caught by large trawlers, both domestic and foreign owned, and by small domestic longliners and trawlers. In the early 1990s the domestic fleet was increased by the addition of several larger longliners fitted with autoline equipment. This caused a large increase in the catches of ling off the east and south of the South Island (LIN 3, 4, 5 and 6). However, since about 2000 there has been a declining trend in catches taken by line vessels in most areas, offset, to some extent, by increased trawl landings.

The principal grounds for smaller domestic vessels are the west coast of the South Island (WCSI) and the east coast of both main islands south of East Cape. For the large trawlers the main sources of ling are Puysegur Bank and the slope of the Stewart-Snares shelf and waters in the Auckland Islands area. Longliners fish mainly in LIN 3, 4, 5 and 6. In 2008–09, landings from all Fishstocks were under-caught relative to the TACC. The LIN 2, LIN 4 and LIN 6 TACCs were significantly under-caught, by 35%, 52% and 62%, respectively. Other TACCs were between 1% and 20% under-caught. Reported landings by nation from 1975 to 1987–88 are shown in Table 1, and reported landings by Fishstock from 1983–84 to 2007–08 are shown in Table 2. Figure 1 shows the historical landings and TACC values for the main LIN stocks.

Under the Adaptive Management Programme (AMP), the TACC for LIN 1 was increased to 400 t from 1 October 2002, within an overall TAC of 463 t. In an earlier proposal for the 1994–95 fishing year, TACCs for LIN 3 and 4 had been increased to 2810 and 5720 t, respectively. These stocks were removed from the AMP from 1 October 1998, with TACCs maintained at the increased level. However, from 1 October 2000, the TACCs for LIN 3 and 4 were reduced to 2060 and 4200 t, respectively. From 1 October 2004, the TACCs for LIN 5 and LIN 6 were increased by about 20% to 3600 t and 8505 t, respectively. From the 2009-10 fishing season, the TACC for LIN 7 has been increased from 2225 t to 2474 t.

All other TACC increases since 1986–87 in all stocks are the result of quota appeals.

Table 1: Reported landings (t) from 1975 to 1987–88. Data from 1975 to 1983 from MAF; data from 1983–84 to 1985–86 from FSU; data from 1986–87 to 1987–88 from QMS. –, no data available.

Fishing year	New Zealand			Foreign Licensed					Grand total
				Longline	Trawl			Total	
	Domestic	Chartered	Total	(Japan + Korea)	Japan	Korea	USSR	Total	
1975*	486	0	486	9 269	2 180	0	0	11 499	11 935
1976*	447	0	447	19 381	5 108	0	1 300	25 789	26 236
1977*	549	0	549	28 633	5 014	200	700	34 547	35 096
1978–79#	*657	24	681	8 904	3 151	133	452	12 640	13 321
1979–80#	*915	2 598	3 513	3 501	3 856	226	245	7 828	11 341
1980–81#	*1 028	–	–	–	–	–	–	–	–
1981–82#	*1 581	2 423	4 004	0	2 087	56	247	2 391	6 395
1982–83#	*2 135	2 501	4 636	0	1 256	27	40	1 322	5 958
1983†	*2 695	1 523	4 218	0	982	33	48	1 063	5 281
1983–84§	2 705	2 500	5 205	0	2 145	173	174	2 491	7 696
1984–85§	2 646	2 166	4 812	0	1 934	77	130	2 141	6 953
1985–86§	2 126	2 948	5 074	0	2 050	48	33	2 131	7 205
1986–87§	2 469	3 177	5 646	0	1 261	13	21	1 294	6 940
1987–88§	2 212	5 030	7 242	0	624	27	8	659	7 901

* Calendar years (1978 to 1983 for domestic vessels only).
# April 1 to March 31.
† April 1 to Sept 30.
§ Oct 1 to Sept 30.

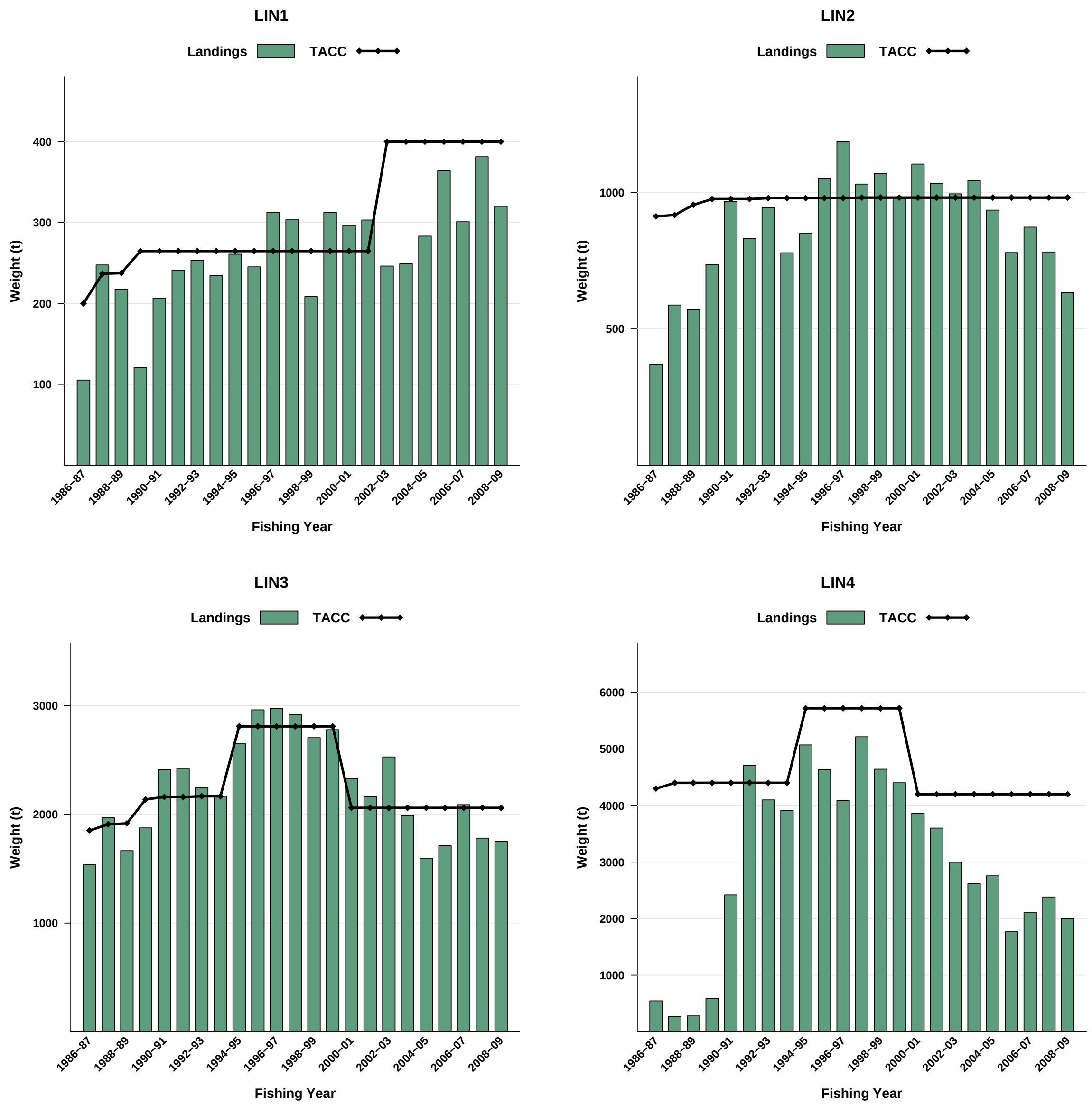


Figure 1: Historical landings and TACC for the seven main LIN stocks. From top left: LIN1 (Auckland East), LIN2(Central East), LIN3 (South East Coast), LIN4 (South East Chatham Rise). [Continued on next page]…

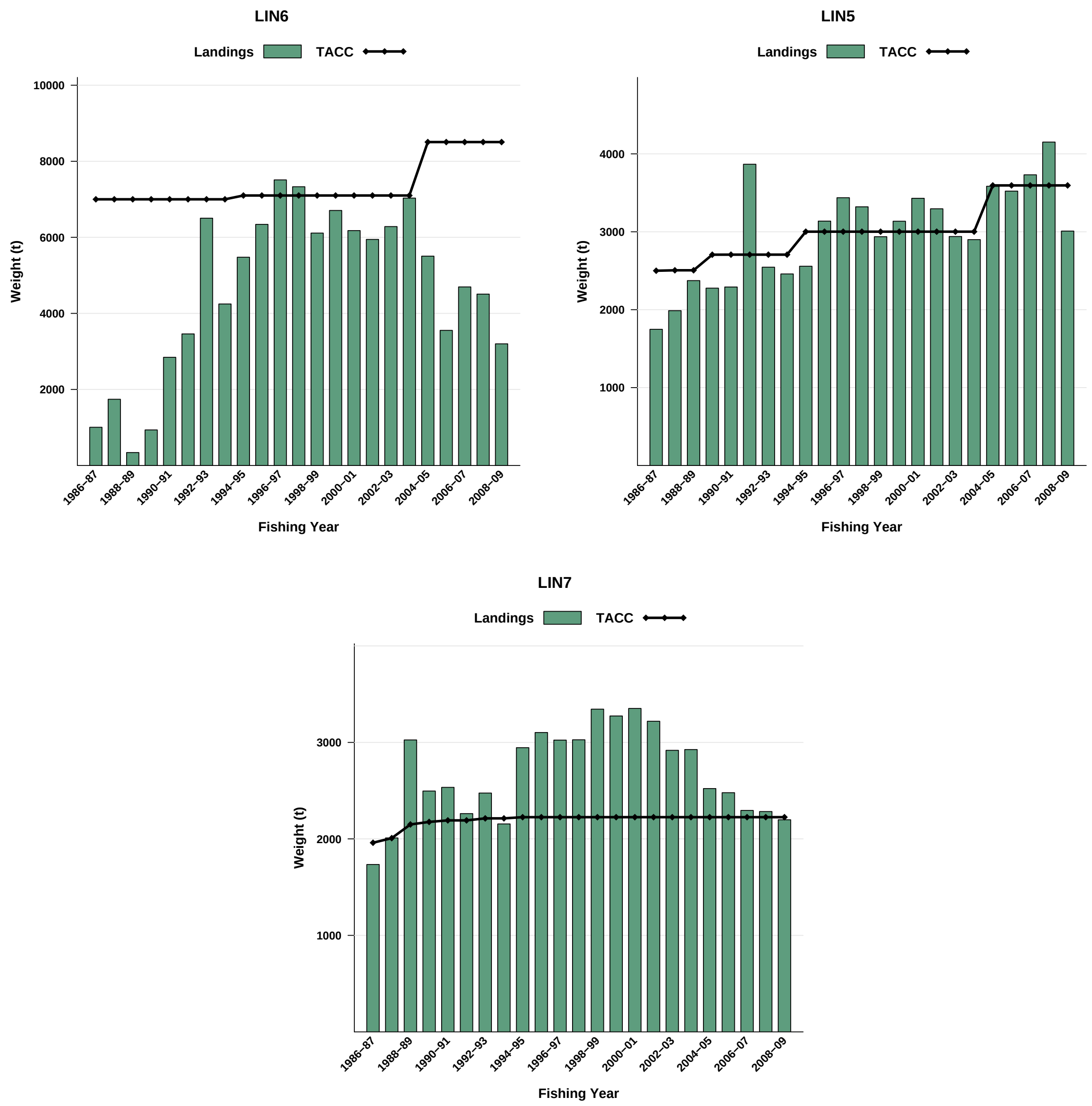


Figure 1 [Continued]: Historical landings and TACC for the seven main LIN stocks. LIN5 (Southland), LIN6 (Sub-Antarctic), and LIN7 (Challenger). Note that these figures do not show data prior to entry into the QMS.

