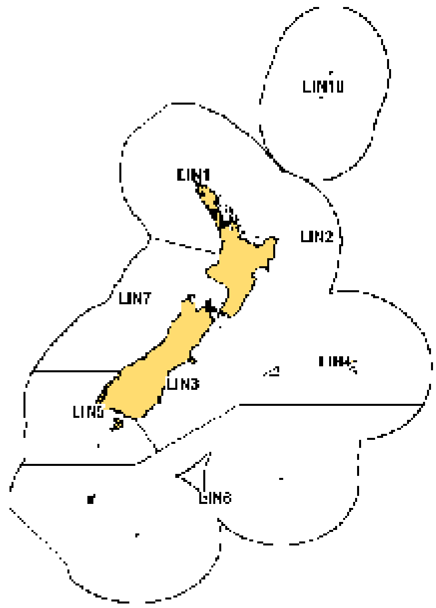
(LIN)

(*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). Since about 2000, there has been a declining trend in catches taken by line vessels in most areas.

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 2004–05 were close to the TACCs in Fishstocks LIN X, above the TACC in LIN Y, but under-caught in LIN Z. The significant TACC overrun (P%) in LIN 7 continues a trend apparent since 1988–89. Reported landings by nation from 1975 to 1987–88 are shown in Table 1, and reported landings by Fishstock from 1983–84 to 2004–05 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 3600 t and 8520 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.

	New Zealand			Foreign Licensed					
				Longline	Trawl				Grand
Fishing Year	Domestic	Chartered	Total	(Japan + Korea)	Japan	Korea	USSR	Total	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.

Table 2: Reported landings (t) of ling by Fishstock from 1983–84 to 2004–05 and actual TACCs (t) from 1986–87 to 2004–05. 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	–	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	3 294	3 001
2002–03#	246	400	996	982	2 528	2 060	2 997	4 200	2 936	3 001
2003–04#	249	400	1 044	982	1 990	2 060	2 617	4 200	2 899	3 001
2004–05#	282	400	933	982	1 596	2 060	2 757	4 200	3 584	3 600

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	2 917	–	2 225	0	10	18 903	19 978
2003–04#	7 032	7 100	2 927	–	2 225	0	10	18 760	19 978
2004–05#	5 506	8 520	2 521	–	2 225	0	10	17 179	21 997

* FSU data.
\# QMS data.
§ Includes landings from unknown areas before 1986–87, and areas outside the EEZ since 1995–96.

(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 (c.v. 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).

(e) Other sources of mortality

The extent of any other sources of mortality is unknown.

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, 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 $M = \log_e 100/\text{maximum age}$, 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). 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 & Dunn (2003).

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	0.00114	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.
LIN 7CK	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.
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, 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 assessment of the west coast South Island section of Fishstock LIN 7 (that part of QMA 7 west of Cape Farewell) has been updated using a Bayesian stock model implemented using the general-purpose stock assessment program CASAL v2.06 (Bull et al. 2004). 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_{2005}) biomass were obtained. Year class strengths and fishing selectivity ogives were also estimated in the model. Trawl selectivity ogives were fitted as double normal curves. In the absence of any length or age data from the WCSI line fishery, the line fishery selectivity ogive is assumed the same as that estimated for the Chatham Rise longline fishery. The assessment would be improved if there were data from the WCSI line fishery. Currently there is an apparent discrepancy between the trawl and line CPUE from this stock, the length and age data would allow this difference to be investigated. Assessments for other stocks (LIN 3&4, Chatham Rise; LIN 5&6, Campbell Plateau and Puysegur; LIN 6B, Bounty Plateau; and LIN 7CK, Cook Strait) are not updated here.

MCMC chains were constructed using a burn-in length of 5×10^5 iterations, with every 1000th 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, but some estimates of selectivity parameters and YCS showed evidence of lack of convergence.

Model input data include catch histories, catch-effort time series, catch-at-age from the commercial trawl fishery, estimates of abundance and catch-at-length from trawl surveys, and estimates of biological parameters. Maturity ogives were derived from gonad stage data collected during research surveys.

Five model runs are presented. The stock assessment model partitions the population into two sexes, and age groups 3 to 28 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 model for LIN 7WC, 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 that is assumed to have taken place when each observation is made (see Table 5 for descriptions of the observations).

