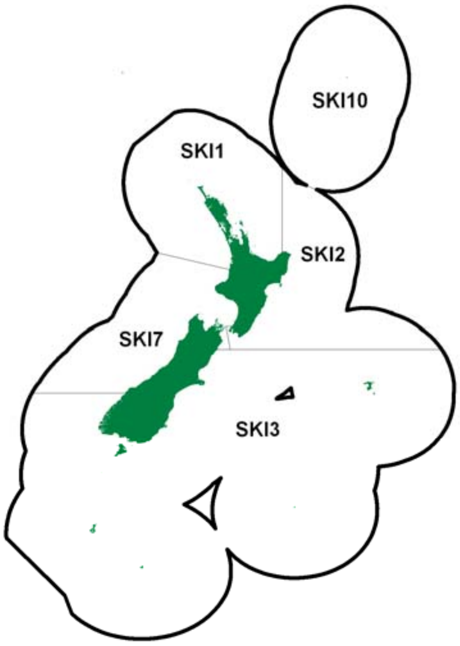
GEMFISH (SKI)

(*Rexea solandri*)
Maka-tikati



1. FISHERY SUMMARY

1.1 Commercial fisheries

Gemfish are caught in coastal waters around mainland New Zealand down to about 550 m. Historical estimated and recent reported gemfish landings and TACCs are shown in Tables 1 and 2, while Figure 1 shows the historical and recent landings and TACC values for the main gemfish stocks. 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 1000 t reported in six of the last eight 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. Both SKI 1 and SKI 2 were allocated customary and recreational allowances of 3 t and 5 t 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	N/A	N/A	N/A	N/A	> 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.
N/A Unknown.

Table 2: Reported landings (t) for the main QMAs from 1931 to 1982.

Year	SKI 1	SKI 2	SKI 3	SKI 7	Year	SKI 1	SKI 2	SKI 3	SKI 7
1931–32	0	0	0	0	1957	2	12	21	10
1932–33	0	0	0	0	1958	5	34	19	28
1933–34	0	42	0	66	1959	2	40	58	38
1934–35	0	70	0	105	1960	3	61	65	39
1935–36	0	39	0	59	1961	6	42	14	19
1936–37	0	37	13	57	1962	5	58	49	27
1937–38	0	86	19	130	1963	19	72	19	38
1938–39	0	50	47	66	1964	17	48	20	29
1939–40	0	48	47	72	1965	19	96	11	28
1940–41	0	58	72	87	1966	12	102	15	26
1941–42	1	63	50	96	1967	32	173	14	46
1942–43	0	47	22	71	1968	18	183	15	33
1943–44	0	15	15	23	1969	60	308	11	22
1944	0	14	15	23	1970	50	281	22	28
1945	6	19	13	30	1971	52	315	24	59
1946	5	20	30	33	1972	85	261	15	37
1947	0	23	74	32	1973	56	237	46	102
1948	1	28	51	44	1974	21	150	14	89
1949	4	19	48	28	1975	2	96	172	37
1950	15	32	59	30	1976	11	108	8	36
1951	5	29	35	27	1977	22	118	4	74
1952	1	21	45	22	1978	36	235	411	1069
1953	1	13	42	10	1979	82	235	2104	628
1954	2	31	12	38	1980	278	287	1899	924
1955	0	25	22	23	1981	236	350	1369	1669
1956	0	31	27	35	1982	546	219	971	676

Notes:

1. The 1931–1943 years are April–March but from 1944 onwards are calendar years.
2. Data up to 1985 are from fishing returns: Data from 1986 to 1990 are from Quota Management Reports.
3. Data for the period 1931 to 1982 are based on reported landings by harbour and are likely to be underestimated as a result of under-reporting and discarding practices. Data includes both foreign and domestic landings.

Table 3: Reported landings (t) of gemfish by Fishstock from 1983–84 to 2014–15 and actual TACs from 1986–87.