1.2 Recreational fisheries

The 1993–94 North region recreational fishing survey (Bradford 1996) estimated the annual recreational catch from LIN 1 as 10 000 fish (CV 23%). With a mean weight likely to be in the range of 1.5 to 4 kg, this equates to a harvest of 15–40 t.

Recreational catch was recorded from LIN 1, 5, and 7 in the 1996 national diary survey. The estimated harvests (LIN 1, 3000 fish; LIN 5, <500; LIN 7, <500) were too low to provide reliable estimates.

1.3 Customary non-commercial fisheries

Quantitative information on the level of Maori customary non-commercial take is not available. Ling bones have been recovered from archaic middens throughout the South Island and southern North Island, and on Chatham Island (Leach & Boocock 1993). In South and Chatham Islands, ling comprised about 4% (by number) of recovered fish remains.

1.4 Illegal catch

It is believed that up to the mid 1990s some ling bycatch from the west coast hoki fishery was not reported. Estimates of total catch including non-reported catch are given in Table 2 for LIN 7.

It is believed that in recent years, some catch from LIN 7 has been reported against other ling stocks (probably LIN 3, 5, and 6). The likely levels of misreporting are moderate, being about 250–400 t in each year from 1989–90 to 1991–92 (Dunn 2003).

1.5 Other sources of mortality

The extent of any other sources of mortality is unknown.

Table 2: Reported landings (t) of ling by Fishstock from 1983–84 to 2008–09 and actual TACCs (t) from 1986–87 to 2008–09. Estimated landings for LIN 7 from 1987–88 to 1992–93 include an adjustment for ling bycatch of hoki trawlers, based on records from vessels carrying observers. QMS data from 1986-present.

Fishstock	LIN 1		LIN 2		LIN 3		LIN 4		LIN 5	
QMA (s)	1 & 9		2		3		4		5	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1983–84*	141	–	594	–	1 306	–	352	–	2 605	–
1984–85*	94	–	391	–	1 067	–	356	–	1 824	–
1985–86*	88	–	316	–	1 243	–	280	–	2 089	–
1986–87	77	200	254	910	1 311	1 850	465	4 300	1 859	2 500
1987–88	68	237	124	918	1 562	1 909	280	4 400	2 213	2 506
1988–89	216	237	570	955	1 665	1 917	232	4 400	2 375	2 506
1989–90	121	265	736	977	1 876	2 137	587	4 401	2 277	2 706
1990–91	210	265	951	977	2 419	2 160	2 372	4 401	2 285	2 706
1991–92	241	265	818	977	2 430	2 160	4 716	4 401	3 863	2 706
1992–93	253	265	944	980	2 246	2 162	4 100	4 401	2 546	2 706
1993–94	241	265	779	980	2 171	2 167	3 920	4 401	2 460	2 706
1994–95	261	265	848	980	2 679	2 810	5 072	5 720	2 557	3 001
1995–96	245	265	1 042	980	2 956	2 810	4 632	5 720	3 137	3 001
1996–97	313	265	1 187	982	2 963	2 810	4 087	5 720	3 438	3 001
1997–98	303	265	1 032	982	2 916	2 810	5 215	5 720	3 321	3 001
1998–99	208	265	1 070	982	2 706	2 810	4 642	5 720	2 937	3 001
1999–00	313	265	983	982	2 799	2 810	4 402	5 720	3 136	3 001
2000–01	296	265	1 105	982	2 330	2 060	3 861	4 200	3 430	3 001
2001–02	303	265	1 034	982	2 164	2 060	3 602	4 200	3 295	3 001
2002–03	246	400	996	982	2 529	2 060	2 997	4 200	2 939	3 001
2003–04	249	400	1 044	982	1 990	2 060	2 618	4 200	2 899	3 001
2004–05	283	400	936	982	1 597	2 060	2 758	4 200	3 584	3 595
2005–06	364	400	780	982	1 711	2 060	1 769	4 200	3 522	3 595
2006–07	301	400	874	982	2 089	2 060	2 113	4 200	3 731	3 595
2007–08	381	400	792	982	1 778	2 060	2 383	4 200	4 145	3 595
2008–09	320	400	634	982	1 751	2 060	2 000	4 200	3 009	3 595

Fishstock	LIN 6		LIN 7			LIN 10			
QMA (s)	6		7 & 8			10		Total	
	Landings	TACC	Reported Landings	Estimated Landings	TACC	Landings	TACC	Landings§	TACC
1983–84*	869	–	1 552	–	–	0	–	7 696	–
1984–85*	1 283	–	1 705	–	–	0	–	6 953	–
1985–86*	1 489	–	1 458	–	–	0	–	7 205	–
1986–87	956	7 000	1 851	–	1 960	0	10	6 940	18 730
1987–88	1 710	7 000	1 853	1 777	2 008	0	10	7 901	18 988
1988–89	340	7 000	2 956	2 844	2 150	0	10	8 404	19 175
1989–90	935	7 000	2 452	3 171	2 176	0	10	9 028	19 672
1990–91	2 738	7 000	2 531	3 149	2 192	<1	10	13 506	19 711
1991–92	3 459	7 000	2 251	2 728	2 192	0	10	17 778	19 711
1992–93	6 501	7 000	2 475	2 817	2 212	<1	10	19 065	19 737
1993–94	4 249	7 000	2 142	–	2 213	0	10	15 961	19 741
1994–95	5 477	7 100	2 946	–	2 225	0	10	19 841	22 111
1995–96	6 314	7 100	3 102	–	2 225	0	10	21 428	22 111
1996–97	7 510	7 100	3 024	–	2 225	0	10	22 522	22 113
1997–98	7 331	7 100	3 027	–	2 225	0	10	23 145	22 113
1998–99	6 112	7 100	3 345	–	2 225	0	10	21 034	22 113
1999–00	6 707	7 100	3 274	–	2 225	0	10	21 615	22 113
2000–01	6 177	7 100	3 352	–	2 225	0	10	20 552	19 843
2001–02	5 945	7 100	3 219	–	2 225	0	10	19 561	19 843
2002–03	6 283	7 100	2 918	–	2 225	0	10	18 903	19 978
2003–04	7 032	7 100	2 926	–	2 225	0	10	18 760	19 978
2004–05	5 506	8 505	2 522	–	2 225	0	10	17 189	21 977
2005–06	3 553	8 505	2 479	–	2 225	0	10	14 184	21 977
2006–07	4 696	8 505	2 295	–	2 225	0	10	16 102	21 977
2007–08	4 502	8 505	2 282	–	2 225	0	10	16 264	21 977
2008–09	3 199	8 505	2 198	–	2 225	0	10	13 113	21 977

* FSU data.

§ Includes landings from unknown areas before 1986–87, and areas outside the EEZ since 1995–96.

2. BIOLOGY

Ling live to a maximum age of about 30 years; fewer than 0.2% of successfully aged ling have been older than 30 years. A growth study of ling from five areas (west coast South Island, Chatham Rise, Bounty Plateau, Campbell Plateau, Cook Strait) showed that females grew significantly faster and reached a greater size than males in all areas, and that growth rates were significantly different between areas. Ling grow fastest in Cook Strait and slowest on the Campbell Plateau (Horn 2005).

M was initially estimated from the equation $M = \log_e 100$/maximum age, where maximum age is the age to which 1% of the population survives in an unexploited stock. The mean *M* calculated from 5 samples of age data was 0.18 (range = 0.17–0.20). However, a recent review of *M*, and results of modelling conducted in 2007, suggests that this parameter may vary between stocks (Horn 2008b). The *M* for Chatham Rise ling appears to be lower than 0.18, while for Cook Strait and west coast South Island the value is probably higher than 0.18.

Ling in spawning condition have been reported in a number of localities throughout the EEZ (Horn 2005). Time of spawning appears to vary between areas: July to November on the Chatham Rise; September to December on Campbell Plateau and Puysegur Bank; September to February on the Bounty Plateau; July to September off west coast South Island and in Cook Strait. Little is known about the distribution of juveniles until they are about 40 cm total length, when they begin to appear in trawl samples over most of the adult range.

Ling appear to be mainly bottom dwellers, feeding on crustaceans such as *Munida* and scampi and also on fish, with commercial fishing discards being a significant dietary component. However, they may at times be caught well above the bottom, for example when feeding on hoki during the hoki spawning season.

Biological parameters relevant to the stock assessment are shown in Table 3.

Table 3: Estimates of biological parameters from Horn (2005). See Section 3 for definitions of Fishstocks.

Fishstock	Estimate
1. Natural mortality (*M*)	
All stocks average (both sexes)	*M* = 0.18
LIN 7WC (current assessment)	*M* = 0.22

2. Weight = a (length)^b (Weight in g, length in cm total length)

	Female		Male		Area
	a	b	a	b	
LIN 3&4	0.00114	3.318	0.00100	3.354	Chatham Rise
LIN 5&6	0.00128	3.303	0.00208	3.190	Southern Plateau
LIN 6B	0.00114	3.318	0.00100	3.354	Bounty Plateau
LIN 7WC	0.00094	3.366	0.00125	3.297	West Coast S.I.
Cook Strait	0.00094	3.366	0.00125	3.297	Cook Strait

3. von Bertalanffy growth parameters

	Female			Male			Area
	K	t_0	$L_{(}$	K	t_0	$L_{(}$	
LIN 3&4	0.083	–0.74	156.4	0.127	–0.70	113.9	Chatham Rise
LIN 5&6	0.124	–1.26	115.1	0.188	–0.67	93.2	Southern Plateau
LIN 6B	0.101	–0.53	146.2	0.141	0.02	120.5	Bounty Plateau
LIN 7WC	0.078	–0.87	169.3	0.067	–2.37	159.9	West Coast S.I.
Cook Strait	0.097	–0.54	163.6	0.080	–1.94	158.9	Cook Strait

3. STOCKS AND AREAS

A review of ling stock structure (Horn 2005) examined diverse information from studies of morphometrics, genetics, growth, population age structures, and reproductive biology and behavior, and indicated that there are at least five ling stocks, i.e., west coast South Island, Chatham Rise, Cook Strait, Bounty Plateau, and the Southern Plateau (including the Stewart-Snares shelf and Puysegur Bank). Stock affinities of ling north of Cook Strait are unknown, but spawning is known to occur off Northland, Cape Kidnappers, and in the Bay of Plenty.

4. STOCK ASSESSMENT

The stock assessment for one ling stock (LIN 7WC, west coast South Island) was updated in 2008 using a Bayesian stock model implemented using the general-purpose stock assessment program CASAL v2.21 (Bull *et al*. 2005) and is presented below. No assessments were updated in 2009. Assessments for other stocks were updated in 2007 (LIN 3&4, Chatham Rise; LIN 5&6, Sub-Antarctic; and Cook Strait) or 2006 (LIN 6B, Bounty Plateau). Results from these assessments were reported in the 2007 and 2008 Plenary documents.