	Approx.		*M*	Age	Observations	
Step	months	Processes	fraction	fraction	Description	propn. mort.
1	Oct-Jun	recruitment	0.8	0.5	Line CPUE	0.5
		fishery (line)			Kaharoa survey	0.5
2	Jul-Sep	increment ages	0.2	0.0	Trawl CPUE	0.5
		fishery (trawl)				

Lognormal errors, with known c.v.s, were assumed for all relative biomass, proportions-at-age, and proportions-at-length observations. The c.v.s 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 5: Summary of the relative abundance series applied in the models, including source years (Years), and the estimated process error (c.v.) added to the observation error.

Data series	Years	Process error
CPUE (longline, all year)	1990–2004	0.15
CPUE (TCEPR, hoki trawl, Jun–Sep)	1990–2004	0.15
CPUE (Observer, hoki trawl, Jun–Sep)	1986–2004	0.15
Commercial trawl proportion-at-age (Mar–Sep)	1991, 1994–2003	0.25
Trawl survey biomass (*Kaharoa*, Mar-Apr)	1992, 94, 95, 97, 2000, 03, 05	0.15
Trawl survey proportion-at-length (*Kaharoa*, Mar-Apr)	1992, 94, 95, 97, 2000, 03, 05	0.4
Trawl survey biomass (*Tangaroa*, July)	2000	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 LIN 7WC assessment. The parameters are mean (in log space) and c.v. for lognormal.

Parameter description	Stock	Distribution	Parameters		Bounds	
B_0	7WC	uniform-log	–	–	10 000	500 000
Year class strengths	7WC	lognormal	1.0	0.7	0.01	100
CPUE *q*'s	7WC	uniform-log	–	–	1e-8	1e-3
Kaharoa survey *q*	7WC	uniform-log	–	–	0.001	10
Tangaroa survey *q*	7WC	lognormal	0.16	0.8	0.01	0.4
Selectivity	7WC	uniform	–	–	0	20–200 *
Process error c.v.	7WC	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 8, and other input parameters are shown in Table 7.

Table 7: Input parameters for the LIN 7WC model.

Parameter	LIN 7WC
Stock-recruitment steepness	0.9
Recruitment variability c.v.	0.6
Ageing error c.v.	0.05
Proportion male at birth	0.5
Proportion spawning	1.0
Spawning season length	0
Maximum exploitation rate (U_{max})	0.6

Maturity ogives*

Age	3	4	5	6	7	8	9	10	11	12
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 history (t) for LIN 7WC (the west coast South Island section of LIN 7). Landings have been separated by fishing method (trawl or line).

Year	Catch		Year	Catch	
	trawl	line		trawl	line
1972	0	0	1989	1 959	370
1973	85	20	1990	2 205	399
1974	144	40	1991	2 163	364
1975	401	800	1992	1 631	661
1976	565	2 100	1993	1 609	716
1977	715	4 300	1994	1 136	860
1978	300	323	1995	1 750	1 032
1979	539	360	1996	1 838	1 121
1980	540	305	1997	1 749	1 077
1981	492	300	1998	1 887	1 021
1982	675	400	1999	2 146	1 069
1983	1 040	710	2000	2 247	923
1984	924	595	2001	2 304	977
1985	1 156	302	2002	2 250	810
1986	1 082	362	2003	1 980	807
1987	1 105	370	2004	2 013	814
1988	1 428	291	2005*	2 000	800

* Assumed catches.

Estimates of relative abundance from trawl surveys (Table 9) and standardised analyses of CPUE (Table 10) are presented below. Two trawl CPUE series were available; one was developed entirely from catch and effort data recorded by observers, the other used TCEPR data from trips where the ling bycatch was believed to have been comprehensively reported based on some thresholds developed from observer data (Horn in prep.a). The Observer series is based on relatively sparse, but presumably accurate, trawl data. The trawl and line CPUE series exhibit conflicting trends in recent years. It is uncertain which of the two fishing methods or three CPUE series provides the most reliable relative abundance series. Because very small catches of ling are often not reported in TCEPR tow-by-tow records, there is a possibility that the TCEPR CPUE indices could be biased upwards.

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	7.0
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
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 c.v.s) for the trawl and line fisheries in LIN 7WC. Year refers to calendar year.

