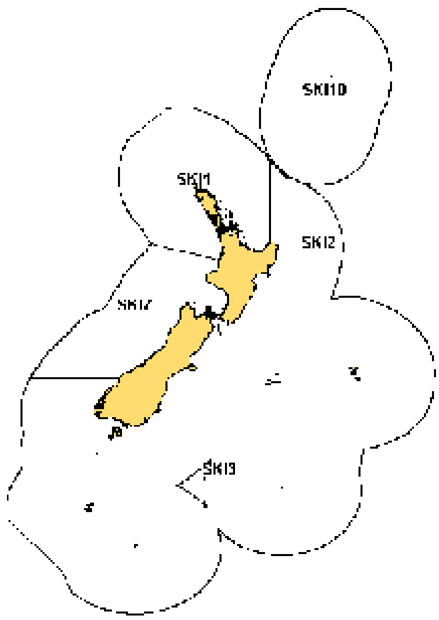
GEMFISH (SKI)

(Rexea solandri)



1. FISHERY SUMMARY

(a) Commercial fisheries

Gemfish are caught in coastal waters around mainland New Zealand down to about 550 m. Annual catches increased significantly in the early 1980s and peaked at about 8250 t in 1985–86 (Table 1). In the late 1980s, annual catches generally ranged from about 4200 to 4800 t per annum, but since then have steadily declined, with landings of less than 1100 t reported in the last five years (Table 2). TACCs were reduced in SKI 3 and SKI 7 for the 1996–97 fishing year and have been progressively reduced in SKI 1 and SKI 2 since 1997–98. TACs and TACCs are 218 t and 210 t for SKI 1, and 248 t and 240 t for SKI 2, respectively.

Table 1: Reported gemfish catch (t) from 1978–79 to 1987–88. Source – MAF and FSU data.

Fishing year	New Zealand		Foreign Licensed			
Year	Domestic	Chartered	Japan	Korea	USSR	Total
1978–79*	352	53	1 509	1 079	0	2 993
1979–80*	423	1 174	1 036	78	60	2 771
1980–81*	1 050	na	na	na	na	>1 050
1981–82*	1 223	1 845	391	16	0	3 475
1982–83*	822	1 368	274	567	0	3 031
1983–83†	1 617	1 799	57	37	0	3 510
1983–84‡	1 982	3 532	819	305	0	6 638
1984–85‡	1 360	2 993	470	223	0	5 046
1985–86‡	1 696	4 056	2 059	442	0	8 253
1986–87‡	1 603	2 277	269	76	0	4 225 §
1987–88‡	1 016	2 331	90	35	0	3 472 §

* 1 April-31 March.
‡ 1 October-30 September.
† 1 April-30 September.
§ These totals do not match those in Table 2 due to under-reporting to the FSU.
na Unknown.

Most of the recorded catch is taken by trawlers. Target fisheries have continued off the eastern and northern coasts of the North Island. There has also been a major shift in effort from east of North Cape to the west, and over 50% of the SKI 1 catch is now taken from QMA 9. Catches off the west and southern coasts of the South Island are primarily bycatch of hoki and squid target fisheries. The total landings in SKI7 have increased over the last 3 years to over double the level of the TACC.

Table 2: Reported landings (t) of gemfish by Fishstock from 1983–84 to 2004–05 and actual TACs for 1986–87 to 2004–05.

Fishstock		SKI 1		SKI 2		SKI 3		SKI 7	SKI 10		
QMA (s)		1 & 9		2		3, 4, 5, & 6		7 & 8	10		Total
	Landings	TAC	Landings	TAC	Landings	TAC	Landings	TAC	TAC	Landings	TAC
1983–84*	588	–	632	–	3 481	–	1 741	–	–	6 442 §	–
1984–85*	388	–	381	–	2 533	–	1 491	–	–	4 793 §	–
1985–86*	716	–	381	–	5 446	–	1 468	–	–	8 011 §	–
1986–87†	773	550	896	860	2 045	2 840	1 069	1 490	10	4 783	5 750
1987–88†	696	632	1 095	954	1 664	2 852	1 073	1 543	10	4 528	5 991
1988–89†	1 023	1 139	1 011	1 179	1 126	2 922	1 083	1 577	10	4 243	6 827
1989–90†	1 230	1 152	1 043	1 188	1 164	3 259	932	1 609	10	4 369	7 218
1990–91†	1 058	1 152	949	1 188	616	3 339	325	1 653	10	2 948	7 342
1991–92†	1 017	1 152	1 208	1 197	287	3 339	584	1 653	10	3 096	7 350
1992–93†	1 292	1 152	1 020	1 230	371	3 345	469	1 663	10	3 152	7 401
1993–94†	1 156	1 152	1 058	1 300	75	3 345	321	1 663	10	2 616	7 470
1994–95†	1 032	1 152	905	1 300	160	3 355	103	1 663	10	2 169	7 480
1995–96†	801	1 152	789	1 300	49	3 355	81	1 663	10	1 720	7 480
1996–97†	965	1 152	978	1 300	58	1 500	238	900	10	2 240	4 862
1997–98†	627	752	671	849	27	300	44	300	10	1 369	2 211
1998–99†	413	460	336	520	17	300	59	300	10	825	1 590
1999–00†	409	460	506	520	62	300	107	300	10	1 083	1 590
2000–01†	335	460	330	520	47	300	87	300	10	799	1 590
2001–02†	201	210	268	240	72	300	123	300	10	664	1 060
2002–03†	206	210	313	240	115	300	268	300	10	902	1 060
2003–04†	221	210	301	240	78	300	542	300	10	1 142	1 060
2004–05†	233	210	259	240	72	300	635	300	10	1 199	1 060

* FSU data.
† QMS data.
§ The totals do not match those in Table 1 as some fish were not reported by area (FSU data prior to 1986–87).