For LIN 7WC, the stock assessment model partitions the population into two sexes, and age groups 3 to 28 with a plus group. The model's annual cycle is described in Table 4. Year class strengths and fishing selectivity ogives were also estimated in the model. Commercial trawl selectivity and research survey selectivity were fitted as double normal curves; line fishery ogives were fitted as logistic curves.

For final runs, the full posterior distribution was sampled using Markov Chain Monte Carlo (MCMC) methods, based on the Metropolis-Hastings algorithm. Bounded estimates of spawning stock virgin (B_0) and current (B_{2008}) biomass were obtained. MCMC chains were constructed using a burn-in length of 2×10^6 iterations, with every 4000th sample taken from the next 4×10^6 iterations (i.e., a final sample of length 1000 was taken from the Bayesian posterior). Single chain convergence tests were applied to resulting chains to determine evidence of non-convergence. No evidence of lack of convergence was found in the estimates of B_0 from the base case model runs, or in the sensitivity runs, but some estimates of selectivity parameters and YCS showed evidence of lack of convergence.

For LIN 7WC, model input data include catch histories, trawl and line fishery CPUE, extensive catch-at-age data from the trawl fishery, sparse catch-at-age and catch-at-length from the line fishery, survey biomass estimates from a multi-survey *Kaharoa* series and a single *Tangaroa* survey, and estimates of biological parameters. The base case used all catch-at-age and catch-at-length data from the fisheries, but no series of relative abundance. Sensitivity runs investigated the signal from the *Tangaroa* trawl survey in 2000 and the effects of using a low value of instantaneous natural mortality (i.e., M = 0.15, replacing the value of 0.22 used in the other runs).

Lognormal errors, with known CVs, were assumed for all relative biomass, proportions-at-age, and proportions-at-length observations. The CVs available for those observations of relative abundance and catch data allow for sampling error only. However, additional variance, assumed to arise from differences between model simplifications and real world variation, was added to the sampling variance. The additional variance, termed process error, was estimated in MPD runs of the model (see Table 5) and fixed in all subsequent runs.

Table 4: Annual cycle of the assessment model for LIN 7WC, showing the processes taking place at each time step, their sequence within each time step, and the available observations. Any fishing and natural mortality within a time step occur after all other processes, with half of the natural mortality for that time step occurring before and after the fishing mortality. An age fraction of 0.5 for a time step means that a 6+ fish is treated as being of age 6.5 in that time step. The last column shows the proportion of that time step's mortality that is assumed to have taken place when each observation is made (see Table 5 for descriptions of the observations).

					Observations	
Stock/Step	Approx. months	Processes	*M* fraction	Age fraction	Description	%*M*
LIN 7WC						
1	Oct–May	recruitment	0.75	0.5		0.5
		fishery (line)			Line catch-at-age/length	
2	Jul–Sep	increment ages	0.25	0		0.5
		fishery (trawl)			Trawl catch-at-age	

Table 5: Summary of the available data including source years (Years), and the estimated process error (c.v.) added to the observation error.

Data series	Years	Process error c.v.
LIN 7WC		
CPUE (hoki trawl, Jun–Sep)	1999–2007	0.2
CPUE (longline, all year)	1990–2007	0.2
Commercial trawl proportion-at-age (Jun–Sep)	1991, 1994–2007	0.25
Commercial longline proportion-at-age	2003	0.15
Commercial longline length-frequency	2006	0.25
Trawl survey biomass (*Kaharoa*, Mar–Apr)	1992, 94, 95, 97, 2000, 03, 05, 07	0.3
Trawl survey proportion-at-length (*Kaharoa*, Mar–Apr)	1992, 94, 95, 97, 2000, 03, 05, 07	0.35
Trawl survey biomass (*Tangaroa*, July)	2000	0.2

The assumed prior distributions used in the assessment are given in Table 6. Most priors were intended to be relatively uninformed, and were specified with wide bounds. The exception was the choice of informative priors for the *Tangaroa* trawl survey *q*. The priors on *q* for the *Tangaroa* trawl survey were estimated assuming that the catchability constant was a product of areal availability (0.5–1.0), vertical availability (0.5–1.0), and vulnerability between the trawl doors (0.03–0.40). The resulting (approximately lognormal) distribution had mean 0.13 and CV 0.70, with bounds assumed to be 0.02 to 0.30. However, the *Tangaroa* survey off WCSI is estimated to have covered only one-third of the likely ling habitat. Consequently, for this survey, the priors were a lognormal distribution with a mean of 0.043 (i.e., 0.13 × 0.33), CV of 0.7, and bounds of 0.01 to 0.20.

Table 6: Assumed prior distributions and bounds for estimated parameters in the assessments. The parameters are mean (in log space) and c.v. for lognormal, and mean and standard deviation for normal.

Parameter description	Distribution	Parameters		Bounds	
B_0	uniform-log	–	–	10 000	500 000
Year class strengths	lognormal	1.0	0.7	0.01	100
Tangaroa survey *q*	lognormal	0.043	0.70	0.01	0.2
Kaharoa survey *q*	uniform-log	–	–	0.001	10
CPUE *q*	uniform-log	–	–	1e-8	1e-3
Selectivities	uniform	–	–	0	20–200*
Process error c.v.	uniform-log	–	–	0.001	2
M	normal	0.20	0.07	0.1	0.3

* A range of maximum values was used for the upper bound

Penalty functions were used to constrain the model so that any combination of parameters that did not allow the historical catch to be taken was strongly penalised. A small penalty was applied to the estimates of year class strengths to encourage estimates that averaged to 1.

4.1 Estimates of fishery parameters and abundance

The catch history used in the model is presented in Table 8, and other input parameters are shown in Table 7.

Table 7: Input parameters for the assessed stocks.

Parameter	LIN 3&4	LIN 5&6	LIN 6B	LIN 7WC	Cook Strait
Stock-recruitment steepness	0.9	0.9	0.9	0.9	0.9
Recruitment variability c.v.	0.6	0.6	1.0	0.6	0.7
Ageing error c.v.	0.05	0.06	0.05	0.05	0.07
Proportion by sex at birth	0.5	0.5	0.5	0.5	0.5
Proportion spawning	1.0	1.0	1.0	1.0	1.0
Spawning season length	0	0.25	0	0	0
Maximum exploitation rate (U_{max})	0.6	0.6	0.6	0.6	0.6

Maturity ogives*

Age	3	4	5	6	7	8	9	10	11	12	13	14	15
LIN 3&4 (and assumed for LIN 6B)													
Male	0.0	0.027	0.063	0.14	0.28	0.48	0.69	0.85	0.93	0.97	0.99	1.00	1.0
Female	0.0	0.001	0.003	0.006	0.014	0.033	0.08	0.16	0.31	0.54	0.76	0.93	1.0
LIN 5&6													
Male	0.0	0.022	0.084	0.27	0.61	0.86	0.96	0.99	1.00	1.0			
Female	0.0	0.001	0.004	0.015	0.06	0.22	0.55	0.84	0.96	1.0			
LIN 7WC (and assumed for Cook Strait)													
Male	0.0	0.015	0.095	0.39	0.77	0.94	1.00	1.00	1.00	1.0			
Female	0.0	0.004	0.017	0.06	0.18	0.39	0.65	0.85	0.94	1.0			

*Proportion mature at age

Table 8: Estimated catch histories (t) for LIN 3&4 (Chatham Rise), LIN 5&6 (Campbell Plateau), LIN 6B (Bounty Platform), LIN 7WC (WCSI section of LIN 7), and Cook Strait (sections of LIN 7 and LIN 2). Landings have been separated by fishing method (trawl or line), and, for the LIN 5&6 line fishery, by pre-spawning (Pre) and spawning (Spn) season.

Year	LIN 3&4		LIN 5&6			LIN 6B	LIN 7WC		LIN 7CK	
	trawl	line	trawl	Line Pre	Line Spn	line	trawl	line	trawl	Line
1972	0	0	0	0	0	0	0	0	0	0
1973	250	0	500	0	0	0	85	20	45	45
1974	382	0	1 120	0	0	0	144	40	45	45
1975	953	8 439	900	118	192	0	401	800	48	48
1976	2 100	17 436	3 402	190	309	0	565	2 100	58	58
1977	2 055	23 994	3 100	301	490	0	715	4 300	68	68
1978	1 400	7 577	1 945	494	806	10	300	323	78	78
1979	2 380	821	3 707	1 022	1 668	0	539	360	83	83
1980	1 340	360	5 200	0	0	0	540	305	88	88
1981	673	160	4 427	0	0	10	492	300	98	98
1982	1 183	339	2 402	0	0	0	675	400	103	103
1983	1 210	326	2 778	5	1	10	1 040	710	97	97
1984	1 366	406	3 203	2	0	6	924	595	119	119
1985	1 351	401	4 480	25	3	2	1 156	302	116	116
1986	1 494	375	3 182	2	0	0	1 082	362	126	126
1987	1 313	306	3 962	0	0	0	1 105	370	97	97
1988	1 636	290	2 065	6	0	0	1 428	291	107	107
1989	1 397	488	2 923	10	2	9	1 959	370	255	85
1990	1 934	529	3 199	9	4	11	2 205	399	362	121
1991	2 563	2 228	4 534	392	97	172	2 163	364	488	163
1992	3 451	3 695	6 237	566	518	1 430	1 631	661	498	85
1993	2 375	3 971	7 335	1 238	474	1 575	1 609	716	307	114
1994	1 933	4 159	5 456	770	486	875	1 136	860	269	84
1995	2 222	5 530	5 348	2 355	338	387	1 750	1 032	344	70
1996	2 725	4 863	6 769	2 153	531	588	1 838	1 121	392	35
1997	3 003	4 047	6 923	3 412	614	333	1 749	1 077	417	89
1998	4 707	3 227	6 032	4 032	581	569	1 887	1 021	366	88
1999	3 282	3 818	5 593	2 721	489	771	2 146	1 069	316	216
2000	3 739	2 779	7 089	1 421	1 161	1 319	2 247	923	317	131
2001	3 467	2 724	6 629	818	1 007	1 153	2 304	977	258	80
2002	2 979	2 787	6 970	426	1 220	623	2 250	810	230	171
2003	3 375	2 150	7 205	183	892	932	1 980	807	280	180
2004	2 525	2 082	7 826	774	471	860	2 013	814	241	227
2005	1 913	2 440	7 870	276	894	50	1 558	871	200	282
2006	1 639	1 840	6 161	178	692	43	1 753	666	129	220
2007	2 322	1 880	7 504	34	651	237	1 306	933	107	189
2008	2 350	1 810	6 990	329	821	507	1 067	1 170	115	110

Estimates of relative abundance from trawl surveys (Table 9) and standardised analyses of CPUE (Table 10) are presented below. The WCSI trawl and line CPUE series exhibit conflicting trends in recent years. Assessment modeling indicates that the trawl series from the hoki target fishery is probably the more reliable abundance series because its trend is supported by the signal from the extensive series of trawl catch-at-age data. However, it is a relatively short series. The line fishery series is long and relatively data rich, but it appears likely that catch rates have been hyper-stable, producing a constant but variable index series despite a reduction in stock size.

Table 9: Biomass indices (t) and estimated coefficients of variation (c.v.).