	TCEPR trawl		Observer trawl		Line	
Year	CPUE	c.v.	CPUE	c.v.	CPUE	c.v.
1986	–	–	1.12	0.07	–	–
1987	–	–	0.60	0.05	–	–
1988	–	–	0.83	0.05	–	–
1989	–	–	1.05	0.06	–	–
1990	0.87	0.06	1.14	0.05	0.95	0.07
1991	1.07	0.07	0.77	0.06	1.15	0.06
1992	1.06	0.08	0.60	0.07	1.13	0.05
1993	1.15	0.09	1.04	0.06	0.91	0.05
1994	1.05	0.06	0.76	0.05	0.95	0.05
1995	0.88	0.14	1.12	0.06	0.97	0.04
1996	1.72	0.06	1.29	0.06	0.77	0.04
1997	1.09	0.07	1.41	0.06	0.85	0.04
1998	1.01	0.04	1.21	0.05	0.95	0.05
1999	1.16	0.04	1.44	0.05	0.98	0.05
2000	0.99	0.04	1.11	0.05	0.97	0.05
2001	0.89	0.03	0.96	0.05	1.12	0.05
2002	0.76	0.03	1.31	0.05	1.10	0.05
2003	0.77	0.04	0.73	0.06	1.17	0.05
2004	0.85	0.04	1.14	0.05	1.14	0.05

Posterior distributions of year class strength estimates from the LIN 7WC 'TCEPR CPUE' run are shown in Figure 1; distributions from the other model runs differed little from this example.

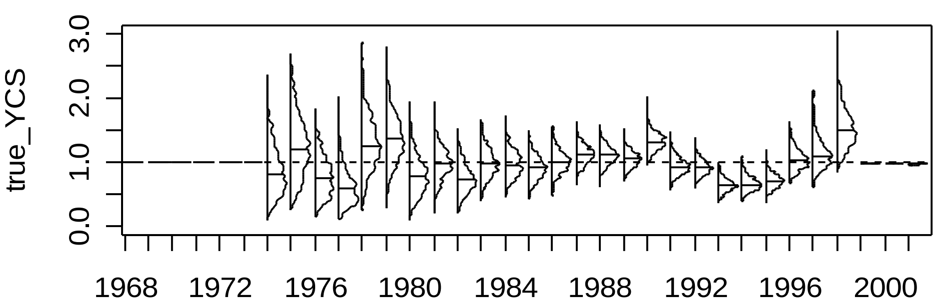


Figure 1: Estimated posterior distributions of year class strength from the LIN 7WC 'TCEPR CPUE ' run. The horizontal line indicates a year class strength of one. Individual distributions show the marginal posterior distribution, with horizontal lines indicating the median.

(b) Biomass estimates

LIN 7WC

Descriptions of the five model runs presented are as follows.

- TCEPR CPUE — catch history, proportion-at-age data from the commercial trawl fishery, and TCEPR trawl CPUE series.
- Observer CPUE — the TCEPR model, but using the observer trawl CPUE series instead of the TCEPR series.
- Trawl & line CPUE — the TCEPR model, but including the line fishery CPUE series.
- *Kaharoa* survey — the TCEPR model, but including the *Kaharoa* inshore survey relative biomass estimates and proportion-at-length data.
- No CPUE — the TCEPR model, but excluding the CPUE series.

The various model runs produced a wide range of results (Figure 2, Table 11). All the assessments are driven by the trawl fishery catch-at-age data, which contains information indicative of a stock decline from the early 1990s to 2004. The model run using that information only is the most pessimistic. The addition of any of the CPUE series produces more optimistic results. The model fits to the TCEPR CPUE series are reasonable. However, fits to the observer trawl CPUE and line CPUE are poor, and the model runs using these series produce even more optimistic, although much less precise, scenarios (owing largely to the conflict in trends between the CPUE series, or between the CPUE and the catch-at-age data). The reliability of all the CPUE series is uncertain; only the TCEPR series indicates a stock reduction in recent years. The trawl fishery catch-at-age data has relatively balanced residuals in all model runs.

Incorporation of data from the *Kaharoa* survey reduced the bounds on the estimated posterior distributions of recent year class strengths and the entire biomass trajectory, but changed the overall assessment very little.

Table 11: Bayesian median and 95% credible intervals (in parentheses) of B_0 and B_{2005} (in tonnes), and B_{2005} as a percentage of B_0 for all model runs for LIN 7WC.