Fishstock	SKI 1		SKI 2		SKI 3		SKI 7		SKI 10		
FMA (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	234	210	259	240	72	300	635	300	†10	1 199	1 060
2005–06	230	210	182	240	27	300	248	300	†10	687	1 060
2006–07	215	210	317	240	26	300	209	300	†10	767	1 060
2007–08	216	210	249	240	18	300	179	300	†10	662	1 060
2008–09	191	210	191	240	11	300	213	300	†10	606	1 060
2009–10	247	210	176	240	20	300	144	300	†10	587	1 060
2010–11	226	210	300	240	33	300	301	300	†10	860	1 060
2011–12	212	210	155	240	11	300	260	300	†10	638	1 060
2012–13	182	210	140	240	23	300	234	300	†10	580	1 060
2013–14	198	210	268	240	39	300	268	300	†10	764	1 060
2014–15	83	210	168	240	21	300	231	300	†10	503	1 060

FSU data.

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

† No recorded landings

Table 4: Catch history for gemfish stocks, divided into pre-spawning and spawning seasons (t). N/A - 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	1984	588	0	588	632	1 220
1953	5	0	5	25	30	1985	388	0	388	381	769
1954	5	0	5	60	65	1986	716	0	716	381	1 097
1955	5	0	5	35	40	1987	773	0	773	896	1 669
1956	5	0	5	35	40	1988	696	0	696	1 095	1 791
1957	5	0	5	55	60	1989	1 023	0	1 023	1 011	2 034
1958	5	0	5	30	35	1990	1 230	0	1 230	1 043	2 273
1959	5	0	5	45	50	1991	1 048	10	1 058	949	2 007
1960	5	0	5	85	90	1992	940	77	1 017	1 208	2 225
1961	5	0	5	70	75	1993	1 137	155	1 292	1 020	2 312
1962	5	0	5	60	65	1994	606	550	1 156	1 058	2 214
1963	15	0	15	70	85	1995	438	594	1 032	906	1 938
1964	15	0	15	65	80	1996	485	316	801	789	1 590
1965	20	0	20	130	150	1997	385	580	965	978	1 943
1966	15	0	15	140	155	1998	N/A	N/A	627	671	1 298
1967	35	0	35	240	275	1999	N/A	N/A	413	335	748
1968	40	0	40	250	290	2000	N/A	N/A	409	506	915
1969	100	0	100	375	475	2001	N/A	N/A	335	330	665
1970	95	0	95	400	495	2002	N/A	N/A	201	268	487
1971	100	0	100	420	520	2003	N/A	N/A	206	313	519
1972	130	0	130	400	530	2004	N/A	N/A	221	301	522
1973	45	0	45	300	345	2005	N/A	N/A	234	259	493
1974	35	0	35	230	265	2006	N/A	N/A	230	182	412
1975	10	0	10	170	180	2007	N/A	N/A	215	317	532
1976	30	0	30	190	220	2008	N/A	N/A	216	249	465
1978	90	0	90	240	330	2009	N/A	N/A	191	191	382
1979	120	0	120	200	320	2010	N/A	N/A	247	176	424
1980	140	0	140	450	590	2011	N/A	N/A	226	300	525
1981	120	0	120	500	620	2012	N/A	N/A	212	155	367
1982	100	0	100	320	420	2013	N/A	N/A	182	140	322
1983	360	0	360	730	1 090						

