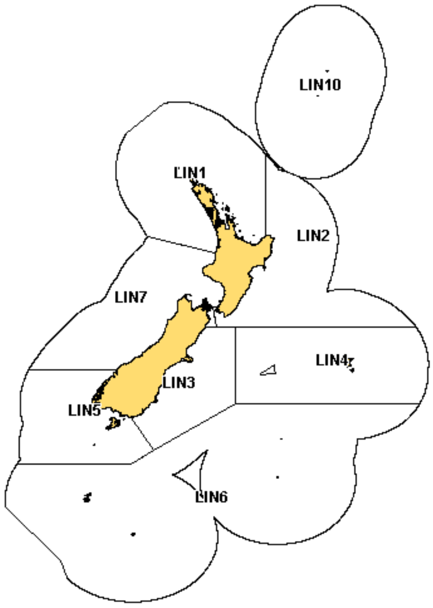
(LIN)

(*Genypterus blacodes*)



1. FISHERY SUMMARY

(a) 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. Landings in 2005–06 were close to the TACC in Fishstock LIN 5, above the TACC in LIN 7, but under-caught in LIN 1, 2, 3, 5, and 6. Landings in LIN 4 and 6 were less than half the TACCs. The TACC overrun in LIN 7 continues a trend apparent since 1988–89. Total landings in 2005–06 were lower than in all years since 1990–91. Reported landings by nation from 1975 to 1987–88 are shown in Table 1, and reported landings by Fishstock from 1983–84 to 2005–06 are shown in Table 2.

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 3595 t and 8505 t, respectively.

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.

				Foreign Licensed					
	New Zealand			Longline	Trawl				Grand
Fishing Year	Domestic	Chartered	Total	(Japan + Korea)	Japan	Korea	USSR	Total	Total
1975*	486	0	486	9269	2180	0	0	11 499	11 935
1976*	447	0	447	19 381	5108	0	1300	25 789	26 236
1977*	549	0	549	28 633	5014	200	700	34 547	35 096
1978–79#	657 *	24	681	8904	3151	133	452	12 640	13 321
1979–80#	915 *	2598	3 513	3501	3856	226	245	7828	11 341
1980–81#	1 028 *	–	–	–	–	–	–	–	–
1981–82#	1 581 *	2423	4 004	0	2087	56	247	2391	6395
1982–83#	2 135 *	2501	4 636	0	1256	27	40	1322	5958
1983†	2 695 *	1523	4 218	0	982	33	48	1063	5281
1983–84§	2 705	2500	5 205	0	2145	173	174	2491	7696
1984–85§	2 646	2166	4 812	0	1934	77	130	2141	6953
1985–86§	2 126	2948	5 074	0	2050	48	33	2131	7205
1986–87§	2 469	3177	5 646	0	1261	13	21	1294	6940
1987–88§	2 212	5030	7 242	0	624	27	8	659	7901

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

(b) 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.

(c) Maori customary fisheries

Quantitative information on the level of Maori customary 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.

(d) 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 Fishstock 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). It is also likely that some catch from LIN 5 has been reported as being taken from LIN 6.

(e) 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 2005–06 and actual TACCs (t) from 1986–87 to 2005–06. 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.

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	–	1306	–	352	–	2605	–
1984–85*	94	–	391	–	1067	–	356	–	1824	–
1985–86*	88	–	316	–	1243	–	280	–	2089	–
1986–87#	77	200	254	910	1311	1850	465	4300	1859	2500
1987–88#	68	237	124	918	1562	1909	280	4400	2213	2506
1988–89#	216	237	570	955	1665	1917	232	4400	2375	2506
1989–90#	121	265	736	977	1876	2137	587	4401	2277	2706
1990–91#	210	265	951	977	2419	2160	2372	4401	2285	2706
1991–92#	241	265	818	977	2430	2160	4716	4401	3863	2706
1992–93#	253	265	944	980	2246	2162	4100	4401	2546	2706
1993–94#	241	265	779	980	2171	2167	3920	4401	2460	2706
1994–95#	261	265	848	980	2679	2810	5072	5720	2557	3001
1995–96#	245	265	1042	980	2956	2810	4632	5720	3137	3001
1996–97#	313	265	1187	982	2963	2810	4087	5720	3438	3001
1997–98#	303	265	1032	982	2916	2810	5215	5720	3321	3001
1998–99#	208	265	1070	982	2706	2810	4642	5720	2937	3001
1999–00#	313	265	983	982	2799	2810	4402	5720	3136	3001
2000–01#	296	265	1105	982	2330	2060	3861	4200	3430	3001
2001–02#	303	265	1034	982	2164	2060	3602	4200	3294	3001
2002–03#	246	400	996	982	2528	2060	2997	4200	2936	3001
2003–04#	249	400	1044	982	1990	2060	2617	4200	2899	3001
2004–05#	283	400	936	982	1597	2060	2758	4200	3584	3595
2005–06#	364	400	780	982	1710	2060	1769	4200	3522	3595