Model run	B_0		B_{2005}		B_{2005} (% B_0)	
TCEPR CPUE	41 220	(37 930–47 240)	14 990	(11 400–21 130)	36	(30–45)
Observer CPUE	58 840	(47 050–90 860)	34 700	(22 200–66 740)	59	(47–75)
Trawl & line CPUE	48 730	(41 380–65 950)	23 820	(16 540–40 620)	49	(40–61)
Kaharoa survey	40 650	(37 990–44 020)	15 340	(12 100–19 230)	38	(32–44)
No CPUE	36 420	(34 350–39 910)	9 260	(6 550–13 770)	26	(19–34)

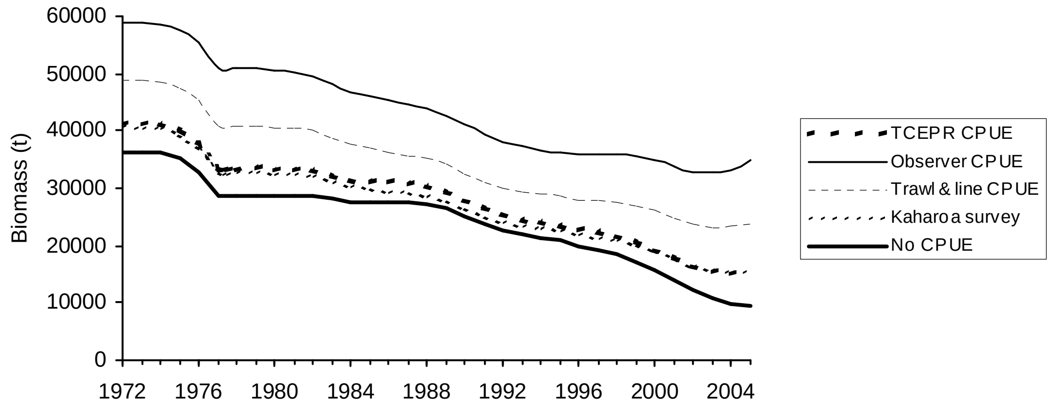


Figure 2: LIN 7WC — Estimated spawning stock biomass median of the posterior distribution for the five model runs.

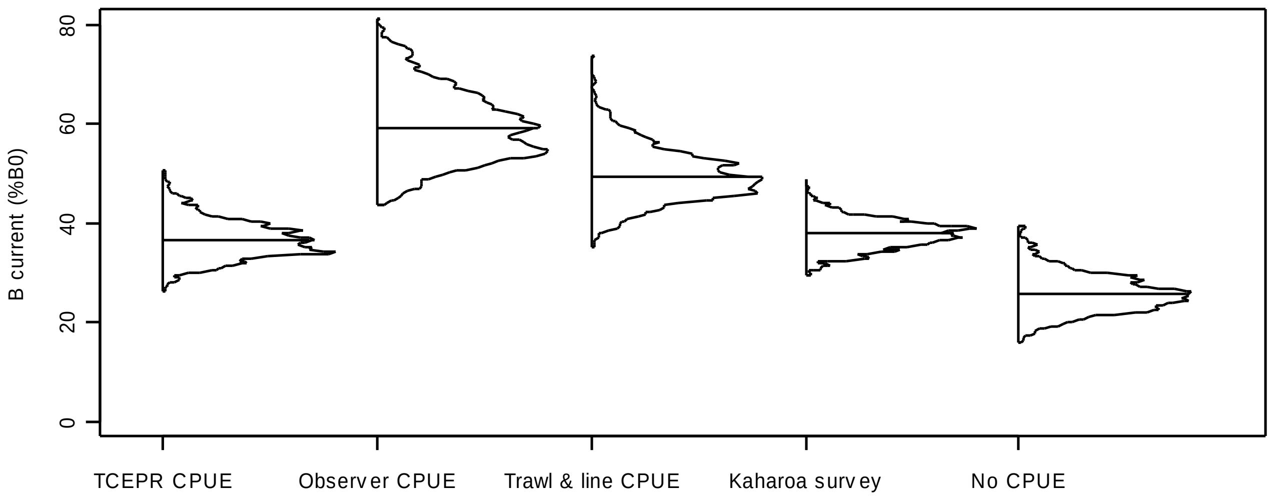


Figure 3: LIN 7WC — Estimated posterior distributions of current biomass as a percentage of B_0, from the five model runs. Distributions are the marginal posterior distribution, with horizontal lines indicating the median.

All assessments (see Figure 2) indicated a declining biomass throughout the history of the fishery (driven by the catch-at-age data). Estimates of current and virgin stock size are uncertain, being based on potentially unreliable CPUE series. The WG acknowledged that the biomass trajectory was tracking downwards, but noted also that there had been no declining trend in catches. Landings from the LIN 7WC stock have been consistently 2800 t or higher since 1996, and have averaged about 2700 t annually since 1989.