Table 3: **Catch history for gemfish stocks, divided into pre-spawning and spawning seasons (t). na – not available.**

Year	SKI 1 (spawn)			SKI 2	Total	Year	SKI 1 (spawn)			SKI 2	Total
	SKI 1E	SKI 1W	Total	(pre-spawn)	SKI 1 & 2		SKI 1E	SKI 1W	Total	(pre-spawn)	SKI 1 & 2
1952	5	0	5	50	55	1978	90	0	90	240	330
1953	5	0	5	25	30	1979	120	0	120	200	320
1954	5	0	5	60	65	1980	140	0	140	450	590
1955	5	0	5	35	40	1981	120	0	120	500	620
1956	5	0	5	35	40	1982	100	0	100	320	420
1957	5	0	5	55	60	1983	360	0	360	730	1 090
1958	5	0	5	30	35	1984	588	0	588	632	1 220
1959	5	0	5	45	50	1985	388	0	388	381	769
1960	5	0	5	85	90	1986	716	0	716	381	1 097
1961	5	0	5	70	75	1987	773	0	773	896	1 669
1962	5	0	5	60	65	1988	696	0	696	1 095	1 791
1963	15	0	15	70	85	1989	1 023	0	1 023	1 011	2 034
1964	15	0	15	65	80	1990	1 230	0	1 230	1 043	2 273
1965	20	0	20	130	150	1991	1 048	10	1 058	949	2 007
1966	15	0	15	140	155	1992	940	77	1 017	1 208	2 225
1967	35	0	35	240	275	1993	1 137	155	1 292	1 020	2 312
1968	40	0	40	250	290	1994	606	550	1 156	1 058	2 214
1969	100	0	100	375	475	1995	438	594	1 032	906	1 938
1970	95	0	95	400	495	1996	485	316	801	789	1 590
1971	100	0	100	420	520	1997	385	580	965	978	1 943
1972	130	0	130	400	530	1998	na	na	627	671	1 298
1973	45	0	45	300	345	1999	na	na	413	335	748
1974	35	0	35	230	265	2000	na	na	409	506	915
1975	10	0	10	170	180	2001	na	na	335	330	665
1976	30	0	30	190	220	2002	na	na	201	268	487

(b) Recreational fisheries

There was no recreational catch reported in marine recreational fishing catch and effort surveys of the MAF Fisheries South and Central regions (1991–92 and 1992–93, respectively). However, there is known to be a target recreational fishery in the Bay of Plenty. Reported gemfish catch in the North region recreational survey December 1993 to November 1994 was negligible (i.e., 3 fish) and scaled up to about 1 t. Gemfish harvest estimates from the 1996 national recreational survey were 5000 fish from SKI 1 & 2 and less than 500 fish from SKI 7.

(c) Maori customary fisheries

Quantitative information on the current level of Maori customary take is not available and assumed negligible.

(d) Illegal catch

The amount of gemfish misreported is not available and assumed negligible.

(e) Other sources of mortality

There may have been some gemfish discarded prior to the introduction of the EEZ, but this is likely to have been minimal since the early 1980's as gemfish is a medium value species.

2. BIOLOGY

Gemfish occur on the continental shelf and slope, from about 50–550 m depth. They probably undertake spawning migrations and pre-spawning runs form the basis of winter target fisheries, but exact times and locations of spawning are not well known. Spawning probably takes place about July near North Cape and late August/September on the west coast of the South Island.

Ageing of southern gemfish indicate that fish attain about 30 cm at the end of the first year, 45 cm at the end of the second year, 53 cm at the end of the third year and 63 cm at the end of the fourth year. Both sexes display similar growth rates until age 5, but subsequently, females grow larger. The maximum ages recorded for gemfish (from 1989 to 1994) are 17 years for both sexes. In the northern fishery (SKI 1, SKI 2), males and females appear to recruit into the fishery from age 3 but are probably not fully recruited until about age 5 (SKI 2) and age 7 or 8 (spawning fishery in SKI 1). In the southern fishery, gemfish start to recruit at age 2 into spawning and non-spawning fisheries but age at full recruitment was difficult to determine because of large variation in year class strength.

Recruitment variability in SKI 3 and SKI 7 has been correlated to wind and sea surface temperature patterns during the spawning season (Renwick et al., 1998). No significant correlations were found between SKI 1 and SKI 2 recruitment indices and a range of ocean climate variables (Hurst et al., 1999).

Biological parameters relevant to the stock assessment are shown in Table 4.

Table 4: Estimates of biological parameters for gemfish.