Fishstock	Area	Vessel	Trip code	Date	Biomass	c.v. (%)
LIN 3 & 4	Chatham Rise	*Tangaroa*	TAN9106	Jan-Feb 1992	8 930	5.8
			TAN9212	Jan-Feb 1993	9 360	7.9
			TAN9401	Jan 1994	10 130	6.5
			TAN9501	Jan 1995	7 360	7.9
			TAN9601	Jan 1996	8 420	8.2
			TAN9701	Jan 1997	8 540	9.8
			TAN9801	Jan 1998	7 310	8.0
			TAN9901	Jan 1999	10 310	16.1
			TAN0001	Jan 2000	8 350	7.8
			TAN0101	Jan 2001	9 350	7.5
			TAN0201	Jan 2002	9 440	7.8
			TAN0301	Jan 2003	7 260	9.9
			TAN0401	Jan 2004	8 250	6.0
			TAN0501	Jan 2005	8 930	9.4
			TAN0601	Jan 2006	9 300	7.4
			TAN0701	Jan 2007	7 800	7.2

Table 9 Continued:

Fishstock	Area	Vessel	Trip code	Date	Biomass	c.v. (%)
			TAN0801	Jan 2008	7 503	6.8
			TAN0901	Jan 2009	10 600	11.5
			TAN1001	Jan 2010	8 820	10.0
LIN 5 & 6	Southern Plateau	*Amaltal Explorer*	AEX8902	Oct–Nov 1989	17 490	14.2
			AEX9002	Nov–Dec 1990	15 850	7.5
LIN 5 & 6	Southern Plateau	*Tangaroa*	TAN9105	Nov-Dec 1991	24 090	6.8
			TAN9211	Nov-Dec 1992	21 370	6.2
			TAN9310	Nov-Dec 1993	29 750	11.5
			TAN0012	Dec 2000	33 020	6.9
			TAN0118	Dec 2001	25 060	6.5
			TAN0219	Dec 2002	25 630	10.0
			TAN0317	Nov-Dec 2003	22 170	9.7
			TAN0414	Nov-Dec 2004	23 770	12.2
			TAN0515	Nov-Dec 2005	19 700	9.0
			TAN0617	Nov-Dec 2006	19 640	12.0
			TAN0714	Nov-Dec 2007	26 492	8.0
			TAN0813	Nov-Dec 2008	22 840	9.5
			TAN0911	Nov-Dec 2009	22 700	9.6
Fishstock	Area	Vessel	Trip code	Date	Biomass	c.v. (%)
LIN 5 & 6	Southern Plateau	*Tangaroa*	TAN9204	Mar-Apr 1992	42 330	5.8
			TAN9304	Apr-May 1993	37 550	5.4
			TAN9605	Mar-Apr 1996	32 130	7.8
			TAN9805	Apr-May 1998	30 780	8.8
LIN 7WC	WCSI	*Kaharoa*	KAH9204	Mar-Apr 1992	286	19
			KAH9404	Mar-Apr 1994	261	20
			KAH9504	Mar-Apr 1995	367	16
			KAH9701	Mar-Apr 1997	151	30
			KAH0004	Mar-Apr 2000	95	46
			KAH0304	Mar-Apr 2003	150	33
			KAH0503	Mar-Apr 2005	274	37
			KAH0704	Mar-Apr 2007	180	27
			KAH0904	Mar-Apr 2009	291	37

Posterior distributions of year class strength estimates from the base case model run are shown in Figure 2; distributions from the sensitivity runs differed little from this example.

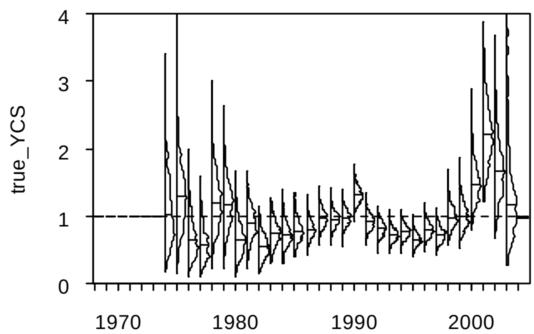


Figure 2: Estimated posterior distributions of year class strength for the LIN 7WC stock. The horizontal line indicates a year class strength of one. Individual distributions show the marginal posterior distribution, with horizontal lines indicating the median.

Table 10: Standardised CPUE indices (with c.v.s) for the ling line and trawl fisheries. Year refers to calendar year.

	LIN 3&4 line		LIN 5&6 line		LIN 6B line		LIN 7WC line		Cook Strait line	
Year	CPUE	c.v.	CPUE	c.v.	CPUE	c.v.	CPUE	c.v.	CPUE	c.v.
1990	2.19	0.07	–	–	–	–	0.91	0.06	0.71	0.16
1991	1.57	0.05	0.89	0.10	–	–	1.17	0.05	1.08	0.13
1992	2.04	0.05	1.20	0.08	1.80	0.13	1.15	0.04	1.07	0.11
1993	1.50	0.04	1.29	0.08	1.58	0.11	0.92	0.05	0.78	0.11
1994	1.44	0.04	0.94	0.07	1.07	0.13	0.93	0.04	0.69	0.11
1995	1.43	0.04	1.28	0.07	1.13	0.13	0.95	0.04	0.65	0.12
1996	1.20	0.04	1.03	0.07	1.05	0.12	0.79	0.04	0.77	0.13
1997	0.84	0.03	1.18	0.05	0.85	0.13	0.86	0.04	1.02	0.19
1998	0.80	0.04	0.98	0.05	1.03	0.12	0.95	0.04	0.72	0.15
1999	0.70	0.04	0.83	0.05	1.04	0.11	1.03	0.04	1.26	0.19
2000	0.82	0.04	0.98	0.06	0.95	0.10	0.99	0.04	1.42	0.19
2001	0.81	0.04	1.10	0.07	0.81	0.10	1.13	0.04	1.27	0.20
2002	0.70	0.04	1.08	0.07	0.72	0.10	1.07	0.05	1.86	0.11
2003	0.85	0.04	0.81	0.09	0.78	0.09	1.13	0.04	1.63	0.11
2004	0.71	0.04	0.75	0.07	0.71	0.14	1.11	0.05	1.38	0.10
2005	0.77	0.04	0.85	0.10	–	–	0.85	0.04	1.14	0.11
2006	0.67	0.04	0.91	0.09	0.97	0.36	0.89	0.05	0.92	0.16
2007	0.72	0.04	1.13	0.10	–	–	1.17	0.04	0.70	0.13
2008	0.78	0.05	0.99	0.10	–	–	1.15	0.05	0.89	0.22

	Cook Strait trawl		LIN 7WC trawl	
Year	CPUE	c.v.	CPUE	c.v.
1986	–	–	0.44	0.07
1987	–	–	0.24	0.05
1998	–	–	0.47	0.05
1989	–	–	0.81	0.06
1990	2.26	0.05	0.52	0.05
1991	1.84	0.04	0.59	0.06
1992	1.61	0.04	0.54	0.07
1993	1.67	0.04	0.97	0.06
1994	1.07	0.04	0.79	0.05
1995	0.91	0.03	1.43	0.06
1996	0.89	0.03	1.50	0.05
1997	0.77	0.03	1.22	0.06
1998	0.78	0.03	1.40	0.05
1999	0.77	0.03	1.95	0.05
2000	0.87	0.03	1.12	0.04
2001	0.98	0.03	1.04	0.04
2002	1.01	0.04	1.54	0.04
2003	1.07	0.03	0.73	0.05
2004	0.85	0.03	1.66	0.04
2005	0.81	0.03	1.27	0.04
2006	0.81	0.04	1.19	0.05
2007	0.67	0.04	0.80	0.06
2008	0.64	0.04	0.62	0.06

4.2 Biomass estimates

Descriptions of the three LIN 7WC model runs presented are as follows.

- Base case — catch history, trawl and line fishery catch-at-age, with double-normal ogives for the trawl fishery and logistic ogives for the line fishery, and $M = 0.22$.
- *Tangaroa* survey — the base case model, but including the *Tangaroa* biomass estimate.
- $M = 0.15$ — the base case model, but setting $M = 0.15$.

The assessment is driven by the trawl fishery catch-at-age data, which contains information indicative of a slight but steady stock decline from the mid 1980s to the early 2000s. The *Tangaroa* survey point provides little additional information to the model; median estimates of absolute biomass are slightly higher than in the base case, but the credible intervals are much wider (Table 11, Figure 3). Reductions in M result in more pessimistic assessments; estimates of absolute biomass and current stock status as a percentage of B_0 decline with declining M values. An M of 0.15 is likely to be near the bottom of the logical range of this parameter for ling.

Model runs fitting to the line and trawl CPUE series and to the *Kaharoa* survey series were also completed, but are not reported here. The inshore *Kaharoa* survey sampled a very small fraction of the LIN 7WC population, and so provided little information to the model. The line CPUE series is flat, but very variable, and resulted in unrealistically high estimates of biomass. This series may be indicative of hyper-stable catch rates in the line fishery. The inclusion of the trawl CPUE series had little influence on the base case biomass trajectory, suggesting that the model output is dominated by the catch-at-age proportions.

All model runs indicated a biomass decline from 1985 to 2005, followed by an increase (driven by the recruitment of some average to strong year classes). Estimates of current and virgin stock vary little in the presented assessments, but are still very uncertain owing to the lack of abundance indices in the basecase and the dominance of the catch at age data on model outputs.

Table 11: Bayesian median and 95% credible intervals (in parentheses) of B_0 and B_{2008} (in tonnes), and B_{2008} as a percentage of B_0 for all model runs for LIN 7WC.

Model run		B_0		B_{2008}		B_{2008} (%B_0)
Base case	66 110	(55 100–88 500)	45 960	(30 810–72 570)	69	(56–85)
Tangaroa survey	70 630	(56 570–119 160)	51 240	(33 490–102 300)	72	(58–89)
M = 0.15	57 210	(46 060–77 600)	24 800	(13 870–44 690)	43	(29–58)

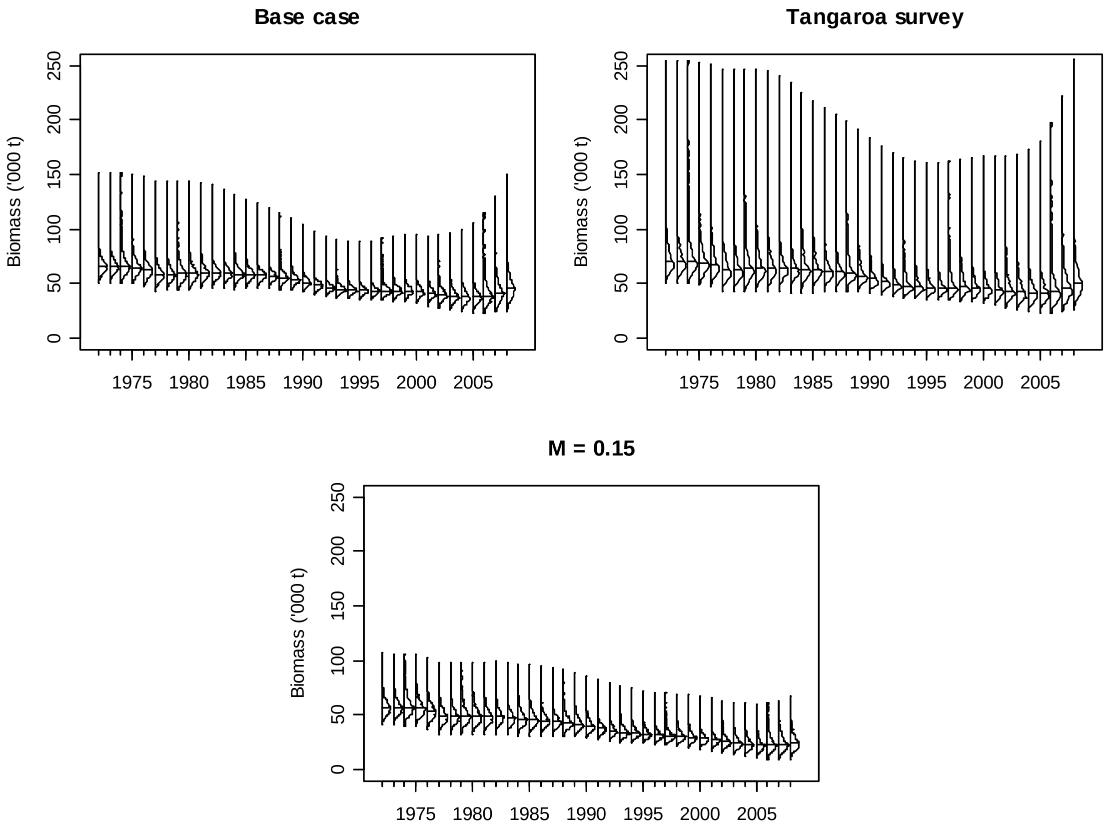


Figure 3: LIN 7WC — Estimated posterior distributions of the biomass trajectory (in tonnes) from the three model runs. Individual distributions show the marginal posterior distribution, with horizontal lines indicating the median.