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	–	1552	–	–	0	–	7696	–
1984–85*	1283	–	1705	–	–	0	–	6953	–
1985–86*	1489	–	1458	–	–	0	–	7205	–
1986–87#	956	7000	1851	–	1960	0	10	6940	18 730
1987–88#	1710	7000	1853	1777	2008	0	10	7901	18 988
1988–89#	340	7000	2956	2844	2150	0	10	8404	19 175
1989–90#	935	7000	2452	3171	2176	0	10	9028	19 672
1990–91#	2738	7000	2531	3149	2192	<1	10	13 506	19 711
1991–92#	3459	7000	2251	2728	2192	0	10	17 778	19 711
1992–93#	6501	7000	2475	2817	2212	<1	10	19 065	19 737
1993–94#	4249	7000	2142	–	2213	0	10	15 961	19 741
1994–95#	5477	7100	2946	–	2225	0	10	19 841	22 111
1995–96#	6314	7100	3102	–	2225	0	10	21 428	22 111
1996–97#	7510	7100	3024	–	2225	0	10	22 522	22 113
1997–98#	7331	7100	3027	–	2225	0	10	23 145	22 113
1998–99#	6112	7100	3345	–	2225	0	10	21 034	22 113
1999–00#	6707	7100	3274	–	2225	0	10	21 615	22 113
2000–01#	6177	7100	3352	–	2225	0	10	20 552	19 843
2001–02#	5945	7100	3219	–	2225	0	10	19 561	19 843
2002–03#	6283	7100	2917	–	2225	0	10	18 903	19 978
2003–04#	7032	7100	2927	–	2225	0	10	18 760	19 978
2004–05#	5506	8505	2522	–	2225	0	10	17 189	21 977
2005–06#	3553	8505	2479	–	2225	0	10	14 182	21 977

* FSU data.
# QMS 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. A growth study of ling from five areas (west coast South Island, Chatham Rise, Bounty Plateau, Campbell Plateau, and 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.

M was 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 from the Chatham Rise and Campbell Plateau was 0.18 (range = 0.17–0.20). A likely minimum value of M = 0.15 was calculated using a maximum age of 30 years. Less than 0.2% of successfully aged ling have been older than 30 years.

Ling in spawning condition have been reported in a number of localities throughout the EEZ. 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. 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 (2006b). See Section 3 for definitions of Fishstocks.

Fishstock	Estimate
1. Natural mortality (M)	
All (both sexes)	M = 0.18

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

	Female		Male		Area
	a	***b***	***a***	***b***	
LIN 3&4	0.001140	3.318	0.001000	3.354	Chatham Rise
LIN 5&6	0.001280	3.303	0.002080	3.190	Southern Plateau
LIN 6B	0.001140	3.318	0.001000	3.354	Bounty Plateau
LIN 7WC	0.000934	3.368	0.001146	3.318	West Coast S.I.
LIN 7CK	0.000934	3.368	0.001146	3.318	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.
LIN 7CK	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, 2005b) 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 (LIN 7WC), Chatham Rise (LIN 3&4), Cook Strait (LIN 7CK), Bounty Plateau (LIN 6B), and the Southern Plateau (including the Stewart-Snares shelf and Puysegur Bank) (LIN 5&6). 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

Stock assessments for two ling stocks (Bounty Plateau and Cook Strait) were updated in 2006. The Cook Strait assessment had a number of shortfalls (discussed later) and therefore the estimates of biomass and stock status are not presented here. The assessment of the Bounty Plateau (LIN 6B, that part of FMA 6 east of 176° E) was updated using a Bayesian stock model implemented using the general-purpose stock assessment program CASAL v2.09 (Bull et al., 2005). 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_{2006}) biomass were obtained. Year class strengths and fishing selectivity ogives were also estimated in the model. The line fishery selectivity was fitted as a logistic ogive. There are no fishery-independent abundance indices for the stock, but catch at age and catch at length are included. Assessments for other stocks (LIN 3&4, Chatham Rise; LIN 5&6, Campbell Plateau and Puysegur; and LIN 7WC, WCSI) are not updated here.

MCMC chains were constructed using a burn-in length of 5×10^5 iterations, with every 1000^{th} sample taken from the next 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 for either stock, but for the LIN 7CK stock some estimates of selectivity parameters and YCS showed evidence of lack of convergence.

For LIN 6B, model input data include catch histories, line fishery CPUE, catch-at-age and catch-at-length from the line fishery, and estimates of biological parameters. In the absence of sufficient stock-specific data, maturity ogives were assumed to be the same as for LIN 3&4, a stock with comparable growth parameters to LIN 6B. Only a base case model run is presented. The stock assessment model partitions the population into two sexes, and age groups 3 to 35 with a plus group. There is one fishery (longline) in the stock. The model's annual cycle is described in Table 4.

For LIN 7CK, model input data include catch histories, trawl and line fishery CPUE, catch-at-age data from the trawl fishery, catch-at-age and catch-at-length from the line fishery, and estimates of biological parameters. In the absence of sufficient stock-specific data, maturity ogives were assumed to be the same as for LIN 7WC, a stock with comparable growth parameters to LIN 7CK. The stock assessment model partitions the population into two sexes, and age groups 3 to 20 with a plus group. There are two fisheries (trawl and longline) in the stock. The model's annual cycle is described in Table 4.