Fishstock	**Estimate**						**Source**
1. Natural mortality (*M*)							
All stocks	$M = 0.25\ y^{-1}$ considered best estimate for all areas for both sexes						Horn & Hurst (1999)
2. Weight = a (length)^{b} (Weight in g, length in cm fork length)							
	Male			**Female**			
	a	**b**		**a**	**b**		
SKI 1	0.0034	3.22		0.0008	3.55		Langley et al. (1993)
SKI 3	0.0012	3.41		0.0095	3.47		Hurst & Bagley (1998)
3. von Bertalanffy growth parameters							
	Male			**Female**			
	L_{∞}	k	t_0	L_{∞}	k	t_0	
East Northland	90.7	0.204	-0.49	122.7	0.114	-1.10	Langley et al. (1993)
East Northland	88.4	0.235	-0.54	108.5	0.167	-0.71	Horn & Hurst (1999)
Wairarapa	90.8	0.287	0.00	103.4	0.231	-0.10	Horn & Hurst (1999)
West Northland	86.3	0.295	-0.11	103.4	0.209	-0.37	Horn & Hurst (1999)
North combined	87.4	0.266	-0.35	105.0	0.194	-0.55	Horn & Hurst (1999)
Southland	88.5	0.242	-0.66	104.2	0.178	-0.88	Horn & Hurst (1999)

3. STOCKS AND AREAS

In previous assessments, analysis of seasonal trends in gemfish fisheries indicated that there may be at least 2 stocks:

1. A southern/west coast stock (SKI 3 & 7), caught in the southern area in spring, summer and autumn, which presumably migrates to the west coast of the South Island to spawn and is caught there mainly in August-September. Spawning is thought to occur in late August/early September.
2. A northern/east coast stock (SKI 1E & SKI 2), caught mainly on the east coast in spring and summer, which migrates north along the east coast of the North Island in May-June to spawn north of the North Island. Seasonal trends in commercial catch data from SKI 1E (QMA 1) are consistent with pre- and post-spawning migrations through the area; similar data from SKI 2 are inconclusive but indicate lower catches during the peak spawning months, although this could be partly due to target fishing on other species, particularly orange roughy, at this time.

The relationship of the pre-spawning fishery in SKI 1W (QMA 9) to the pre-spawning fishery in SKI 1E was investigated by Horn and Hurst (1999). They presented age frequency distributions from commercial catches for SKI 1E, SKI 1W, SKI 2 and from research sampling for SKI 3. Age distributions for the two SKI 1 spawning fisheries appear similar, with year classes in 1980, 1982, 1984, 1986 and 1991 appearing to be strong relative to other year classes. The SKI 2 distribution also exhibits the same pattern, although the relative dominance of the 1991 year class is greater, as might be expected from an area in which pre-recruit fish occur. The age distribution from SKI 3 gemfish showed that the 1982, 1984, 1985 and 1989 year classes were the stronger ones. There were no significant differences in the von Bertalanffy growth parameters calculated for northern and southern gemfish (Horn & Hurst 1999).

Recent biochemical analyses of Australasian gemfish suggested that there may be a very low level of mixing between eastern Australian and New Zealand gemfish, but not high enough to treat them as a single stock. There was also a suggestion of a difference between north-eastern and southern New Zealand gemfish.

Two alternative hypotheses have been proposed, that either SKI 1 and SKI 2 are one stock or that SKI 1W is separate from SKI 1E and SKI 2. The Middle Depths Working Group concluded that based on the close similarity in declines in CPUE indices and in age distributions from commercial catches that the northern gemfish should be assessed using SKI 1 and 2 combined.

4. STOCK ASSESSMENT

The northern gemfish stock was assessed using the hypothesis of one stock (SKI 1 and SKI 2). The alternative hypothesis, that SKI 1W is separate from SKI 1E and SKI 2 was not modelled, as results from previous assessments were similar to those from SKI 1 and SKI 2 combined. Estimates of virgin biomass (B_0) and mature biomass for 2001–02 (B_{2002}) are presented below.

The stock assessment was implemented as a Bayesian single stock model using the general-purpose stock assessment program CASAL v2.01 (Bull et al., 2002). The assessment used catch-per-unit-effort time series, catch-at-age from the commercial fishery, and estimates of biological parameters.

New information from the previous assessment included revised CPUE abundance indices (Phillips et al., 2003), two years of catch sampling proportions-at-age data for SKI 2, and one year of catch sampling proportions-at-age data for SKI 1 (Phillips & Horn 2003).

The assessment of the southern stock (SKI 3 & 7) was not updated, as there were no new indices of biomass or proportion at age available. The results of the 1997 assessment are summarised later.

4.1 Auckland (SKI 1) and Central East (SKI 2)

(a) Estimates of fishery parameters and abundance

The stock assessment model includes two fishery types, based on spawning activity. The first is on the home ground, SKI 2, where all age classes occur and where fishing is mainly in the pre-spawning season. The second is on the spawning migrations, SKI 1, where only mature age classes occur and where fishing is in the winter months. The pre-spawning (SKI 2) and spawning (SKI 1) season landings used in the assessment are given in Table 3. This table also shows the split between east and west coast catches in SKI 1 from 1991 to 1997.

Commercial catch-at-age data included in the models were: SKI 1E for 1989 to 1994, 997 to 1999, and 2002; SKI 1W for 1996 to 1999, and 2002; and SKI 2 for 1996 to 2002.

Standardised CPUE indices for SKI 1 and SKI 2 are shown in Table 5. The indices for SKI 1 are from SKI 1E and SKI 1W combined and for SKI 2 include both midwater and bottom trawl methods. Both time series show declines of almost 90%.

Table 5: Standardised catch per unit effort indices and coefficient of variation (c.v.) for SKI 1 and SKI 2.