4.3 Estimation of Maximum Constant Yield (MCY)

Two methods were used to estimate MCY.

(i) MCY = cY_{av}, where c = 0.8 based on M = 0.18 and Y_{av} is the mean catch for the years 1983–84 to 1990–91.

(ii) MCY = pB_0 where p is determined for each stock using the simulation method of Francis (1992) such that the spawning biomass does not go below 20% B_0 more than 10% of the time. MCY estimates and related parameters are listed in Table 12.

Auckland (LIN 1)

An MCY for LIN 1 was estimated from the equation MCY = cY_{av}, and is 101 t. It has not been re-estimated since the 1992 Plenary Report.

Central (East), including Cook Strait (LIN 2)

An MCY for all of LIN 2 (394 t) was estimated from the equation MCY = cY_{av} in 1992. Modelling of the Cook Strait stock (parts of LIN 2 and LIN 7) was completed in 2007, and estimates of MCY were derived from this assessment using a variant of method (ii) above. About 75% of the Cook Strait landings are from Fishstock LIN 2 (the rest being from LIN 7), and in recent years they have accounted for about 40% of the LIN 2 landings.

South-East (Coast), and South-East (Chatham Rise) (LIN 3 & 4)
Estimates of MCY are presented from several LIN 3&4 CASAL runs using a variant of method (ii) above. They were derived from the 2007 assessment.

Southland, and Sub-Antarctic (LIN 5 & 6)
Estimates of MCY are presented from several LIN 5&6 CASAL runs using a variant of method (ii) above. They were derived from the 2007 assessment. B_0 and current biomass for this stock are poorly known, so the yield estimates are very uncertain.

An estimate of MCY for the Bounty Plateau stock (LIN 6B) was derived from the 2006 CASAL assessment using a variant of method (ii) above. B_0 and current biomass for this stock are poorly known, so the yield estimate is very uncertain.

Challenger, and Central (West) (LIN 7)
The ling stock off west coast South Island was assessed in 2008, but no yields were calculated as no sufficiently reliable estimates of biomass were obtained. See LIN 2 (above) for yield estimates for the Cook Strait stock.

Table 12: Estimates of B_{MCY} and MCY from base case and sensitivity model runs.

Fishstock	Model run	B_{MCY} (t)	MCY (t)	B_{MCY} (% of B_0)	MCY (% of B_0)
LIN 3&4	Fixed *M*	57 170	8 240	40.3	5.8
	Estimate *M*	45 750	4 960	40.6	4.4
LIN 5&6	Fixed *M*	122 510	16 640	46.1	6.3
	Estimate *M*	267 240	25 880	60.0	5.8
LIN 6B	Base case	7 520	720	55.4	5.3
Cook Strait	Split trawl CPUE	3 140	390	43.9	5.5

4.4 Estimation of Current Annual Yield (CAY)

The simulation method of Francis (1992) was also used to estimate CAY with the same definition of risk. CAY estimates from the reported model runs for LIN 3&4, 5&6, 6B, and Cook Strait are given in Table 13. There are no reliable CAY estimates for any other stocks.

Table 13: CAY estimates and associated parameters for the model runs for LIN 3&4, LIN 5&6, and LIN 7CK (from the 2007 assessment), and for LIN 6B (from the 2006 assessment).

Model run		B_{MAY} (t)	MAY (t)	F_{CAY}	CAY (t)	B_{MAY} (% of B_0)	MAY (% of B_0)
LIN 3&4	Fixed *M*	38 710	9 320	0.22	21 160	27.3	6.6
	Estimate *M*	30 230	5 650	0.18	9 560	26.8	5.0
LIN 5&6	Fixed *M*	75 220	20 710	0.27	55 830	28.3	7.8
	Estimate *M*	134 480	39 930	0.29	114 620	30.2	8.9
Cook Strait	Split trawl CPUE	2 040	460	0.22	740	28.5	6.4
LIN 6B	Base case	4 780	940	0.18	1 680	35.2	6.9

4.5 Other yield estimates and stock assessment results

Projections for LIN 6B from the 2006 assessment are shown in Table 14. The LIN 6B stock (Bounty Plateau) is likely to decline out to 2011, but probably will still be higher than 50% of B_0. Projections made in 2007 out to 2012 for LIN 3&4, 5&6, and Cook Strait, assuming future annual catches equal to recent catch levels, are shown in Table 15. For LIN 3&4 and LIN 5&6, stock size is likely to increase slightly. For Cook Strait ling, stock size is likely to decline, but probably will still be higher than 50% of B_0. New projections out to 2013 for LIN 7WC, assuming future annual catches equal to the TACC, are shown in Table 16. They indicate that the biomass increase that began about 2005 is likely to continue to 2013, with even the most pessimistic assessment projecting biomass to be higher than 50% of B_0 by then.

Table 14: Bayesian median and 95% credible intervals (in parentheses) of projected B_{2011}, B_{2011} as a percentage of B_0, and B_{2011}/B_{2006}(%) for the base case LIN 6B.

Stock and model run		Future catch (t)	B_{2011}		B_{2011} (%B_0)		B_{2011}/B_{2006} (%)	
LIN 6B	Base case	600	7 460	(2 950–18 520)	53	(26–116)	86	(51–168)

Table 15: Bayesian median and 95% credible intervals (in parentheses) of projected B_{2012}, B_{2012} as a percentage of B_0, and B_{2012}/B_{2007}(%) for the LIN 3&4, 5&6, and 7CK base case and sensitivity runs.

Stock and model run		Future catch (t)	B_{2012}		B_{2012} (%B_0)		B_{2012}/B_{2007} (%)	
LIN 3&4	Fixed M	4 100	95 890	(76 200–124 250)	68	(58–82)	108	(96–127)
	Estimate *M*	4 100	54 770	(43 900–71 250)	49	(40–60)	106	(94–125)
LIN 5&6	Fixed *M*	8 000	208 250	(138 230–315 690)	77	(62–101)	103	(88–132)
	Estimate *M*	8 000	394 120	(204 070–725 870)	86	(69–112)	104	(89–133)
Cook Strait	Split trawl CPUE	450	2 520	(1 520–4 260)	35	(22–57)	74	(50–120)

Table 16: Bayesian median and 95% credible intervals (in parentheses) of projected B_{2013}, B_{2013} as a percentage of B_0, and B_{2013}/B_{2008}(%) for the LIN 7WC base case and sensitivity runs.

Stock and model run		Future catch (t)	B_{2013}		B_{2013} (%B_0)		B_{2013}/B_{2008} (%)	
LIN 7WC	Base case	2 225	58 900	(37 580–97 670)	89	(67–112)	127	(108–150)
	Tangaroa survey	2 225	65 920	(41 830–133 050)	93	(71–118)	127	(111–151)
	M = 0.15	2 225	31 620	(15 200–61 350)	55	(33–80)	127	(104–151)

5. ANALYSIS OF ADAPTIVE MANAGEMENT PROGRAMMES (AMP)

The Ministry of Fisheries revised the AMP framework in December 2000. The AMP framework is intended to apply to all proposals for a TAC or TACC increase, with the exception of fisheries for which there is a robust stock assessment. In March 2002, the first meeting of the new Adaptive Management Programme Working Group was held. Two changes to the AMP were adopted:

- a new checklist was implemented with more attention being made to the environmental impacts of any new proposal
- the annual review process was replaced with an annual review of the monitoring requirements only. Full analysis of information is required a minimum of twice during the 5 year AMP.

LIN 1

In October 2002, the TACC for LIN 1 was increased from 265 t to 400 t within the AMP. A full-term review of the LIN 1 AMP was carried out in 2007.

Mid-term Review 2009 (AMP WG/09/09)

Fishery Characterization

- LIN1 entered the QMS in 1986-87 at a TACC of 200t, which was increased to 238t in 1988-89 and 265t in 1989/90, probably due to the quota appeal process. LIN 1 catches remained slightly under the TACC up to 1994-94, but then exceeded the TACC, reaching ~300t over most of the period 1996-97 to 2001-02. LIN 1 entered the AMP programme in 2002-03, with a TACC increase from 265t to 400t.
- After implementation of the AMP, catches dropped back to the previous TACC level for two years, and then increased to 364t by 2005-06, dipped to 201t in 2006-07, and increased to 381t in 2007-08, the highest catch level over the data series.
- 53% of LIN 1 landings come from the bottom trawl fishery and a further 46% by bottom longline since 1989-90. The remaining methods account for < 2% of the total landings.
- Most BT and BLL landings come from the Bay of Plenty. The majority of bottom trawl catches are taken in Statistical Areas 008 to 010, although there have been significant bottom trawl catches of ling on the west coast of the North Island in some years in Areas 046 to 048. There were substantial ling by-catches made by trawl on the North Island west coast from 1996/97 - 2000/01 in the gemfish fishery (which has since ceased), and longline catches have increased from the East Northland area.
- Ling are caught in small quantities across many fisheries. The distribution of BT effort is broader than the distribution of catch, with effort taking some LIN 1 in East Northland and the west coast

in most years. Bottom longline landings of LIN 1 have a wider distribution and are more sporadic, with the Bay of Plenty landings coming primarily from Areas 009 and 010. Bottom longline landings increased after about 2000 in East Northland Area 002, but have fallen off considerably in 2007–08.

- There is a small targeted ling trawl fishery, while trawl catches of LIN1 are mainly made in the scampi and gemfish targeted fisheries. The gemfish fishery mainly contributed catches from 1996-97 to 2000-01 and has since considerably diminished with the reduction of the SKI 1 TACC. The Bay of Plenty scampi fishery has also changed considerably during this period, particularly after SCI entered the QMS, moving from a competitive fishery requiring multiple vessels to a more rationalised fishery requiring only a single vessel. In contrast, ~75% of the ling longline catch is taken in a targeted ling fishery, with only minor by-catches coming from bluenose, ribaldo and hapuku targeted longline fisheries.
- The bottom longline landings of LIN 1 are taken mainly in the final two months of the fishing year, probably due to the economics of the vessels switching from tuna longlining to cleaning up available quota at the end of the fishing year. Bottom trawl catches of ling tend to be more evenly distributed across the year and reflect the fishing patterns of the diverse trawl targets, such as scampi which is also a consistent fishery over the entire year. Both of the major fishing methods which take ling have sporadic seasonal patterns, reflecting the small landings in most years and the by-catch nature of many of the fisheries.
- The depth distribution of ling catches in the trawl fisheries shows two main depths associated with the target species. Most ling are caught in the scampi / hoki / ling fishery at ~400m depth, but some are taken in the tarakihi / snapper / barracouta / trevally fisheries around 100m depth. Bottom longline depth records indicate that target ling fishing (as well as target bluenose fishing) takes place at even deeper depths, with most of the records lying between 500 and 600 m.