Table 4: Annual cycle of the assessment models, showing the processes taking place at each time step, their sequence within each time step, and the available observations of relative abundance. 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 (%*M*) that is assumed to have taken place when each observation is made (see Table 5 for descriptions of the observations).

Step	Approx. months	Processes	*M* fraction	Age fraction	Observations: Description	%*M*
LIN 6B						
1	Dec-Sep	recruitment	0.9	0.5	Line CPUE	0.5
		fishery (line)			Line catch-at-age/length	0.5
2	Jul-Sep	increment ages	0.1	0.0	–	
LIN 7CK						
1	Oct–May	recruitment	0.67	0.5	Line CPUE	0.5
		fishery (line)			Line catch-at-age/length	0.5
2	Jul-Sep	increment ages	0.33	0.0	Trawl CPUE	0.5
		fishery (trawl)			Trawl catch-at-age	0.5

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 base case model (see Table 5) and fixed in all subsequent runs.

Table 5: Summary of the relative abundance series applied in the models, including source years (Years), and the estimated process error (CV) added to the observation error.

Data series	Years	Process error
LIN 6B		
CPUE (longline, all year)	1992–2004	0.15
Commercial longline length-frequency (Nov–Feb)	1996, 2000–04	0.5
Commercial longline proportion-at-age (Dec–Feb)	2000–01, 2004	0.4
LIN 7CK		
CPUE (hoki trawl, all year)	1990–2005	0.2
CPUE (longline, all year)	1990–2005	0.2
Commercial trawl proportion-at-age (May–Sep)	1999–2005	0.1
Commercial longline proportion-at-age (May–Sep)	2001, 2003	0.1
Commercial longline length-frequency (May–Sep)	2002, 2004, 2006	0.1

The assumed prior distributions used in the assessment are given in Table 6. All priors were intended to be relatively uninformed, and were estimated with wide bounds.

Table 6: Assumed prior distributions and bounds for estimated parameters for the assessments. The parameters are mean (in log space) and CV for lognormal.

Parameter description	Distribution	Parameters		Bounds	
B_0 (LIN 6B)	uniform-log	–	–	5000	100 000
B_0 (LIN 7CK)	uniform-log	–	–	2000	60 000
Year class strengths	lognormal	1.0	0.7	0.01	100
CPUE *q*	uniform-log	–	–	1e-8	1e-3
Selectivities	uniform	–	–	0	20–200
Process error CV	uniform-log	–	–	0.001	2

* A range of maximum values were 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.

(a) Estimates of fishery parameters and abundance

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

Table 7: Estimated catch history (t) for LIN 6B and LIN 7CK. Landings have been separated by fishing method (trawl or line).

Year	LIN 6B	LIN 7CK		Year	LIN 6B	LIN 7CK	
	line	trawl	line		line	trawl	line
1972	0	0	0	1990	11	362	121
1973	0	45	45	1991	172	488	163
1974	0	45	45	1992	1 430	498	85
1975	0	48	48	1993	1 575	307	114
1976	0	58	58	1994	875	269	84
1977	0	68	68	1995	387	344	70
1978	10	78	78	1996	588	392	35
1979	0	83	83	1997	333	417	89
1980	0	88	88	1998	569	366	88
1981	10	98	98	1999	771	316	216
1982	0	103	103	2000	1 319	317	131
1983	10	97	97	2001	1 153	258	80
1984	6	119	119	2002	623	230	171
1985	2	116	116	2003	932	280	180
1986	0	126	126	2004	860	241	227
1987	0	97	97	2005	50	200	282
1988	0	107	107	2006*	400	220	280
1989	9	255	85				

* Estimated catch

Table 8: Input parameters for the models.

Parameter	LIN 6B	LIN 7CK
Stock-recruitment steepness	0.9	0.9
Recruitment variability CV	1.0	0.7
Ageing error CV	0.05	0.07
Proportion male at birth	0.5	0.5
Proportion spawning	1.0	1.0
Spawning season length	0	0
Maximum exploitation rate (U_{max})	0.6	0.6

Maturity ogives*

Age	3	4	5	6	7	8	9	10	11	12	13	14	15
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 7CK													
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

Estimates of relative abundance from trawl surveys (Table 9) and standardised analyses of CPUE (Table 10) are presented below. No trawl survey indices or other fishery-independent series are available for the LIN 6B or LIN 7CK stocks. CPUE series were available for both stocks; a line fishery series for LIN 6B, and both trawl and line series for LIN 7CK. However, the LIN 7CK trawl and line CPUE series exhibit conflicting trends in recent years. The trawl series from the hoki target fishery is believed to provide the more reliable index of abundance series because it is derived from a data rich fishery with relatively constant behaviour, reasonably accurate tow-by-tow catch records, and with little incentive to target or avoid ling. The line fishery series is data poor in some years, and, because it uses data from target ling sets only, may be biased owing to the reported target species being determined after the catch is onboard.