	SKI 1		SKI 2	
Year	**Index**	**c.v.**	**Index**	**c.v.**
1990	2.03	0.06	3.14	0.07
1991	1.91	0.06	2.33	0.08
1992	1.22	0.06	2.01	0.06
1993	1.51	0.05	1.70	0.05
1994	1.45	0.06	1.12	0.05
1995	1.29	0.06	0.83	0.06
1996	0.86	0.06	0.72	0.06
1997	1.05	0.06	0.71	0.05
1998	0.76	0.07	0.55	0.06
1999	0.65	0.08	0.59	0.08
2000	0.71	0.08	0.70	0.08
2001	0.56	0.07	0.52	0.07
2002	0.42	0.08	0.72	0.08

Assessment model

The assessment model partitions the stock into two areas (spawning (SKI 1E and 1W) and home ground (SKI 2)), two sexes and age groups 1–20, with no plus group. There are four time steps in the model (Table 6). In the first time step, the 1 year-olds are recruited to the population, which is then subjected to fishing mortality in SKI 2. In the second time step, fish migrate into SKI 1, and again are subjected to fishing mortality. In time step 3, fish ages are incremented, and spawning occurs. Fish migrate back to SKI 2 in the final time step.

Table 6: Annual cycle of the stock model for gemfish, showing the processes taking place at each time step, their sequence within each time step, and the available observations. Fishing and natural mortality that occur 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.

				Observations	
Step	**Period**	**Processes**	***M***	**Description**	**%M**
1	Oct–Apr	Fishing (SKI 2)	0.58	CPUE (SKI 2)	50
		Recruitment		Proportions at age (SKI 2)	50
2	May–Jun	Migration to SKI 1	0.17	CPUE (SKI 1)	50
		Fishing (SKI 1)		Proportions at age (SKI 1)	50
3	Jul	Spawning	0.08		
		Increment age			
4	Aug–Sep	Migration to SKI 2	0.17		

1. *M* is the proportion of natural mortality that was assumed to have occurred in that time step.
2. %*M* is the percentage of the natural mortality within each time step that was assumed to have taken place at the time each observation was made.

The model used three ogives; a combined male and female length based fishing ogive for SKI 2, and separate male and female age based migration ogives for SKI 1. The SKI 1 fishing ogives were assumed known and were fixed at 1 for all ages.

Even though the model is an age-based model and fish size does not feature in the partition, size-at-age can still be an element in the model. Size-at-age is based on the von Bertalanffy growth curve, which specifies the mean size at a given age (Bull et al. 2003). The model can incorporate changes in size-at-age during the year, i.e., growth between fish birthdays by incrementing ***age*** as specified by the age fraction. The use of a length based fishing selectivity has the advantage of reducing the number of estimated parameters. The same fishing ogive can be used for both males and females although they have different growth curves, if it assumed that fishing selectivity is equal at length.

The length based fishing selectivity for SKI 2 was assumed to be logistic. The model used two migration ogives, one for each sex to determine the rates that fish will mature from time-step 1 to time-step 2.

Maximum exploitation rates for gemfish were assumed to be 0.5 for SKI 2 and 0.7 for SKI 1. The choice of the maximum exploitation rate has the effect of determining the minimum possible virgin biomass allowed by the model. This value was set relatively high as there was little external information from which to determine this value.

Lognormal errors, with known c.v.s, were assumed for all relative biomass and proportions-at-age observations. The c.v.s available for the relative abundance and catch-at-age observations 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 early runs of the model using all available data from MPD fits. Hence, the overall c.v. assumed in the initial model runs for each observation was calculated by adding process error and observation error. The process error added was a c.v. of 0.16 and 0.31 for the SKI 1 and SKI 2 CPUE series respectively, and 0.42 for both SKI 1 and SKI 2 proportions-at-age data.

Year class strengths were assumed known (and equal to one) for years prior to 1978 and after 1997, when inadequate or no age data were available. Otherwise year class strengths were estimated under the assumption that the estimates from the model should average one.

The assumed prior distributions used in the assessment are given in Table 7. All priors were intended to be relatively uninformed, and were estimated with wide bounds.

Table 7: The assumed priors assumed for key distributions (when estimated). The parameters are mean (in natural space) and c.v. for lognormal.

Parameter description	Distribution	Parameters		Bounds	
		Mean	c.v.	Lower	Upper
B_0	uniform-log	–	–	2 500	250 000
SKI 1 CPUE *q*	uniform-log	–	–	$1x10^{-7}$	0.01
SKI 2 CPUE *q*	uniform-log	–	–	$1x10^{-7}$	0.01
YCS	lognormal	1	0.9	0.01	10.0
Selectivity	uniform	–	–	0.1	80.0
Maturation	uniform	–	–	1.3	10.0
Process error c.v.	uniform	–	–	1e-3	2.0

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.

MCMC chains were estimated using a burn-in length of 10^6 iterations, with every 10 000th sample taken from the next 10^7 iterations (i.e., a final sample of length 1000 was taken from the Bayesian posterior). Autocorrelations, and single chain convergence tests of Geweke (1992) and Heidelberger & Welch (1983) were applied to resulting chains to determine evidence of non-convergence (Smith 2001).

Projections were estimated under two scenarios where recruitment was randomly resampled from a set time period. In the first scenario, recruitment was randomly resampled from 1978 to 1997 (period of both strong and weak year classes), and in the second scenario, recruitment was randomly resampled from 1992 to 1997 (period of only weak year classes). Both scenarios had catch set equal to the current TACC.