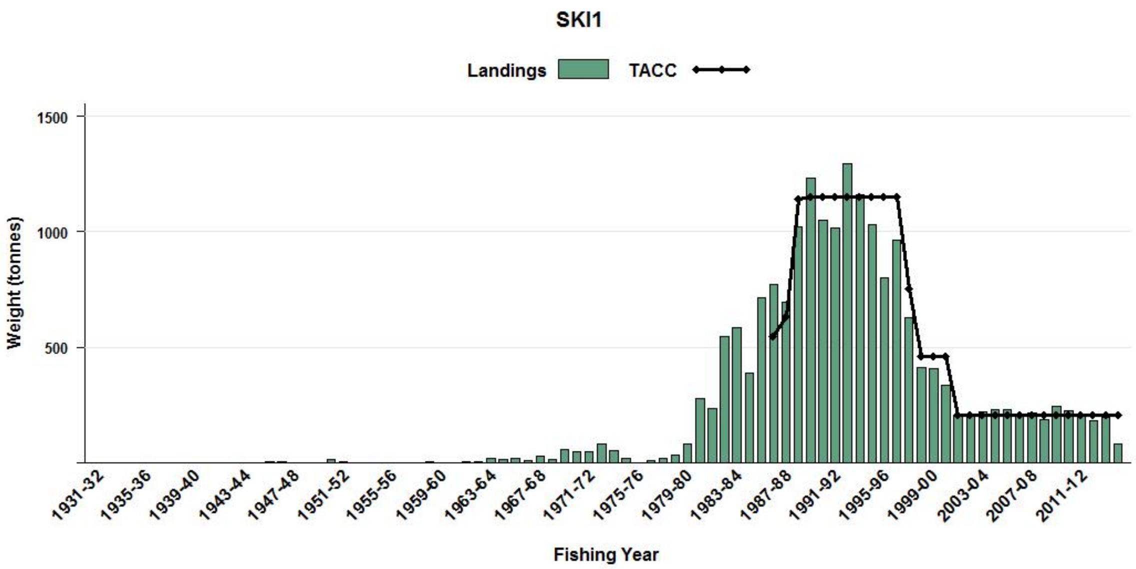
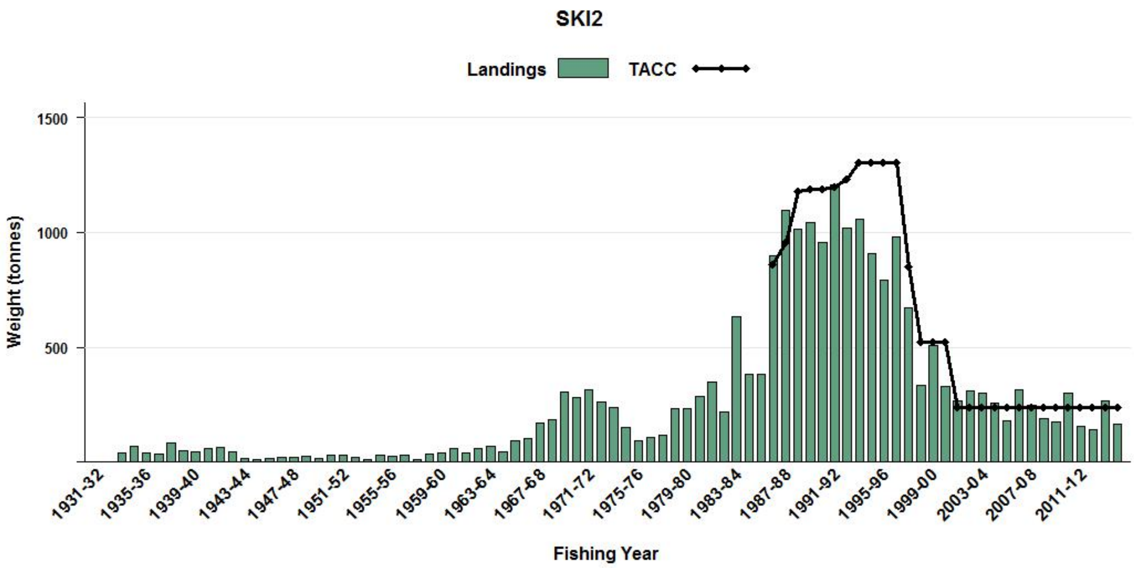
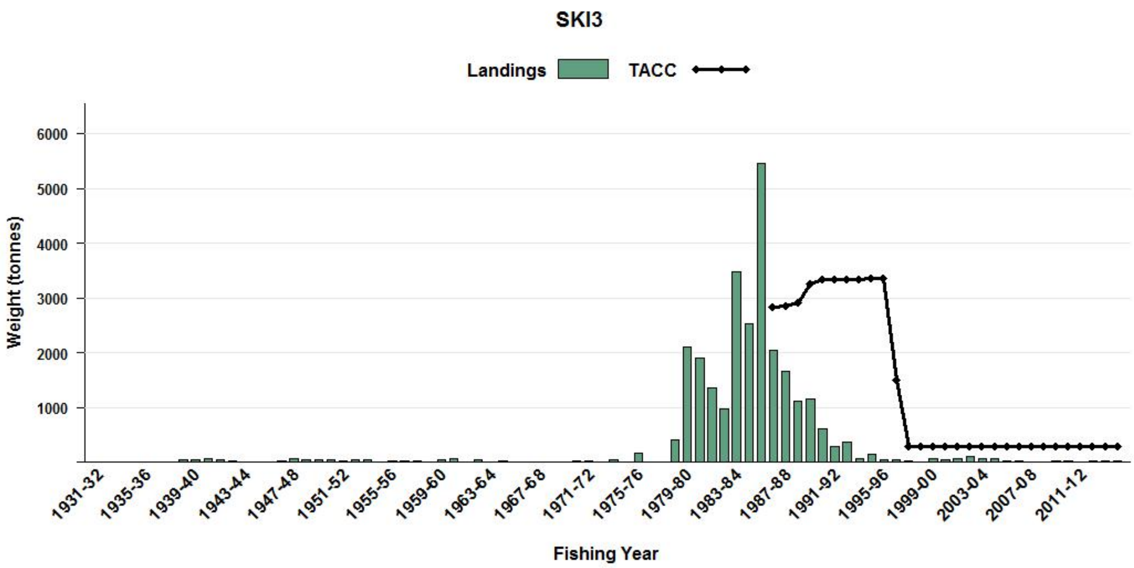