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

Fishstock	Area	Vessel	Trip code	Date	Biomass	CV (%)
LIN 3 & 4	Chatham Rise	*Tangaroa*	TAN9106	Jan-Feb 1992	8930	5.8
			TAN9212	Jan-Feb 1993	9360	7.9
			TAN9401	Jan 1994	10 130	6.5
			TAN9501	Jan 1995	7360	7.9
			TAN9601	Jan 1996	8420	8.2
			TAN9701	Jan 1997	8540	9.8
			TAN9801	Jan 1998	7310	8.0
			TAN9901	Jan 1999	10 310	16.1
			TAN0001	Jan 2000	8350	7.8
			TAN0101	Jan 2001	9350	7.5
			TAN0201	Jan 2002	9440	7.8
			TAN0301	Jan 2003	7260	9.9
			TAN0401	Jan 2004	8250	6.0
			TAN0501	Jan 2005	8930	9.4
			TAN0601	Jan 2006	9300	7.4
			TAN0701	Jan 2007	7900	7.2
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	19 660	12.0
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

Table 10: Standardised CPUE indices (with CVs) for LIN 6B and LIN 7CK. Year refers to calendar year.

	LIN 6B line		LIN 7CK trawl		LIN 7CK line	
Year	CPUE	CV	CPUE	CV	CPUE	CV
1990	–	–	2.02	0.05	0.72	0.16
1991	–	–	1.66	0.04	1.06	0.13
1992	1.79	0.12	1.46	0.04	1.05	0.11
1993	1.57	0.10	1.52	0.04	0.76	0.11
1994	1.06	0.13	0.99	0.04	0.67	0.10
1995	1.12	0.13	0.86	0.03	0.61	0.11
1996	1.04	0.11	0.84	0.03	0.74	0.13
1997	0.84	0.13	0.72	0.03	0.96	0.18
1998	1.03	0.12	0.74	0.03	0.67	0.15
1999	1.04	0.11	0.73	0.03	1.24	0.20
2000	0.95	0.09	0.83	0.03	1.41	0.19
2001	0.81	0.10	0.93	0.03	1.31	0.21
2002	0.73	0.09	0.97	0.04	1.77	0.12
2003	0.78	0.09	1.02	0.03	1.50	0.11
2004	0.73	0.15	0.81	0.03	1.27	0.11
2005	–	–	0.77	0.04	1.08	0.12

Posterior distributions of year class strength estimates from the base case model runs for both stocks are shown in Figure 1; distributions from the other LIN 7CK model runs differed little from the base case example.

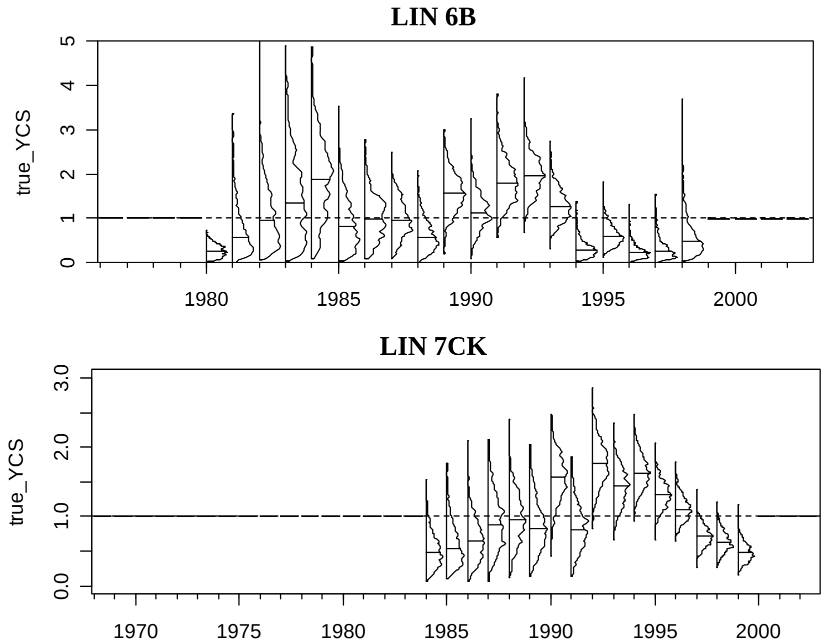


Figure 1: Estimated posterior distributions of year class strength from the LIN 6B and LIN 7CK base case runs. The horizontal line indicates a year class strength of one. Individual distributions show the marginal posterior distribution, with horizontal lines indicating the median.

(b) Biomass estimates

LIN 6B

Only a base case model run was completed. The assessment was driven largely by the catch-at-age and catch-at-length series from the line fishery; the first two years of CPUE data were not well fitted. Biomass estimates are listed in Table 11 and the biomass trajectory is shown in Figure 2. The assessment indicates a declining biomass throughout the history of the fishery. Estimates of current and virgin stock size are not well known, but current biomass is very likely to be above 50% of B_0.

Table 11: Bayesian median and 95% credible intervals (in parentheses) of B_0 and B_{2006} (in t), and B_{2006} as a percentage of B_0 for all model runs for LIN 6B.