Model estimates

Base case estimates of biomass were estimated using the biological parameters and model input parameters described earlier. Sensitivity runs were chosen to investigate aspects of the model where strong model assumptions may have influenced the model output. Table 8 lists the names and describes the base case and sensitivity runs.

Table 8: Model run labels and descriptions for the base case and sensitivity model runs.

Model run	Description
Base case	Base case model using all data, with length based logistic fishing selectivities for SKI 2 and CPUE time series from 1990 to 2002
Agesel	Age and sex based logistic fishing selectivities for SKI 2
Lengthselfsu	CPUE time series from 1984 to 2002
Ageselfsu	Age and sex based logistic fishing selectivities for SKI 2 and CPUE time series from 1984 to 2002
Normalpaa	Assumed normal error structure for SKI 1 and 2 proportions-at-age

For each model run, MPD fits were obtained and qualitatively evaluated. In addition, MCMC estimates of the median posterior and 95% percentile credible intervals are reported for current and virgin biomass and year class strengths.

The estimated MCMC marginal posterior distributions for year class strengths and biomass trajectories for the base case are shown in Figures 1 and 2.

No evidence of lack of convergence from the MCMC chains was found in the estimates of B_0, although some estimates of selectivity parameters and YCS showed evidence of lack of convergence.

Year class strength estimates were poorly estimated before 1990 when the only data available to determine year class strength were from older fish (Figure 1). The estimates suggest a period of generally higher than average recruitment during the 1980s, followed by a period of generally lower than average recruitment.

Biomass is currently estimated to be at its lowest level since fishing began. Current biomass was estimated at 23% of B_0 (95% credible intervals 18–30%) (See Figure 2 and Table 9). The stock declined markedly during the early 1980s, followed by a small period of recovery due to recruitment of strong year classes in the late 1980s. Since 1992, the stock declined to its current level due to increasing exploitation rates combined with a long period of low recruitment since the early 1990s (Figure 1).

The ogives for males and females taken by the commercial trawl fishery in SKI 2 were very steep, and it appears they were poorly estimated. The 3 and 4-year-old fish had broad posterior density estimates, suggesting considerable uncertainty. There were no marked differences in the ogives, and it appears that males and females were not fully selected until aged 9. There is no information outside the model that allows the shape of the estimated ogives to be verified

The spawning migration ogives appeared to be poorly estimated. Both male and female ogives had broad posterior density estimates. There were no marked differences in the ogives, and it appears that males were not fully mature until age 9, and females age 10.

Projections where recruitment was resampled from 1978 to 1997 (period of strong and weak year classes) suggests the stock biomass will increase (Table 10 and Figure 2). The model suggests that estimated biomass in 2007 will be about 58–315% of current biomass, and between 13–75%B_0.

Projections with recruitment randomly resampled 1992 to 1997 (period of weak year classes) predict a decline in stock biomass towards 2007. Estimated biomass in 2007 will be about 44–95% of current biomass, and between 8–25% B_0 (see Table 11 and Figure 3)

These projections suggest that if future recruitment continues to be poor, the expected stock size will continue to decline.

Sensitivity runs did not suggest any great departure from the base case estimates of current biomass (approximate ranges over all sensitivities was 17–33% B_0, see Table 9).

Table 9: Bayesian median and 95% credible intervals of B_0, B_{2002}, and B_{2002} as a percentage of B_0 for the base and sensitivity cases.

Model run	B_0	B_{2002}	B_{2002} (% B_0)
Base case	12 024 (10 955–13 436)	2 765 (1 975–3 906)	23.0 (17.8–29.7)
Agesel	12 289 (11 171–13 689)	2 890 (2 073–4 194)	23.4 (18.4–31.2)
Lengthselfsu	12 332 (11 227–13 945)	3 094 (2 231–4 423)	25.1 (19.3–32.7)
Ageselfsu	11 754 (10 656–13 256)	2 816 (1 852–4 132)	24.0 (17.4–31.9)
Normalpaa	11 189 (10 266–12 383)	2 369 (1 747–3 255)	21.2 (16.5–26.9)