Figure 3 shows the posterior distribution of current biomass as a percentage of virgin biomass for the 5 runs. In all case except "No CPUE" the distribution is above 30%.

(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, Central (East), (LIN 1 & 2)

The MCY for these areas was estimated from the equation MCY = cY_{av}. Estimates were 101 t for LIN 1 and 394 t for LIN 2. These have not been re-estimated since the 1992 Plenary Report.

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. The estimates of B_0 for the Bounty Plateau stock (LIN 6B) were those derived from the 2001 MIAEL stock assessment. That MCY was estimated using pB_0.

Challenger, and Central (West) (LIN 7)

MCY for LIN 7WC was estimated from several CASAL runs, but owing to the uncertainty of the assessments these estimates are also very uncertain. There are no yield estimates for the LIN 7CK (Cook Strait) stock.

Table 12: Base case model estimates of B_{MCY} and MCY, from the MIAEL (LIN 6B) and CASAL (LIN 3&4, 5&6, and7) modelling procedures.

Fishstock	Model run	B_{MCY} (% of B_0))	MCY (t)	MCY Range (t)
LIN 6B	Basecase	40.7	830	370–3 060

Fishstock	Model run	B_{MCY} (t)	MCY (t)	B_{MCY} (% of B_0)	MCY (% of B_0)
LIN 5&6	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	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 7WC	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 and 3&4 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), and for LIN 3&4 (from the 2004 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	8 460	0.25	18 080	24.7	6.4
No CPUE	36 090	9 980	0.25	22 910	23.7	6.6

(e) Other yield estimates and stock assessment results

Stock projections out to 2008 were completed for LIN 5&6 in the 2003 assessment assuming future annual catches equal to the current TACC (Table 14). Stock projections out to 2009 were completed for LIN 3&4 in the 2004 assessment (Table 15) assuming future annual catches equal to recent catch levels, i.e., 5600 t. Stock projections out to 2010 were completed for LIN 7WC in the current assessment (Table 16) assuming future annual catches equal to recent catch levels from the WCSI i.e., 2800 t (Note the TACC for LIN 7 is 2100 t).In most cases the stock status of WCSI ling does not change in the next 5 years despite the overrun projected, however, for the No CPUE run the stock is projected to decline to 82% of current biomass.

Table14: Bayesian median and 95% credible intervals (in parentheses) of projected B_{2008}, B_{2008} as a percentage of B_0, and B_{2008}/B_{2003} (%) for the LIN 5&6 model runs from the 2003 assessment.

Model run	Future catch (t)	B_{2008}		B_{2008} (% B_0)		B_{2008}/B_{2003} (%)	
Base case	10 100	383 800	(250 500–569 100)	89	(77–106)	105	(98–124)
Summer q = 0.10	10 100	220 300	(167 100–290 200)	79	(68–95)	101	(90–119)
Summer q = 0.20	10 100	108 600	(81 800–147 700)	60	(49–77)	94	(83–110)
Summer q = 0.30	10 100	79 600	(57 500–112 200)	52	(40–69)	89	(75–108)

Table15: Bayesian median and 95% credible intervals (in parentheses) of projected B_{2004}, B_{2004} as a percentage of B_0, and B_{2009}/B_{2004} (%) for the LIN 3&4 model runs from the 2004 assessment.

Model run	Future catch (t)	B_{2009}		B_{2009} (% B_0)		B_{2009}/B_{2004} (%)	
Base case	5 600	105 000	(79 880–141 170)	69	(58–81)	119	(108–134)
M estimation	5 600	104 590	(71 840–161 110)	71	(56–89)	118	(106–133)
Length based sel	5 600	79 550	(62 280–101 380)	60	(50–72)	118	(104–134)
No CPUE	5 600	104 650	(73 970–151 230)	69	(56–83)	118	(106–134)

Table16: Bayesian median and 95% credible intervals (in parentheses) of projected B_{2005}, B_{2005} as a percentage of B_0, and B_{2010}/B_{2005} (%) for the LIN 7WC model runs from the current assessment.

Model run	Future catch (t)	B_{2010}		B_{2010} (% B_0)		B_{2010}/B_{2005} (%)	
TCEPR CPUE	2 800	14 510	(8 920–23 240)	35	(23–51)	96	(71–122)
Observer CPUE	2 800	37 330	(21 530–74 660)	64	(45–85)	107	(90–126)
Trawl & line CPUE	2 800	24 920	(14 990–44 540)	51	(35–71)	104	(84–124)
Kaharoa survey	2 800	14 580	(9 340–21 830)	36	(24–50)	94	(73–122)
No CPUE	2 800	7 510	(4 370–14 450)	20	(12–36)	82	(55–117)

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.