Model run	B_0		B_{2006}		B_{2006} (% B_0)	
LIN 6B						
Base case	13 570	(10 850–19 030)	8 330	(4 860–14 730)	61	(45–79)

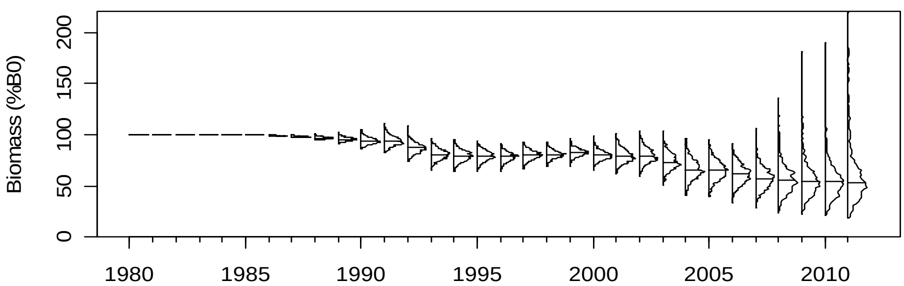


Figure 2: Estimated posterior distributions of biomass trajectories as a percentage of B_0, from the base case model run for LIN 6B (including 5-year projections through to 2011 with assumed constant annual catch of 400 t). Distributions are the marginal posterior distribution, with horizontal lines indicating the median.

LIN 7CK

Descriptions of the six model runs completed are as follows.

- Base case — catch history, catch-at-age data from the trawl fishery, catch-at-age and catch-at-length data from the line fishery, and the trawl CPUE series.
- Trawl & line CPUE — the base case model, but including line CPUE series.
- Line CPUE — the base case model, but including line CPUE series instead of the trawl series.
- No CPUE — the base case model, but excluding the trawl CPUE series.
- Differential *M* — the base case model, but setting *M* at 0.19 for males and 0.17 for females (cf. *M* of 0.18 for both sexes).
- Logistic trawl selectivity — the base case model, but estimating the trawl fishing selectivity ogives as logistic curves rather than double normal.

The results from all the runs are driven by the trawl and line fishery catch-at-age and catch-at-length data, which contain information indicative of a stock decline from the late 1980s to 1999, a brief period of rebuilding to 2003, and a subsequent decline. All biomass trajectories tracked downwards from 1972 to 1989 (reducing biomass by about 20%) even though extractions are believed to have been only 100–200 t annually. The trawl CPUE series is fitted well in the model runs where it is the only relative abundance series. In contrast, the line CPUE series is always poorly fitted, and when modeled with the trawl CPUE series it causes that series to also be poorly fitted. For the reasons given earlier (section 4a) the Cook Strait trawl CPUE is believed to be a more reliable relative abundance series than the line CPUE.

When fitting trawl selectivity as double-normal ogives, the selectivity for both sexes tended to peak at about ages 15–19, whereas line selectivity ogives, fitted as logistic functions, produced full selectivity at ages 13–17. It is unusual for age at full selectivity in a line fishery to be less than age at full selectivity in a trawl fishery in the same area. A model run where trawl fishery ogives were estimated as logistic curves was conducted to see whether this would produce ages at full selectivity that were lower than those for the line fishery. It did not, so the “aberrant” selectivity ogives for fisheries in Cook Strait are not explained.

It was assumed in all but the ‘Differential *M*’ model run that *M* is 0.18 y^{-1} for both sexes, as used in recent assessments of other ling stocks. However, as for most teleosts, the true value for males is likely to be slightly higher than for females. A model run (‘Differential *M*’) where *M* was set at 0.19 for males and 0.17 for females produced markedly different results to the ‘Base case’. Selectivity of males became much higher relative to females, and the estimates of virgin and current biomass were about 30% and 60% higher, respectively, than in the base case run. This model run brought into question the robustness of any of the model runs and therefore no biomass estimates from this assessment are presented here. Similar behaviour has not been observed in other ling stocks when small changes in M are tested.

In summary, the LIN 7CK assessment has several shortfalls. First, there are no fishery-independent indices of relative abundance. Second, the two CPUE series exhibit conflicting trends, although as noted above the trawl series is probably the more reliable of the two. Third, the stock structure of Cook Strait ling is uncertain. While ling in this area are almost certainly biologically distinct from the west coast South Island and Chatham Rise stocks their association with ling off the lower east coast of the North Island is unknown. Fourth, the catch-at-length and 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 length-frequency data are available from the ‘hand-baiting’ fishery, so it is not known if its catch composition differs from the autoline catch. Fifth, the age-length keys used to convert the autoline catch-at-length into catch-at-age were derived from the trawl fishery, necessitating the assumption that mean age-at-length is the same in both the trawl and line fisheries. And finally (and most worrying from a modelling perspective), the model is extremely sensitive to small changes in *M.*

(c) 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 (LIN 7CK, parts of LIN 2 and LIN 7) was completed in 2006, but estimates of B_0 and current biomass were not considered reliable, so no yield estimates are reported. About 75% of the Cook Strait landings are from Fishstock LIN 2, 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 2004 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 2003 assessment. B_0 is poorly known, but the yield estimate derived from the 'summer survey *q* = 0.3' run is a likely minimum for this stock.

An estimate of MCY for the Bounty Plateau stock (LIN 6B) was derived from the 2006 CASAL stock 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)

Estimates of MCY for LIN 7WC are presented from several CASAL runs, but they are based on assessments that are very uncertain. They were derived from the 2005 assessment.