CPUE Analysis

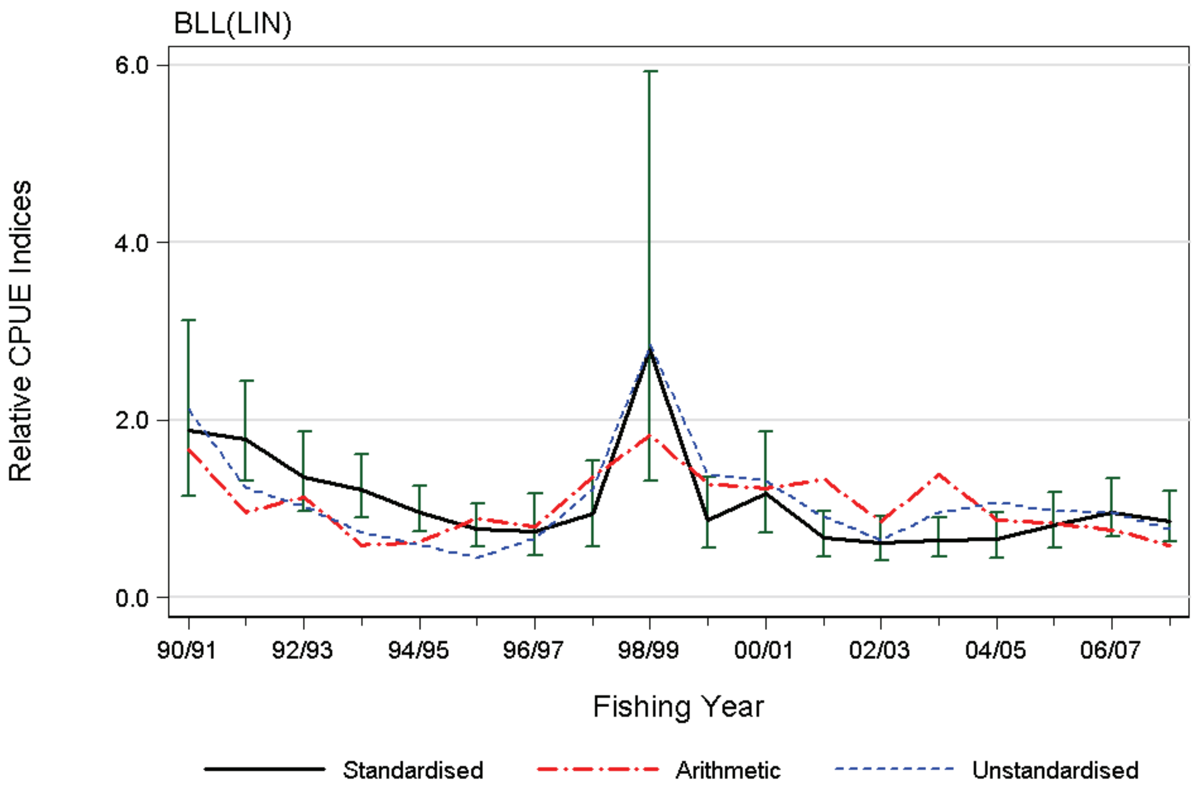


Figure 4: LIN 1 CPUE analysis based on target ling bottom longline data stratified by trip, target species and statistical area for Statistical Areas 002, 003, 004, 008, 009 and 010 standardised with respect to fishing year, number of hooks, vessel, month and number of lines set. Indices from two unstandardised analyses are presented for comparison: a) "arithmetic", the annual sum of landings divided by the total annual number of hooks; and b) "unstandardised", the geometric mean of landings per hook by trip-stratum.

- The WG has previously noted substantial problems with the quality of LIN1 data. Estimated catches tend to be less than landed greenweight (the median landed greenweight is about 25% greater than the estimated catch in the same trip), but only 4% of trips by weight neglect to report estimated catches of ling when there are landings. The biggest problem with this data set is the confusion, largely confined to the period prior to about 1995–96, where the FMA has been reported as the statistical area of capture rather than the true statistical area. This is a problem for a LIN 1 analysis because (for instance) FMA 4 (Chatham Rise) will be included in this dataset because statistical area 004 is valid for LIN 1. It is not possible to independently validate such a report because the CELR reporting form used by these vessels does not require a noon position or some other corroborating evidence of location. This problem is further exacerbated because many trips which apparently are legitimately fishing in FMAs 1 and 9 (the two LIN 1 FMAs) also tend to range widely, circumnavigate the entire North Island and venture into South Island waters. There is a large amount of landings made to the intermediate destination code R (retained on board) which further confounds the analysis because this breaks the continuity of the landings with the effort section of the form, resulting in much of the data being excluded and severely limiting the amount of data available for CPUE analyses.
- The diverse nature and broad geographic range of the LIN 1 fisheries has further complicated the selection of representative CPUE indices. Eight potential fisheries were previously identified as potential CPUE indices, but none of the analyses were considered to be robust due to the diverse nature of the fisheries and relative paucity of data. The AMP WG concluded in 2007, when it last reviewed the LIN 1 fishery, that landed catch data were particularly unreliable, and recommended that estimated catch data should be used instead.
- The 2007 review of the LIN 1 CPUE indices concluded that the LIN bycatch fishery in the target scampi bottom trawl fishery in the Bay of Plenty and the target ling bottom longline fishery in the Bay of Plenty and East Northland had sufficient information to warrant attempting standardised CPUE analyses (Starr et al. 2007).
- These two candidate CPUE analyses were updated for this review. However, noting that there is now only one vessel in the scampi fishery, and that the amount of LIN catch data from the scampi bycatch fishery continues to decrease, the WG concluded that the only candidate index of LIN 1 abundance worth considering in this review was the BLL(LIN) index (target ling fishing using bottom longline). The WG recommended that future analyses which included mixed target species bottom trawl effort should be investigated to replace the BT(SCI) index.
- In 2009, the BLL(LIN) index was updated to exclude vessels which only fished in a single year, and calculated alternately using estimated and landed catches. The updated BLL index essentially remains unchanged from the one presented in 2007, consisting of two periods of slowly declining CPUE from 1990-91 to 1996-97 and 1999-00 to 2005-06, separated by a strong, highly uncertain and likely anomalous peak in 1998-99.
- In 2007, the WG noted that BLL reporting rates greatly exceed landed catch weights, reaching 700% in 1998-99. The high CPUE peak in 1998-99 appeared to result from landings which occurred in a single month by two vessels which typically had high catch rates. Many new participants have entered and left this fishery and the vessel effect needs to be investigated further.
- The WG made a number of recommendations for additional data selection procedures and analyses to investigate vessel effects on the BLL(LIN) index (see below).

Status of the Stock

Analysis Recommendations

The following analyses were conducted or recommended during the 2009 review:

- The WG requested that the vessels which only fished in one year be removed from the analysis. This was done and updated analyses were presented to the review.
- At the next review, BLL index standardisations need to further explore the reasons for the peak in 1998-99 (which resulted only from 2 vessels which fished only 2 and 4 trip strata respectively). The linkage of core fleet vessels across this and the effect of inclusion of large autoliners in the BLL index also needs to be investigated.

- Other options should be explored for excluding autoliners or vessels which do not belong in FMA 1 during data extraction, and then modifying grooming procedures to retain a higher proportion of data for the remaining vessels.
- For future analyses, a mixed target BT(HOK,LIN,SKI) index should be calculated to replace the BT(SCI) index.

Abundance Indices
The WG concluded that the BT(SCI) index was not an appropriate index for LIN 1, and had numerous shortcomings related to limited number of vessels, particularly in the most recent 4 years and poor linkage across years. The BLL(LIN) target index appears to have more potential as an index for LIN 1, but shows an apparently anomalous peak in 1998-99 and also has a relatively small amount of data. If this anomalous peak is excluded, the BLL(LIN) index has been stable without trend since 1995/96. However, until the reasons for the peak in BLL CPUE are understood, the WG concluded that the CPUE indices from this series are not reliable indices of LIN 1 abundance.

Sustainability of Current Catches
In the absence of a representative index of abundance, it is not known whether current LIN 1 catches or the TACC are sustainable

Stock Status
The state of the stock in relation to B_{MSY} is unknown.

6. STATUS OF THE STOCKS

Stock Structure Assumptions
Ling are assessed as six independent biological stocks, based on the presence of spawning areas and some differences in biological parameters between areas (Horn 2005).

The Chatham Rise biological stock comprises all of Fishstock LIN 4, and LIN 3 north of the Otago Peninsula. The Sub-Antarctic biological stock comprises all of Fishstock LIN 5, all of LIN 6 excluding the Bounty Plateau, and LIN 3 south of the Otago Peninsula. The Bounty Plateau (part of Fishstock LIN 6) holds another distinct biological stock. The WCSI biological stock occurs in Fishstock LIN 7 west of Cape Farewell. The Cook Strait biological stock includes those parts of Fishstocks LIN 7 and LIN 2 between the northern Marlborough Sounds and Cape Palliser. Ling around the northern North Island (Fishstock LIN 1) are assumed to comprise another biological stock, but there is no information to support this assumption. The stock affinity of ling in LIN 2 between Cape Palliser and East Cape is unknown.

- **LIN 1 Stock**

Stock Status	
Year of Most Recent Assessment	2009
Assessment Runs Presented	None. Fishstock LIN 1 has been managed under an AMP programme since 2003.
Reference Points	Management Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Unknown
Status in relation to Limits	Unknown
Historical Stock Status Trajectory and Current Status Not available	

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Unknown

Recent Trend in Fishing Mortality or Proxy	Unknown
Other Abundance Indices	Two CPUE series have been estimated (scampi-targeted bottom trawl, and a ling targeted bottom longline), but neither are considered reliable.
Trends in Other Relevant Indicators or Variables	None available

Projections and Prognosis	
Stock Projections or Prognosis	Unknown
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unknown Hard Limit: Unknown

Assessment Methodology		
Assessment Type	Level 3 – Qualitative evaluation	
Assessment Method	Evaluation of fishery trends.	
Main data inputs	- CPUE series	
Period of Assessment	Latest assessment: 2009	Next assessment: Unknown
Changes to Model Structure and Assumptions	No modeling completed.	
Major Sources of Uncertainty	Only fishery dependent abundance series were available (CPUE), and these were not considered reliable. The biological stock affinities of ling in LIN 1 are unknown.	