Mid-term Review of LIN 1 AMP in 2005

In 2005 the AMP FAWG reviewed the LIN 1 AMP after 2 years in its current 5-year term (SeaFIC 2005). The WG noted:

Characterisation

- Reported landings in 2002/03 and 2003/04 were lower than the pre-AMP TACC of 265t

CPUE standardization

- Unstandardized CPUE indices were provided for four longline and four bottom trawl fisheries.
- Given the size of the catch and area of operation, the target bottom longline fishery would probably provide the best index of abundance.
- Standardized indices should be provided for the full-term review if the available data support such an analysis

Effects of fishing

- Although a code of practice under the NPOA for Seabirds will be implemented for ling longliners by 30 June 2005, this will not include the recording and monitoring of seabird bycatch.
- Seabird bycatch should be recorded in order to monitor the impact of the additional LIN 1 TACC on seabird populations.
- The Northern Inshore Fisheries Company Ltd will set up a meeting with MFish to determine the environmental affects to be monitored.

Log Book Programme

- One vessel provided length information for ling taken by the mixed trawl fishery in two statistical areas with the BOP.
- Most of the LIN 1 catch is taken by scampi trawlers and ling longliners in fisheries not covered by the logbook programme. Therefore, the existing logbook programme does not provide representative information for the main fisheries that take LIN1 and is not adequately meeting the AMP obligations.
- The AMP FAWG noted in March 2004 that "Logbook coverage is currently completely inadequate and needs to be substantially improved". While there was some improvement in 2003/04, the programme failed to address the most important shortcomings.
- Industry should aim at representative spatial and temporal coverage of the target longline and scampi bottom trawl fisheries.

Conclusion

- Given the shortfalls in the Logbook programme and the lack of adequate data to perform a CPUE analysis, the abundance of LIN 1 is presently not effectively monitored.
- Since the landed catch remained below the pre-AMP TACC, risk to the sustainability of LIN 1 is at this stage not anticipated.
- Assuming that LIN 1 was at or above Bmsy when it was introduced into the AMP in 2002/03, the status of LIN 1 is unlikely to have changed since then.
- Effective logbook coverage of the target longline and scampi bottom trawl fisheries is required.
- Monitoring seabird bycatch in the target longline fishery is required.

Annual Review of LIN 1 AMP in 2006

In 2006 the AMP FAWG reviewed the Log Book Programme operating in this fishery (AMP-WG-06/14). The WG noted:

Log Book Programme

- Catches of LIN 1 since the increase in TACC to in 2002/03 have ranged from 246 t to 282 t, which is less than the pre-AMP TACC.
- Only one vessel participated in the logbook programme and less than 0.5% of the catch was sampled.
- Coverage was not representative of spatial and temporal patterns in catch.
- Logbook coverage is currently completely inadequate and needs to be substantially improved.

6. STATUS OF THE STOCKS

Since the 2005 Plenary report was published, the only new stock assessment for ling is an update of the west coast South Island section of LIN 7

LIN 1

The current stock size is considered to be above B_{MSY} based on an analysis of CPUE from the longline fisheries. In October 2002, the TACC for LIN 1 was increased to 400 t within the AMP.

LIN 2

It is not known if recent landings and the current TACCs 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

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

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 above B_{MAY}. There is no separate TACC for this stock.

LIN 7WC

The current assessment does not include ling from the Cook Strait section of QMA 7. 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 do 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.

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	2004–05 Actual TACC	2004–05 Reported landings
LIN 1	Auckland	1 & 9	101	–	400	282
LIN 2	Central (East)	2	394	–	982	933
LIN 3	South-East (Coast)	3			2 060	1596
LIN 4	South-East (Chatham Rise)	4	8 290	18 080	4 200	2757
LIN 5	Southland	5			3600	3584
LIN 6§	Sub-Antarctic	6	10 600	24 800	8520	5506
LIN 7†	Challenger, Central (West)	7 & 8	2 100	–	2 225	2521
LIN 10	Kermadec	10	–	–	10	0
Total					21 997	17 179

\# Based on cY_{av} for LIN 1 & 2, and CASAL estimates for LIN 3 & 4, 5 & 6, and 7.

§ MCY and CAY exclude ling stock on the Bounty Plateau.

† MCY excludes ling stock in Cook Strait.

7. FOR FURTHER INFORMATION

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