Figure 1: Reported commercial landings and TACC for the four main SKI stocks. SKI 1 (Auckland East). [Continued on next page].





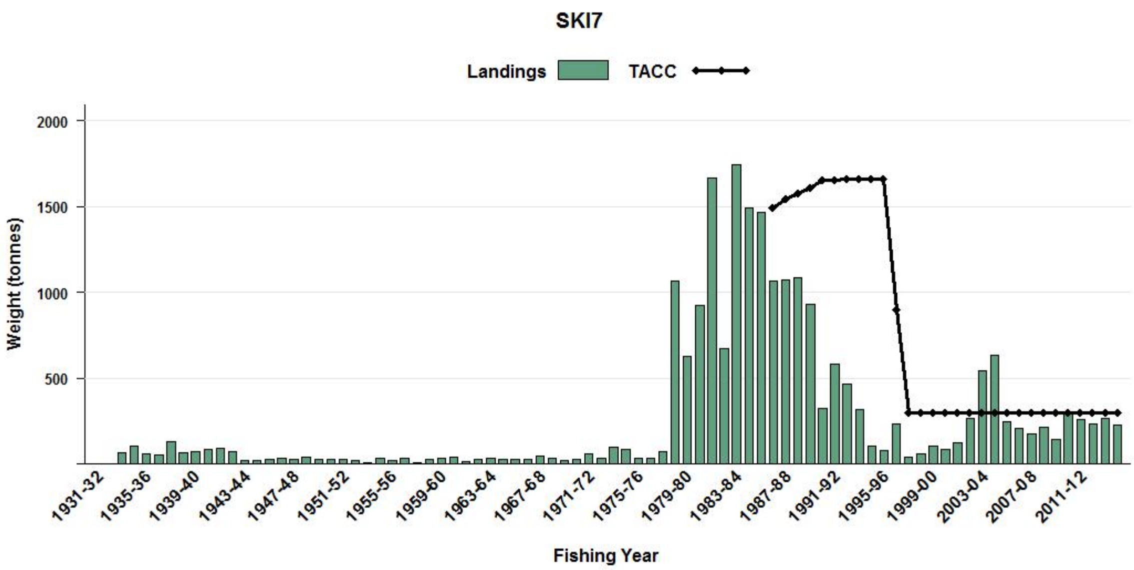


Figure 1: Reported commercial landings and TACC for the four main SKI stocks. From top to bottom right: SKI 1 (Auckland East), SKI 2 (Central East), SKI 3 (South East Coast) and SKI 7 (Challenger).

Most of the recorded catch is taken by trawlers. Target fisheries developed off the eastern and northern coasts of the North Island. From 1993 to 2000 there was a major shift in effort from east of North Cape to the west (Table 4), and over 50% of the SKI 1 catch was taken from QMA 9 in some years. However, the distribution of fishing changed substantially after 2001 when the quota was last reduced. The west coast fishery has since virtually disappeared, as has the fishery off East Northland, each accounting for less than 10% of the SKI 1 catch since 2001–02. . The Bay of Plenty fishery has correspondingly increased, accounting for over 80% of the SKI 1 landings in the same period. While landings in SKI 1 are almost entirely concentrated in the months of May and June, landings in SKI 2 are spread fairly evenly from October to May. SKI 2 landings occur as a bycatch in a range of trawl fisheries, including tarakihi, barracouta, scampi and hoki, although over 80% of the SKI 2 landings are targeted at gemfish. Catches off the west and southern coasts of the South Island are primarily bycatch of hoki and squid target fisheries. Reported landings in SKI 7 increased from 2000, with 2005 being more than double the level of the TACC in 2004–05, but decreased to 144 t in the 2009–10 fishing year. Landings then increased to the TACC in 2010–11, followed by a slight drop in the 2011–12 fishing year. Landings in SKI 3 have remained at very low levels. Figure 1 shows the historical landings and TACC values for the main SKI stocks.