Table 12: Estimates of B_{MCY} and MCY from base case and sensitivity model runs. The year of the most recent assessment for each stock is given in parentheses.

Fishstock	Model run	B_{MCY} (t)	MCY (t)	B_{MCY} (% of B_0)	MCY (% of B_0)
LIN 5&6 (2003)	Base case	211 700	26 400	49.3	6.1
	Summer *q* = 0.1	120 200	18 700	43.4	6.7
	Summer *q* = 0.2	74 900	12 300	41.9	6.9
	Summer *q* = 0.3	62 800	10 600	41.2	7.0
LIN 3&4 (2004)	Base case	55 740	9 180	36.6	6.0
	M estimation	53 650	9 660	36.6	6.6
	Length-based selectivity	41 410	8 290	31.4	6.3
	No CPUE	58 350	9 050	38.5	6.0
LIN 6B (2006)	Base case	7 520	720	55.4	5.3
LIN 7WC (2005)	TCEPR CPUE	15 490	2 360	37.6	5.7
	Observer CPUE	28 250	3 090	48.0	5.3
	Trawl & line CPUE	21 170	2 670	43.4	5.5
	Kaharoa survey	14 550	2 360	35.8	5.8
	No CPUE	13 430	2 100	36.9	5.8

(d) 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 base and sensitivity cases for LIN 5&6, 3&4, and 6B are given in Table 13. There are no reliable CAY estimates for any other stocks.

Table 13: CAY estimates and associated parameters for the base and sensitivity runs for LIN 5&6 (from the 2003 assessment), for LIN 3&4 (from the 2004 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 5&6						
Base case	117 600	35 300	0.23	99 800	27.3	8.2
Summer *q* = 0.10	75 900	22 800	0.23	59 600	27.3	8.2
Summer *q* = 0.20	48 700	14 600	0.23	32 200	27.3	8.2
Summer *q* = 0.30	41 500	12 500	0.23	24 800	27.3	8.2
LIN 3&4						
Base case	38 240	10 040	0.25	23 440	25.1	6.6
M estimation	38 920	10 140	0.28	26 210	26.5	6.9
Length-based selectivity	32 600	8460	0.25	18 080	24.7	6.4
No CPUE	36 090	9980	0.25	22 910	23.7	6.6
LIN 6B						
Base case	4780	940	0.18	1680	35.2	6.9

(e) Other yield estimates and stock assessment results

New projections for LIN 6B are shown in Table 14 (and are also depicted in Figure 2). The LIN 6B stock (Bounty Plateau) is likely to decline in the next 5 years, but probably will still be higher than 50% of B_0.

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_{X2006}(%) for the base case LIN 6B.

Model run	Year	Future catch (t)	B_{2011}		B_{2011} (% B_0)		B_{2011}/B_{2006} (%)	
LIN 6B								
Base case	2006	600	7460	(2950–18 520)	53	(26–116)	86	(51–168)

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. The AMP was reviewed in 2007.

Full-term Review of LIN 1 AMP in 2007

In 2007 the AMP FAWG reviewed the performance of the AMP after 4 years at the higher TACC (SeaFIC, 2007).

Fishery Characterization

- Ling catches remained slightly under the TACC up to 1995/96, but then exceeded the TAC, reaching ~300t over most of the period 1996/97 - 2001/02, prompting the AMP proposal.

- After implementation of the AMP, catches dropped back to the previous TACC level for two years, and then increased slowly to reach 364t in 2005/06, 36t under the AMP TACC.
- 54% of the QMA1 ling catch is taken by bottom trawl, and 44% in the ling bottom longline fishery, with catches by both methods mainly coming from the Bay of Plenty (statistical areas 8 to 10). There were substantial ling bycatches made by trawl on the North Island west coast from 1996/97 - 2000/01 in the gemfish fishery, and longline catches have increased from the East Northland area.
- The WG noted that there are substantial problems with the quality of LIN 1 data, and that this is one of the worst data sets analysed under the AMPs. Catches are substantially under-reported compared to landings, with large landings declared in apparently incorrect areas (statistical areas possibly instead of QMA). Individual trips appear to circumnavigate the entire North Island, and a substantial proportion of some catches are retained on board, and so are excluded from the analyses.
- The trawl fishery spans much of the year, with some emphasis from 1996 on fishing in late winter/spring from June to December. The longline fishery is strongly seasonal, taking much of its catch in spring from Aug - Oct each year.
- There is a small targeted ling trawl fishery, and trawl catches of LIN 1 are mainly made in the scampi and gemfish fisheries. The gemfish fishery mainly contributed catches from 1996/97 - 2000/01, with the scampi fishery dominating before and after that.
- In contrast, ~75% of the ling longline catch is taken in the targeted longline fishery, with only minor bycatches coming from the bluenose, ribaldo and hapuka targeted longline fisheries.
- Depth distribution of ling catches in the trawl fisheries shows two main depths associated with specific fisheries. Most ling are caught in the scampi / hoki / ling fishery at ~400 m depth, but some are taken in the tarakihi / snapper / barracouta / trevally fisheries around 100 m depth.