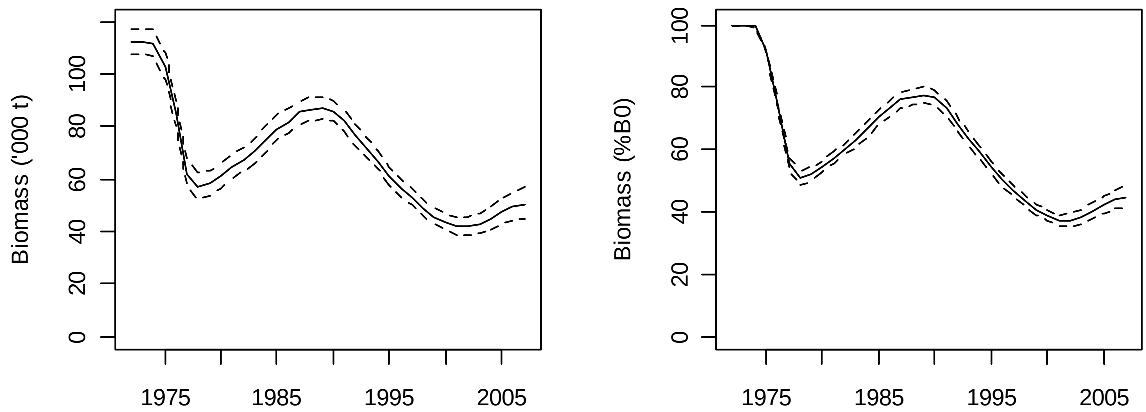
Qualifying Comments
In the absence of a representative and useful index of abundance, it is not known whether current LIN 1 catches or the TACC can be maintained without reducing the stock size. Current stock status is unknown.

Fishery Interactions
Ling are often taken as a bycatch in hoki target trawl fisheries, and scampi target trawl fisheries off northern New Zealand. Target line fisheries for ling have the main bycatch species of spiny dogfish, sea perch, sharks and skates and ribaldo. Bycatch species of concern include sharks, skates, fur seals and seabirds (trawl fisheries), and sharks, skates and seabirds (longline fisheries).

- **Chatham Rise Stock**

Stock Status	
Year of Most Recent Assessment	2007
Assessment Runs Presented	Two model runs (*M* fixed at 0.18, and *M* estimated). The run estimating *M* was the preferred model.
Reference Points	Management Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	B_{2007} was estimated to be about 45% B_0; Likely (> 60%) to be above the target
Status in relation to Limits	B_{2007} is Very Unlikely (< 10%) to be below the Soft Limit and Exceptionally Unlikely (< 1%) to be below the Hard Limit.

Historical Stock Status Trajectory and Current Status



Trajectory over time of spawning biomass (absolute, and %B_0, with 95% credible intervals shown as broken lines) for the Chatham Rise ling stock from the start of the assessment period in 1972 to the most recent assessment in 2007. Years on the x-axis are fishing year with "1995" representing the 1994–95 fishing year. Biomass estimates are based on MCMC results.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Median estimates of biomass are unlikely to have been below 35% B_0. Biomass is estimated to have been increasing since 2002.
Recent Trend in Fishing Mortality or Proxy	Fishing pressure is estimated to have been declining since 1999.
Other Abundance Indices	–
Trends in Other Relevant Indicators or Variables	Recruitment since the early 1990s is estimated to have been fluctuating slightly around the long-term average for this stock.

Projections and Prognosis (2007)	
Stock Projections or Prognosis	Stock status is predicted to improve over the next 5 years at a catch level equivalent to the mean from 2004 to 2007 (i.e., 4100 t per year), which is about two-thirds of the available LIN 3 & 4 TACC.
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Very Unlikely (< 10%) Hard Limit: Very Unlikely (< 10%)

Assessment Methodology		
Assessment Type	Level 1 – Quantitative stock assessment	
Assessment Method	Age-structured CASAL model with Bayesian estimation of posterior distributions.	
Main data inputs	- Summer *Tangaroa* trawl survey series, annually since 1992. - Proportions-at-age data from the commercial fisheries and trawl survey. - Line fishery CPUE series (annual indices since 1990). - Estimates of biological parameters (but note that *M* was estimated in the model to be about 0.14)	
Period of Assessment	Latest assessment: 2007	Next assessment: Unknown
Changes to Model Structure and Assumptions	No significant changes since the previous assessment, except that in the preferred model run *M* was estimated, rather than being fixed at 0.18.	
Major Sources of Uncertainty	The assessment model is moderately sensitive to relatively small changes in *M*. Although the catch history used in the assessment has corrected for some misreported catch (see section 1.4), it is possible that some significant misreporting has not been accounted for.	

Qualifying Comments
The more pessimistic of the two reported models was the preferred run. The alternate model estimated B_{2007} to be 68% B_0. However, both model runs indicated a likely improvement in stock status at recent catch levels.

Fishery Interactions
Ling are often taken as a bycatch in hoki target trawl fisheries. Target line fisheries for ling have the main bycatch species of spiny dogfish, sea perch, sharks and skates and ribaldo. Bycatch species of concern include sharks, skates, fur seals and seabirds (trawl fisheries), and sharks, skates and seabirds (longline fisheries).

- **Sub-Antarctic Stock**

Stock Status	
Year of Most Recent Assessment	2007
Assessment Runs Presented	Two model runs (*M* fixed at 0.18, and *M* estimated). Neither of the runs was more preferred.
Reference Points	Management Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	B_{2007} was estimated to be between 55% and 95% B_0; Very Likely (> 60%) to be at or above the target
Status in relation to Limits	B_{2007} is Very Unlikely (< 10%) to be below the Soft Limit and Exceptionally Unlikely (< 1%) to be below the Hard Limit

Historical Stock Status Trajectory and Current Status

Trajectory over time of spawning biomass (absolute, and %B_0, with 95% credible intervals shown as broken lines) for the Sub-Antarctic ling stock from the start of the assessment period in 1972 to the most recent assessment in 2007, for the 'fixed *M*' model run. Years on the x-axis are fishing year with "1995" representing the 1994–95 fishing year. Biomass estimates are based on MCMC results.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Median estimates of biomass are unlikely to have been below 65% B_0. Biomass is estimated to have been increasing since 2000.
Recent Trend in Fishing Mortality or Proxy	Fishing pressure is estimated to have always been low, and declining since 1998.
Other Abundance Indices	–
Trends in Other Relevant Indicators or Variables	Recruitment throughout the 1980s wa low relative to the long-term average for this stock, but has been average or better since 1993.

Projections and Prognosis	
Stock Projections or Prognosis	Stock status is predicted to improve over the next 5 years at a catch level equivalent to the average from 2004 to 2007 (i.e., 8000 t per year), which is about two-thirds of the available LIN 5 & 6 TACC.

Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Very Unlikely (< 10%) Hard Limit: Very Unlikely (< 10%)

Assessment Methodology		
Assessment Type	Level 1 – Quantitative stock assessment	
Assessment Method	Age-structured CASAL model with Bayesian estimation of posterior distributions.	
Main data inputs	- Summer and autumn *Tangaroa* trawl survey series. - Proportions-at-age data from the commercial fisheries and trawl surveys. - Line fishery CPUE series (annual indices since 1991). - Estimates of biological parameters (but note that *M* was estimated in one model to be about 0.20)	
Period of Assessment	Latest assessment: 2007	Next assessment: Unknown
Changes to Model Structure and Assumptions	No significant changes since the previous assessment, except that in one model run *M* was estimated, rather than being fixed at 0.18.	
Major Sources of Uncertainty	The assessment model is very sensitive to relatively small changes in *M*. Because of the relative lack of contrast in the abundance series, estimates of absolute current and reference biomass are unreliable. Although the catch history used in the assessment has been corrected for some misreported catch (see section 1.4), it is possible that additional misreporting exists.	

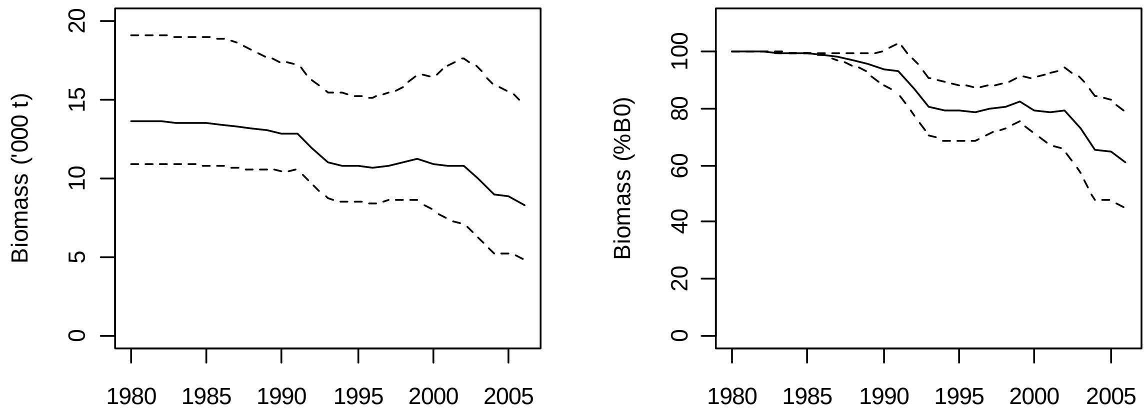
Qualifying Comments
Although estimates of absolute current and reference biomass are unreliable, B_0 was probably over 200 000 t. The stock has probably only been lightly fished.

Fishery Interactions
Ling are often taken as a bycatch in hoki target trawl fisheries. Target line fisheries for ling have the main bycatch species of spiny dogfish, sea perch, sharks and skates and ribaldo. Bycatch species of concern include sharks, skates, fur seals and seabirds (trawl fisheries), and sharks, skates and seabirds (longline fisheries).

- **Bounty Plateau Stock**

Stock Status	
Year of Most Recent Assessment	2006
Assessment Runs Presented	A single model run
Reference Points	Management Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	B_{2006} was estimated to be 61% B_0; Very Likely (> 90%) to be at or above the target
Status in relation to Limits	B_{2006} is Very Unlikely (< 10%) to be below the Soft Limit and Exceptionally Unlikely (< 1%) to be below the Hard Limit.

Historical Stock Status Trajectory and Current Status



Trajectory over time of spawning biomass (absolute, and %B_0, with 95% credible intervals shown as broken lines) for the Bounty Plateau ling stock from the start of the assessment period in 1980 to the most recent assessment in 2006. Years on the x-axis are fishing year with "1995" representing the 1994–95 fishing year. Biomass estimates are based on MCMC results.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Median estimates of biomass are unlikely to have been below 61% B_0. Biomass is estimated to have been declining since 1999.
Recent Trend in Fishing Mortality or Proxy	Fishing pressure is estimated to have been low, but erratic, since 1980.
Other Abundance Indices	–
Trends in Other Relevant Indicators or Variables	Recruitment was above average in the early 1990s, but below average in the late 1990s. No estimates of recruitment since 1999 are available.