1.2 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. The recently completed national panel survey of New Zealand recreational fishing gave an estimated total NZ harvest of just under 3000 fish (MPI unpublished data).

1.3 Customary non-commercial fisheries
Quantitative information on the current level of customary non-commercial take is not available and is assumed to be negligible.

1.4 Illegal catch
The amount of gemfish misreported is not available and is assumed to be negligible.

1.5 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 1980s as gemfish is a medium value species.

2. BIOLOGY

Gemfish occur on the continental shelf and slope, from about 50–550 m depth. They are known to undertake spawning migrations and the pre-spawning runs have formed 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 is 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 climate variables (Hurst et al 1999).
Biological parameters relevant to the stock assessment are shown in Table 5.

Table 5: 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	-1.1	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	-0.1	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	0.194	-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 two 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 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 & 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 assessment for the SKI 1 and SKI 2 stock was updated in 2007 with new standardised CPUE indices and addition of catch-at-age data up to 2005–06. Further analysis was carried out in 2008 incorporating SKI 2 catch-at-age for 2006–07. A number of changes were made to the 2003 model including the use of age-based selectivities and differential natural mortality.

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 current mature biomass are presented below.

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 non-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 non-spawning (SKI 2) and spawning (SKI 1) season landings used in the assessment are given in Table 4. This table also shows the split between east and west coast catches in SKI 1 from 1991 to 1997. The stock assessment was implemented as a Bayesian single stock model using the general-purpose stock assessment program CASAL v2.20 (Bull et al 2008). 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 a revised catch history, new CPUE abundance indices, four years of catch sampling proportions-at-age data for SKI 2, and one year of catch sampling proportions-at-age data for SKI 1.

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 below.

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

4.1.1 Age composition of commercial catches

Commercial catch-at-age data included in the models were: SKI 1E for 1989 to 1994, 1997 to 1999, 2002, and 2006; SKI 1W for 1996 to 1999, and 2002; and SKI 2 for 1996 to 2005, and 2007. Age data for SKI 1E and SKI 1W were combined for the stock assessment model.

4.1.2 Estimates of abundance

Standardised CPUE indices for SKI 1 and SKI 2 were calculated for three fishery sub-groups in 2007: (1) target catch only; (2) all gemfish catch; and (3) all gemfish catch on TCEPR forms (Figures 2 and 3). The indices for TCEPR all gemfish catch (SKI 1 for 1990 to 2006, SKI 2 for 1994 to 2006) were used in the assessment (Table 6). 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 steep declines to the early 2000s, followed by marked increases in recent years.

In 2007, the WG considered year*area interactions in the CPUE model. This model was used to overcome the difference in timing of catch rate declines in different statistical areas of SKI 1. The catch rate in each statistical area had a different scale but a similar trend. Weighting of data would require relative population sizes (by area) to do correctly.

The WG thought at the time (2007) that the CPUE series should stop in 2001 when the quota was last reduced. Since then the indices are unlikely to be proportional to abundance in the stock given the changes observed in the fishery. The distribution of fishing in SKI 1 has shrunk to a small area in the Bay of Plenty and no fishing occurred on the WCNI in the last three years. In SKI 2 many vessels have left the area or have stopped targeting gemfish, therefore the CPUE series from 1994 to 2001 only should be used. The WG agreed in 2007 to use the CPUE indices from each fishery in the stock assessment based on TCEPR data including all SKI catch (Table 5).

Table 6: Standardised catch per unit effort indices and coefficient of variation (CV) for SKI 1 and SKI 2. The SKI 2 model is the combined mixed target species model (including SKI), based on daily effort data.