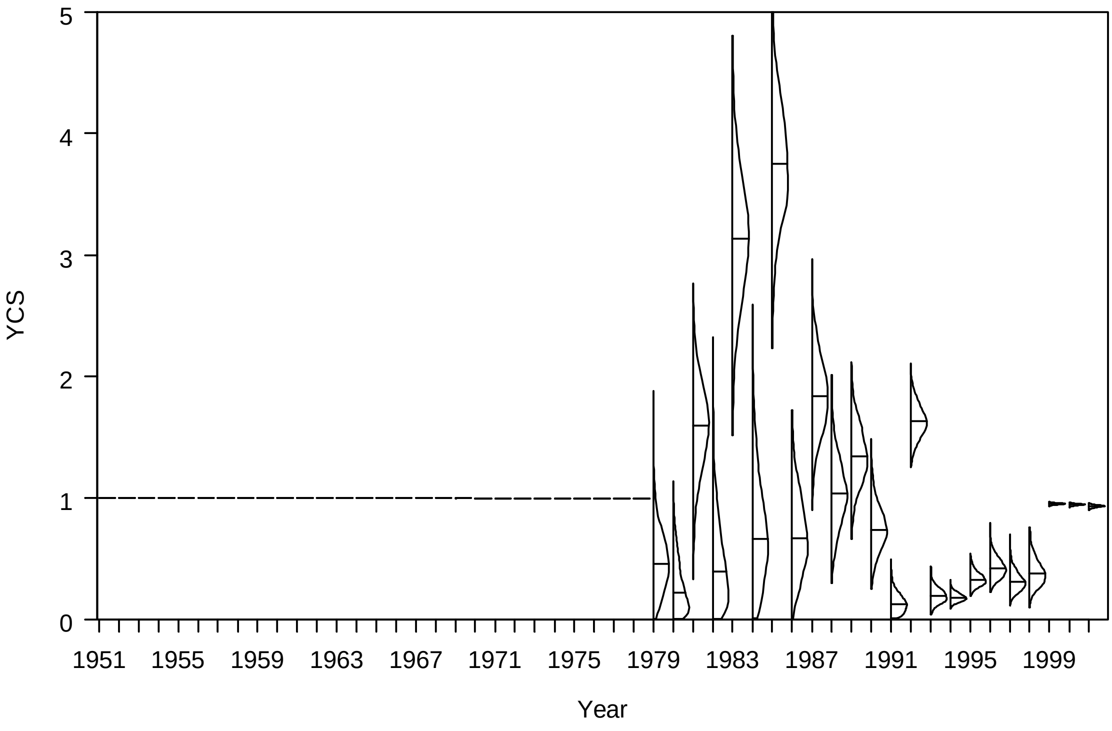


Figure 1: Estimated posterior distributions of year class strengths for the base case. Individual distributions show the marginal posterior distribution, with horizontal lines indicating the median.

Table 10: Bayesian median and 95% credible intervals of projected B_{2007}, B_{2007} as a percentage of B_0, and B_{2007}/B_{2002} (%) for the base case and sensitivity runs where future recruitments were randomly resampled from 1978 to 1997.

Model run	B_{2007}	B_{2007} (% B_0)	B_{2007}/B_{2002} (%)
Base case	4 251 (1 511–9 365)	35.1 (12.8–75.0)	150.3 (58.1–314.7)
Agesel	6 309 (3 059–13 760)	51.7 (25.9–107.4)	127.0 (68.4–261.4)
Lengthselfsu	4 663 (2 032–9 934)	37.8 (16.5–78.7)	147.5 (69.3–307.4)
Ageselfsu	6 095 (2 854–12 324)	51.7 (25.0–99.8)	124.8 (64.8–239.3)
Normalpaa	3 496 (1 366–7 681)	31.1 (15.5–66.8)	144.1 (65.1–307.4)

Table 11: Bayesian median and 95% credible intervals of B_{2007}, B_{2007} as a percentage of B_0, and B_{2007}/B_{2002} (%) for the base case and sensitivity runs where future recruitments were randomly resampled from 1992 to 1997.

Model run	B_{2007}	B_{2007} (%B_0)	B_{2007}/B_{2002} (%)
Base case	1 841 (963–3 284)	15.3 (8.6–25.2)	67.3 (44.4–95.4)
Agesel	3 347 (1 996–5 391)	27.2 (16.8–40.8)	67.5 (52.6–86.7)
Lengthselfsu	2 129(1 108–3 735)	17.2 (9.5–28.1)	96.7 (46.5–95.2)
Ageselfsu	3 082 (1 625–4 982)	26.3 (14.7 (39.0)	63.6 (46.9–82.7)
Normalpaa	1 530 (741–2 590)	13.7 (7.1–21.7)	64.9 (41.6–89.9)

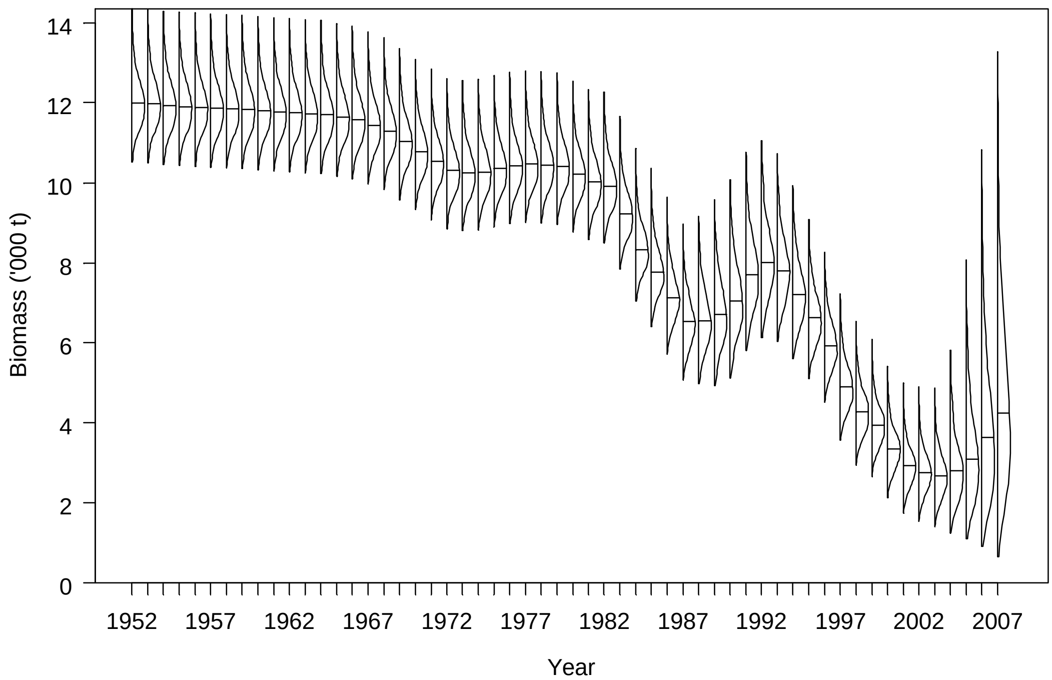


Figure 2: Estimated posterior distributions of biomass trajectories for the base case projected to 2007 with recruitments randomly resampled from 1978 to 1997. Individual distributions show the marginal posterior distribution, with horizontal lines indicating the median.