Projections and Prognosis (2006)	
Stock Projections or Prognosis	Stock status is predicted to continue declining slightly over the next 5 years at a catch level equivalent to the average since 1991 (i.e., 600 t per year).
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Very Unlikely (< 10%) Hard Limit: Very Unlikely (< 10%)

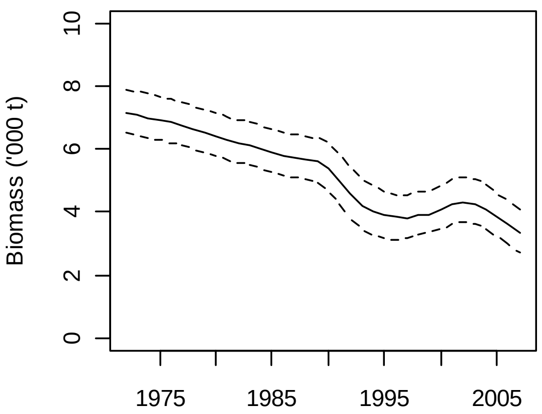
Assessment Methodology		
Assessment Type	Level 1 – Quantitative stock assessment	
Assessment Method	Age-structured CASAL model with Bayesian estimation of posterior distributions.	
Main data inputs	- Proportions-at-age data from the commercial line fishery. - Line fishery CPUE series (annual indices since 1992). - Estimates of biological parameters.	
Period of Assessment	Latest assessment: 2006	Next assessment: Unknown
Changes to Model Structure and Assumptions	No significant changes since the previous assessment.	
Major Sources of Uncertainty	There are no fishery-independent indices of relative abundance, so the assessment is driven largely by the line fishery CPUE series. Stock projections are based on a constant future catch of 600 t per year. However, historic catches from this fishery have fluctuated widely, so future catches could be markedly different from 600 t per year.	

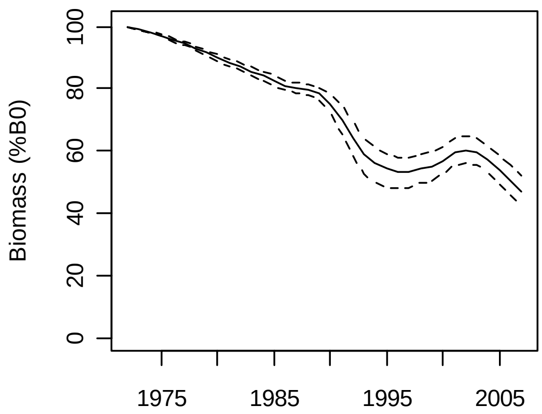
Qualifying Comments
There is no separate TACC for this stock; it is part of the LIN 6 Fishstock with a TACC of 8505 t.

Fishery Interactions
Target line fisheries for ling have the main bycatch species of spiny dogfish, sharks and skates and ribaldo. Bycatch species of concern include sharks, skates and seabirds.

- **Cook Strait Stock**

Stock Status	
Year of Most Recent Assessment	2007
Assessment Runs Presented	A base case and four sensitivity model runs.
Reference Points	Management Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	B_{2007} was estimated to be 47% B_0; Likely (> 60%) to be at or above the target
Status in relation to Limits	B_{2007} is Very Unlikely (< 10%) to be below the Soft Limit and Exceptionally Unlikely (< 1%) to be below the Hard Limit.
Historical Stock Status Trajectory and Current Status	





Trajectory over time of spawning biomass (absolute, and %B_0, with 95% credible intervals shown as broken lines) for the Cook Strait ling stock from the start of the assessment period in 1972 to the most recent assessment in 2007. Years on the x-axis are fishing year with "1995" representing the 1994–95 fishing year. Biomass estimates are based on MCMC results.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Median estimates of biomass are unlikely to have been below 45% B_0 (in the year 2007). Biomass is estimated to have been declining since 2002.
Recent Trend in Fishing Mortality or Proxy	Fishing pressure is estimated to have been relatively constant since the mid 1990s.
Other Abundance Indices	–
Trends in Other Relevant Indicators or Variables	Recruitment from 1995 to 2001 was low relative to the long-term average for this stock. There are no estimates for the more recent year classes.

Projections and Prognosis (2007)	
Stock Projections or Prognosis	Stock status is predicted to continue declining, but at a decreasing rate, over the next 5 years at a catch level equivalent to that since 2000 (i.e., 500 t per year).
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Very Unlikely (< 10%) Hard Limit: Very Unlikely (< 10%)

Assessment Methodology	
Assessment Type	Level 1 – Quantitative stock assessment
Assessment Method	Age-structured CASAL model with Bayesian estimation of

	posterior distributions.	
Main data inputs	- Proportions-at-age data from the commercial fisheries. - Trawl fishery CPUE series (annual indices since 1990, but split into two series between 1993 and 1994). - Estimates of biological parameters.	
Period of Assessment	Latest assessment: 2007	Next assessment: 2010
Changes to Model Structure and Assumptions	No significant changes since the previous assessment.	
Major Sources of Uncertainty	There are no fishery-independent indices of relative abundance. Line and trawl CPUE series are available, but exhibit conflicting trends. (The trawl series is probably more reliable, but early and recent parts of this series may not be comparable.) The stock structure of Cook Strait ling is uncertain. While ling in this area are almost certainly biologically distinct from the WCSI and Chatham Rise stocks, their association with ling off the lower east coast of the North Island is unknown. The catch-at-age data used to estimate the line fishery selectivity ogives are from the autoline sector of this fishery only. All the line catch before 1998, and about half of the line catch since then, has been taken by smaller 'hand-baiting' vessels that often fish in areas different to the autoliners. No catch-at-age data are available from the 'hand-baiting' fishery, so it is not known if the selectivity of the fishery differs from the autoline selectivity used in the asssessment. The model is moderately sensitive to small changes in *M*.	

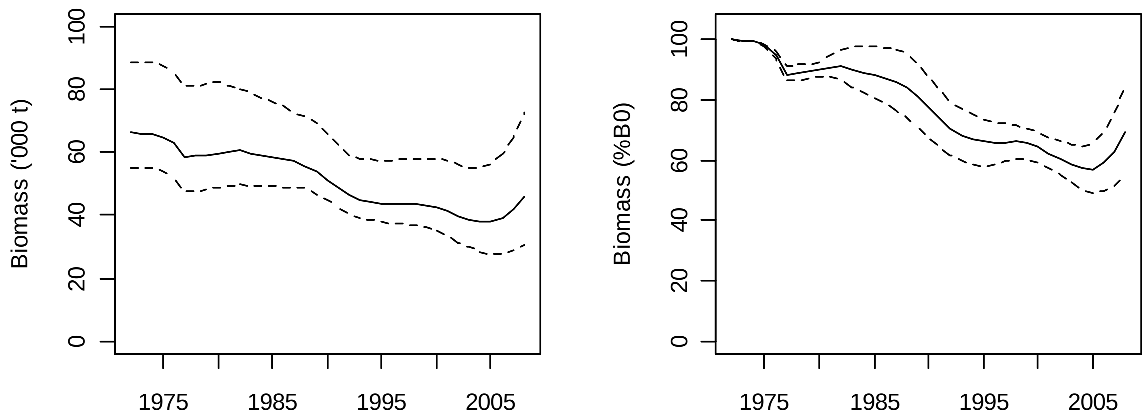
Qualifying Comments
This assessment is very unreliable, but it is probable that stock size is declining. There is no separate TACC for this stock; it comprises parts of Fishstocks LIN 7 and LIN 2.

Fishery Interactions
Ling are often taken as a bycatch in hoki target trawl fisheries. Target line fisheries for ling have the main bycatch species of spiny dogfish, sea perch, sharks and skates and ribaldo. Bycatch species of concern include sharks, skates, fur seals and seabirds (trawl fisheries), and sharks, skates and seabirds (longline fisheries).

- **West coast South Island Stock**

Stock Status	
Year of Most Recent Assessment	2008
Assessment Runs Presented	A base case and four sensitivity model runs.
Reference Points	Management Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	B_{2008} was estimated to be about 69% B_0; Very Likely (> 90%) to be at or above the target
Status in relation to Limits	B_{2008} is Very Unlikely (< 10%) to be below the Soft Limit and Exceptionally Unlikely (< 1%) to be below the Hard Limit.

Historical Stock Status Trajectory and Current Status



Trajectory over time of spawning biomass (absolute, and %B_0, with 95% credible intervals shown as broken lines) for the WCSI ling stock from the start of the assessment period in 1972 to the most recent assessment in 2008. Years on the x-axis are fishing year with "1995" representing the 1994–95 fishing year. Biomass estimates are based on MCMC results.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Median estimates of biomass are unlikely to have been below 56% B_0 (in the year 2005). Biomass is estimated to have been increasing since 2005.
Recent Trend in Fishing Mortality or Proxy	Fishing pressure is estimated to have been relatively constant, but quite low, since the mid 1990s.
Other Abundance Indices	Series of CPUE indices are available from the line (target) and trawl (bycatch) fisheries, but neither is considered reliable.
Trends in Other Relevant Indicators or Variables	Recruitment throughout the 1990s is estimated to be lower than the long-term average for this stock, but recent recruitment is higher than average (2000–2003).

Projections and Prognosis (2008)	
Stock Projections or Prognosis	No projections were reported in the Plenary document, but all tested models predicted an improvement in stock status over the next 5 years at a catch level equivalent to the TACC.
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Very Unlikely (< 10%) Hard Limit: Very Unlikely (< 10%)

Assessment Methodology		
Assessment Type	Level 1 – Quantitative stock assessment	
Assessment Method	Age-structured CASAL model with Bayesian estimation of posterior distributions.	
Main data inputs	- Proportions-at-age data from the commercial fisheries. - Estimates of biological parameters.	
Period of Assessment	Latest assessment: 2008	Next assessment: Unknown
Changes to Model Structure and Assumptions	No significant changes since the previous assessment.	
Major Sources of Uncertainty	There are no reliable relative abundance series for this stock. Consequently, the model relies on changes in the catch-at-age data to determine the fishing mortality rates for the stock, and estimate past and current biomass. Although the catch history used in the assessment has been corrected for some misreported catch (see section 1.4), it is possible that additional misreporting exists. It is assumed in the assessment models that natural mortality is constant over all ages.	

Qualifying Comments
All model runs produced quite similar estimates of stock status (i.e., B_{2008} = 43–69% B_0). However, owing to the lack of a reliable abundance series this assessment is very uncertain, but it is probable that B_{2008} is greater than 40% B_0, and it could be much higher. The relatively constant catch history since 1989 and the relative constancy of the trawl catch-at-age distributions since 1991 suggest that future catches at the current level can be maintained without causing the stock size to decline. The assessment did not include ling from the Cook Strait section of Fishstock LIN 7, which produces about 5% of the LIN 7 landings.

Fishery Interactions
Ling are often taken as a bycatch in hoki target trawl fisheries. Target line fisheries for ling have the main bycatch species of spiny dogfish, sea perch, sharks and skates and ribaldo. Bycatch species of concern include sharks, skates, fur seals and seabirds (trawl fisheries), and sharks, skates and seabirds (longline fisheries).

Table 17: Summary of yields (t), TACCs (t), and reported landings (t) for the most recent fishing year. Where a range of yield estimates has been presented above, the minimum yield is listed here.

Fishstock	QMA		MCY#	CAY	TACC	Landings
LIN 1	Auckland	1 & 9	101	–	400	320
LIN 2	Central (East)	2	394	–	982	634
LIN 3	South-East (Coast)	3	(	(	2 060	1 751
LIN 4	South-East (Chatham Rise)	4	4 950	9 460 (	4 200	2 000
LIN 5	Southland	5	(	(	3 595	3 009
LIN 6§	Sub-Antarctic	6	14 880 (	45 370 (	8 505	3 199
LIN 7	Challenger, Central (West)	7 & 8	–	–	2 225	2 198
LIN 10	Kernadec	10	–	–	10	0
Total					21 997	13 113

\# Based on cY_{av} for LIN 1 & 2, and CASAL estimates for LIN 3 & 4, 5 & 6, and 7.
§ MCY and CAY include ling stock on the Bounty Plateau.

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