CPUE Analysis

- The diverse nature and broad geographic range of the LIN 1 fisheries has 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 relative paucity of data.
- Two fishery definitions were explored this year as candidates for LIN 1 standardised indices: the scampi-targeted bottom trawl fishery in the Bay of Plenty (BT (SCI) and the ling targeted bottom longline fishery from the east North Island to Bay of Plenty (BLL (LIN).
- CPUEs for these fishery definitions were standardised using a lognormal model based on non-zero catches. In additional, a binomial model was used to investigate the effect of changing proportion of non-zero catches.
- The two standardised indices show conflicting trends. The BLL index appears to show two periods of gently declining CPUE from 1990/91 - 1996/97 and 1999/00 - 2005/06, but separated by a strong, highly uncertain and likely anomalous peak in 1998/99. In contrast, the BT index appears to be stable until 1997/98, rises to a peak in 2000/01 and then declines slowly back to about the previous level by 2005/06.
- The two indices appear to agree to some extent on a gradual decline since 2000/01, and perhaps on a period of stability around the mid 1990s, but the WG was concerned that the substantial and apparently anomalous peak in BLL indicated that this series is not reliable.
- The WG noted that BLL reporting rates greatly exceed landed catch weights, reaching 700% in 1998/99. The high CPUE peak in the BLL index in 1998/99 also appeared to result from one high landing in one month, suggesting that this might have been a discharge of a large amount of catch retained on board. Although 43% of landings do not have catch estimates, the WG concluded that landed catch should not be used, and that the BLL CPUE analysis should be repeated using estimated catches.
- The WG also noted that many new participants have entered and left this fishery, and questioned whether analyses should focus on e.g. the one vessel that has been in the fishery throughout. The group concluded that the vessel effect needed to be investigated further.

- The WG also recognised many other problems related to possible changes in net width in the scampi fishery, and questions regarding the effectiveness of scampi nets in catching ling. However, it was unclear how this might alter trends, given the relatively sparse data.
- Following the requested re-analysis of the BLL CPUE data using estimated catches, the standardised target LIN 1 BLL CPUE index removed the big peak in 1998/99 and now shows a strong declining trend, but is based on only 700 records.

Logbook Programme

- Only one vessel has participated in the bottom trawl logbook programme implemented in 2002/03, and coverage has been very low, averaging <1% over the four years. The number of fish sampled has increased slightly from 132 to 361 fish in the last year.
- At this low coverage level, the programme has not been able to obtain representative coverage of either areas or seasons.
- Most length samples came from area 9 in the Bay of Plenty, and the length ranges differ somewhat between years, with the range in 2002/03 being smaller and that in 2003/04 being larger. Two modes are apparent in data from 2003/04 onwards, with some evidence of progression of a mode of very small fish (55 cm – 65 cm) from 2003/04 to 2005/06.
- The WG questioned whether the size of ling bycatch in the scampi fishery was at all useful to assessing the state of the stock, and recommended that efforts focus on sampling the target ling fishery.

Effects of Fishing

- There is a specific problem with seabird bycatches in the bottom longline fisheries. Previous studies (McKenzie & Fletcher, unpub. 2006) on seabird captures in commercial trawl and longline fisheries from 1997/98 - 2003/02 concluded that 5% of seabirds killed in New Zealand waters were caught by small bottom longline vessels in FMAs 1 and 2.
- Observer coverage of the LIN 1 fisheries has never been adequate to provide reliable estimates of seabird interactions. We are also still awaiting publication of the DOC report on past observer evaluation of seabird catches.
- Following identification of the ling fishery in the seabird NPOA as a fishery with known seabird interactions, the industry has implemented a Code of Practice specifically for the ling longline fishery. This code includes use of tori lines, restrictions on offal discharge, thawing of bait and minimisation of lights when setting at night.
- The draft observer plan for 2007/08 has a target of 20% coverage (251 observer days) of the inshore ling, bluenose and hapuku fisheries in FMAs 1, 3, 5 and 7. The target for inshore trawl is 10% (258 days), and it was recently proposed that this be increased to 400 days.
- The WG noted that actual catch increases under the AMP were small, and had probably had little effect on the extent or magnitude of impacts. In fact, ling bycatch in the scampi and gemfish trawl fisheries has decreased.
- The WG noted that it is not possible to generating adequate maps of fishing effort to evaluate changes in area of impact, as most data are provided on CELR returns which do not provide fine-scale positional information.
- The WG emphasized the need to improve fishing position reporting, particularly in bottom trawl and longline fisheries, to enable the production of accurate maps of fishing effort distribution, and how this may have changed over time.

Conclusions

- The WG agreed with previous observations that CPUE data for the various ling fisheries do not appear to provide any reliable index of ling abundance. Indices remain highly variable and uncertain, with very limited ling catch data available for each series.
- Efforts to resolve problems using landed catches did seem to improve performance of the longline CPUE index. However, use of estimated catches further reduced the already limited data, further increasing uncertainty around these indices.