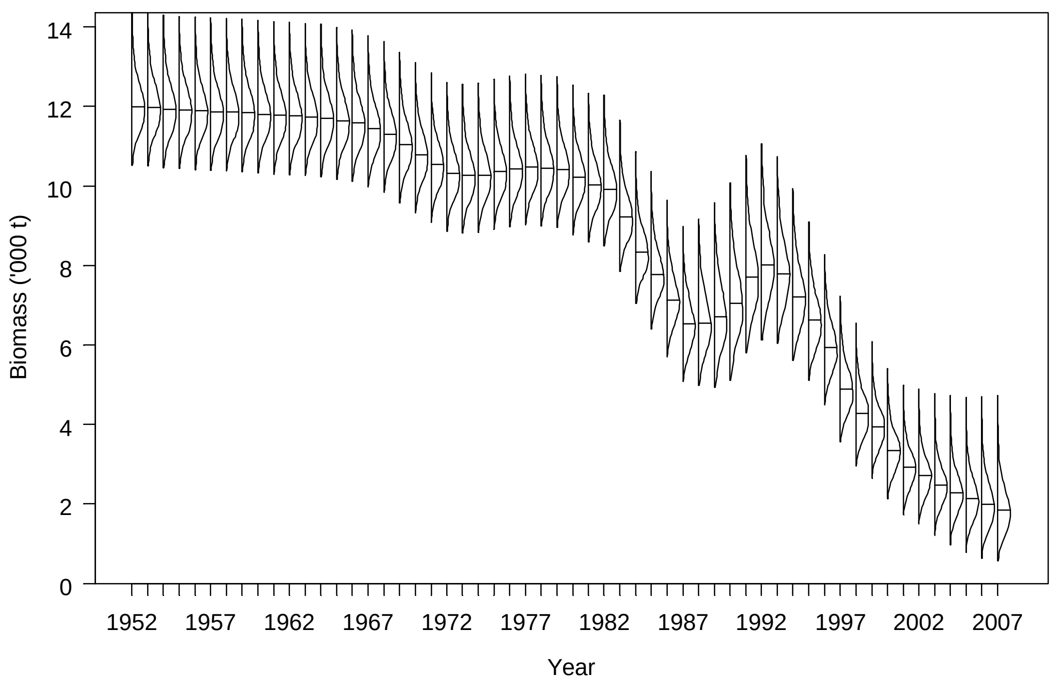


Figure 3: Estimated posterior distributions of biomass trajectories for the base case projected to 2007 with recruitments randomly resampled from 1992 to 1997. Individual distributions show the marginal posterior distribution, with horizontal lines indicating the median.

Discussion of model results

This assessment uses a different model structure, revised catch histories, revised CPUE abundance indices, and two further years of proportions-at-age than the previous assessment. Biomass estimates, and estimates from maturation and fishing ogives from the previous assessments of Dunn et al. (2001) and Hurst et al. (2000) are consistent with the results from this assessment. Model estimates of the state of the northern gemfish stock indicate the current biomass is about 23% the virgin level, and is likely to increase slightly in the short term.

As with previous assessments of Dunn et al. (2001) and Hurst et al. (2000), fits to the CPUE and proportions-at-age are still poor. The use of FSU data in the sensitivity runs did not improve CPUE fits. There appears to be some inconsistency between SKI 1 and SKI 2 CPUE indices. Both show declining trends, but the SKI 2 indices decline faster for the first few years, and are relatively flat for the remainder of the time series. However SKI 1 declines in a more linear fashion. None of the models were able to adequately explain the commercial proportions-at-age data without assuming relatively high variability. Using different model assumptions, or different fishing ogives in SKI 2 did not improve fits to the proportions at age.

(b) Estimation of Maximum Constant Yield (MCY) and Current Annual Yield (CAY)

MCY and CAY were determined using stochastic sample-based simulations. One simulation run is done for each sample from the posterior, ultimately producing an estimate of yield that has been averaged over all samples (Bull et al. 2003). Each run extended over 150 years with recruitment randomly sampled, but with the first 100 of those years discarded to allow the population to stabilise where harvest rate was set at the current TACC. Yield calculation was based on the procedures of Francis (1992), where yields were maximised subject to the constraint that spawning stock biomass should not fall below 20% of B_0 more than 10% of the time.

Table 12: Yield estimates (MCY and CAY) and associated parameters for the base and sensitivity cases where simulations were based on recruits randomly resampled from 1978 to 1997.