- Both indices investigated showed similarly declining CPUE over the past 5 years, which may be of concern. However, the paucity of data and high uncertainty results in low confidence in the CPUE trends in general.
- Re-analysis of CPUE data for the targeted ling longline fishery removed the big peak 1998/99 seen in the analysis of landings data. The standardised longline CPUE now shows a strong declining trend, but is based on only 700 records.

AMP review Checklist

1. The potential CPUE indices explored to date for the LIN 1 fishery do not appear to be adequately robust or reliable to serve as indicators of abundance. Data on actual ling catches in the many fisheries that catch ling are sparse. There are substantial problems with data quality related to under-reporting of catch, reporting against incorrect areas and retaining catch on board for later landing. Further work is needed to ascertain whether any of the ling fisheries can provide a reliable CPUE-based index of abundance.
2. Logbook coverage is inadequate in terms of coverage of fisheries, catch and effort, areas and seasons.
3. The WG suggested the following additional analyses:
   - In future it would be useful to analyse the ratio of ling catches to other target species to explore e.g. whether ling bycatches increased due to increased gemfish catches, or an actual increase in ling targeting / abundance. However, it was noted that this would be a substantial analysis.
   - Historic information on the size-frequency of ling in the scampi fishery should be summarised and tabled.
4. Given the high levels of uncertainty and variability in the two CPUE series explored, the WG was not able to draw any conclusions regarding whether current catches might be sustainable or not. Recent declines in both standardised CPUE indices investigated are of concern, but it is not clear to what extent these might reflect abundance declines.
5. The state of the stock in relation to B_{MSY} is unknown.
6. Effects of fishing are not adequately monitored.
7. Rates of non-fish bycatch were not reported.
8. This AMP does not need to be reviewed by the Plenary.

6. STATUS OF THE STOCKS

Since the 2006 Plenary report was published, new stock assessments have been produced for the Bounty Plateau (LIN 6B) and Cook Strait (LIN 7CK) biological stocks. LIN 6B comprises part of Fishstock LIN 6, and LIN 7CK is a trans-boundary stock split between Fishstocks LIN 7 and LIN 2.

LIN 1

The state of the stock in relation to B_{MSY} is unknown. In October 2002, the TACC for LIN 1 was increased to 400 t within the AMP. The biological stock affinities of ling in LIN 1 are unknown.

LIN 2

LIN 2 comprises waters off east coast North Island from East Cape to Cook Strait. The biological stock affinities of ling in LIN 2 are unknown. In recent years about 40% of the LIN 2 landings have been taken in Cook Strait (i.e., west of Cape Palliser). The model results from a Cook Strait assessment do not provide reliable estimates of B_0 or current biomass, but do suggest that the stock has declined, particularly since the late 1980s. It is not known if recent landings and the current TACC are sustainable in the long term, or are at levels which will allow the stocks to move towards a size that will support the MSY.

LIN 3 & 4

Based on the 2004 stock assessment current stock size is estimated to be above B_{MAY} and building. Catches at the level of the current TACC are likely to be sustainable.

LIN 5 & 6

Based on the 2003 assessment ling stocks LIN 5 and LIN 6 (but excluding fish on the Bounty Plateau) are probably only lightly fished and current stock sizes are estimated to be well above B_{MAY}. Estimates of absolute current and reference biomass are unreliable, although reliable minimum estimates have been reported above. It is likely that the current TACC is sustainable, as current catches do not appear to be having a measurable impact on biomass levels. The assessment is indicative of surplus ling production being available, at least in the short to medium term.

LIN 6B (Bounty Plateau)

The ling stock on the Bounty Plateau (part of the LIN 6 Fishstock) is estimated to be well above B_{MAY}. Average annual landings since the line fishery began are slightly higher than the MCY estimate. Annual extractions have never exceeded the 2006 estimate of CAY. There is no separate TACC for this stock.

LIN 7WC

The assessment did not include ling from the Cook Strait section of QMA 7, which produces about 5% of the LIN 7 landings and is believed to be a distinct biological stock. Based on the 2005 assessment the status of the LIN 7WC stock is highly uncertain. It is not known if recent landings are sustainable in the long term, or are at levels which will allow the stocks to move towards a size that will support the MSY. The stock assessment model results did not provide reliable estimates of current biomass as a percentage of B_0. The relatively constant catch history since 1989 and the relatively flat CPUE indices suggest that future catches at the current level are probably sustainable, at least in the short term.

Yield estimates, TACCs and reported landings for the 2005/06 fishing year are summarised in Table 15.

Table 15: 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	2005–06 Actual TACC	2005–06 Reported landings
LIN 1	Auckland	1 & 9	101	–	400	364
LIN 2	Central (East)	2	394	–	982	780
LIN 3	South-East (Coast)	3			2060	1710
LIN 4	South-East (Chatham Rise)	4	8290	18 080	4200	1769
LIN 5	Southland	5			3600	3522
LIN 6§	Sub-Antarctic	6	11 300	26 500	8520	3553
LIN 7†	Challenger, Central (West)	7 & 8	2100	–	2225	2479
LIN 10	Kermadec	10	–	–	10	0
Total					21 997	14 182

\# 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.
† Excludes ling stock in Cook Strait.

7. FOR FURTHER INFORMATION

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