Model run	B_{MCY} (t)	B_{MCY} (%B0)	MCY (t)	B_{MAY} (t)	B_{MAY} (%B0)	MAY (t)	$CAY_{2002-03}$ (t)
Base case	6 776	56	875	4 237	35	1 298	767
Agesel	8 121	66	1 159	4 377	36	1 757	1 643
Lengthselfsu	6 744	55	928	4 249	34	1 330	875
Ageselfsu	7 560	64	1 170	4 095	35	1 729	1 655
Normalpaa	6 134	55	855	3 882	35	1 238	681

4.2 South–East/Southland (SKI 3) and Challenger/Central (West) (SKI 7)

(a) Estimation of fishery parameters and abundance

Estimates of relative abundance from two time series of trawl surveys used in the model for SKI 3 are presented in Table 13. Proportion-at-age data included in the model came from the *Tangaroa* trawl surveys. Model input parameters used in the assessment are given in Table 14.

Table 13: Biomass indices (t) and coefficients of variation (c.v.) from trawl surveys (assuming areal availability, vertical availability and vulnerability = 1).

Fishstock	Area	Vessel	Trip code	Date	Biomass	% c.v.
SKI 3	Southland	*Shinkai Maru*	SHI8102	Feb 1981	3 900	17
			SHI8201	Mar-Apr 1982	3 100	31
			SHI8303	Apr 1983	5 500	33
SKI 3	Southland	*Tangaroa*	TAN9301	Feb-Mar 1993	1 066	17
			TAN9402	Feb-Mar 1994	406	18
			TAN9502	Feb-Mar 1995	539	25
			TAN9604	Feb-Mar 1996	529	23

Table 14: MIAEL model input parameters used in the SKI 3 & 7 assessment.

Parameter	Estimate
Steepness	0.75
Recruitment variability	1.0
Proportion spawning	0.95
M	0.23
Maximum exploitation (r_{max}) pre-spawning, spawning	0.6, 0.8
Minimum exploitation with maximum catch (r_{mmx})	0.1
Maturity ogive (ages 2–5)	0.1, 0.4, 0.8 1.0

Year class strength was estimated in the model. As some year classes were exceptionally weak or strong, constraints were set to give more realistic estimates of year class strengths. The estimated year class strengths are given in Table 15. These year class strengths were poorly estimated and should be considered as indicative of poor and strong year classes only.

Table 15: Estimated or assumed (*) year class strengths for the base case SKI 3 & 7 assessment.

Year class	Estimate	Year class	Estimate	Year class	Estimate
1979	3.310	1986	0.300	1993	0.010*
1980	1.940	1987	0.001	1994	0.010*
1981	0.001	1988	0.010		
1982	5.690	1989	0.240		
1983	0.070	1990	0.010		
1984	4.250	1991	0.001*		
1985	2.250	1992	0.001*		

(b) Biomass estimates

There was concern over the MIAEL point estimates due to the low value of the performance indices and therefore only the upper and lower bounds using r_{mmx} and r_{max} were reported. B_0 ranged from 26 000 to 73 000 t, B_{mid97} from 0 to 63%, and B_{beg98} from 200 to 51 400 t (see also Figure 1 in the 1997 Plenary Report).

(c) Estimation of Maximum Constant Yield (MCY)

Details of the modelling procedure which produced the B_0 estimates from which MCY was estimated for SKI 3 & 7 are given above. The MCY ranges from 990 to 2770 t. MIAEL point estimates were not reported due to the low value of the performance indices.

(d) Estimation of Current Annual Yield (CAY)

Details of the modelling procedure which produced the B_{beg98} estimates from which CAY was estimated for SKI 3 & 7 are given above. The range of CAY for SKI 3 & 7 for 1998–99 was 20–5900 t. MIAEL point estimates were not reported due to the low value of the performance indices.

5. STATUS OF THE STOCKS

SKI 1 & 2

The assessment of the southern gemfish stock was not updated in 2006. The results presented are from the assessment completed in 2003.

Virgin and current biomass for the northern gemfish stock were estimated assuming one stock (SKI 1 & 2). Year class strengths from 1989 to 1997 appear to have been low, except for one strong cohort in 1991. Under the assumption that the commercial CPUE data are relative abundance indices, the base case model results suggest that the stock is at about 23% of virgin biomass, which is less than B_{MAY}. Projections at current catch levels suggest the stock may increase with average recruitment (1978 to 1997 period) but is likely to decline if recruitment remains at the levels seen in more recent years (1992 to 1997 period).

SKI 3 & 7

The assessment of the southern gemfish stock has not been updated since 1997. Landings from SKI7 have increased in recent years and were over twice the TACC in 2004-05.

Because of the great uncertainty in the stock assessment, only ranges for biomass and yield estimates are presented. These ranges are based on maximum and minimum estimates of B_0. Reported catches in SKI 3 & 7 have increased in the last year with SKI 7 now at 90% of the TACC. Weak year classes appear to be correlated with cold meteorological anomalies and El Nino events between 1989 and 1994 may be responsible for the weak recruitment observed. It is not known if recent catches and the current TACC are sustainable or whether they will allow the stock to move towards the size that will support the MSY.

Summary of yields (t) from base case assessments, TACCs (t) and reported landings (t) for gemfish for the most recent fishing year.

Fishstock	QMA		MCY	CAY	2004–05 Actual TACC	2004–05 Reported landings
SKI 1	Auckland (East) (West)	1 & 9 }			210	233
SKI 2	Central (East)	2 }	850–1 180	680–1 660	240	259
SKI 3	South–East (Coast) (Chatham), Southland, Sub–Antarctic	3, 4, 5, & 6 }			300	72
SKI 7	Challenger, Central (West)	7 & 8 }	990–2 770	–	300	635
SKI 10	Kermadec	10	–	–	10	0
Total					1 060	1199

6. FOR FURTHER INFORMATION

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