	SKI 1		SKI 2	
Year	Index	CV	Index	CV
1990	1.94	0.10	6.28	0.061
1991	1.71	0.12	3.18	0.056
1992	1.36	0.10	1.52	0.053
1993	1.48	0.07	1.65	0.052
1994	1.73	0.06	1.24	0.051
1995	1.65	0.07	1.25	0.053
1996	1.05	0.06	0.76	0.063
1997	1.20	0.06	0.51	0.067
1998	0.86	0.06	0.38	0.068
1999	0.68	0.07	0.55	0.071
2000	0.66	0.07	0.53	0.074
2001	0.56	0.08	0.54	0.070
2002	–	–	0.66	0.070
2003	–	–	0.84	0.062
2004	–	–	1.18	0.060
2005	–	–	0.62	0.065
2006	–	–	0.52	0.061
2007	–	–	0.98	0.057
2008	–	–	1.05	0.063
2009	–	–	0.86	0.060
2010	–	–	0.83	0.056
2011	–	–	1.74	0.052
2012	–	–	1.74	0.053
2013	–	–	1.15	0.060

4.1.3 2014 SKI 2 CPUE update

The SKI 2 CPUE series was updated in 2014 with data up to the end of 2012–13. The SKI 1 series was not updated because of the cessation of fishing in East Northland and SKI 1W. The SKI 2 CPUE series differed from the previous series in a number of ways: a) only bottom trawl was used; b) data from all form types were amalgamated into a day of fishing by a vessel, selecting the modal target species and modal statistical area when there were multiple values within a day; c) target species (including SKI) was included in the analysis as an explanatory variable. Sensitivity analyses included excluding target SKI records and repeating both analyses using only the event-level forms in their original tow-by-tow stratification. These data were used to prepare lognormal models based on positive catch records and binomial models based on the presence/absence of gemfish, which were subsequently combined into a single model using the delta-lognormal method. Gemfish landings from the scampi target fishery were analysed separately as another sensitivity, recognising that this fishery is quite different from the finfish fisheries used in the other analyses, using slower towing speeds and a very different type of net. These data were also analysed using two different data preparation methods: daily amalgamated data or original event-level (tow-by-tow) stratification.

These analyses appear to be extremely robust, with only small differences in the models that excluded or included SKI as a target category (Figure 3). There was also good correspondence with the 2007 CPUE series (even with the SKI 1 series), except at the beginning and the end of the series (Figure 4). The scampi target models were much more variable, given the much smaller data sets being used, but there was broad general agreement in the CPUE indices calculated from all three data sets.

The two daily amalgamated series show a precipitous drop in the first two years of data, followed by a long slow decline up to the end of the 1990s, when the fishery was severely curtailed (Table 3). Since then, there appears to have been gradual increase in relative CPUE, with current levels 3 to 4 times greater than the lowest value observed in 1998 (Table 6). The two tow-by-tow series show the same pattern as the daily effort series over the period of overlap, without the initial steep decline because there are insufficient tow-by-tow data in the years before 1994 (Figure 3).

4.1.3 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 7). 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.

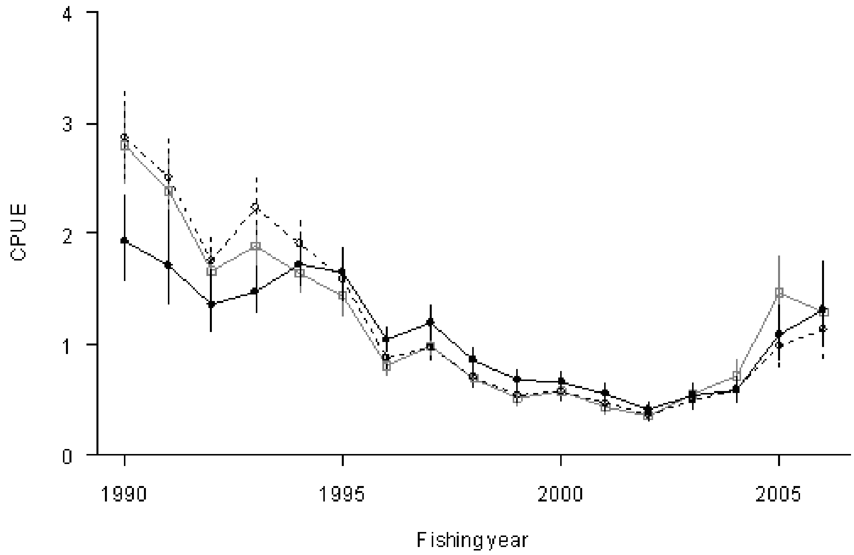


Figure 2: Standardised CPUE indices for the three fishery subgroups in SKI 1: "target catch", black solid; "all catch", black dotted; "TCEPR all catch", gray solid. Vertical bars represent 95% confidence interval.

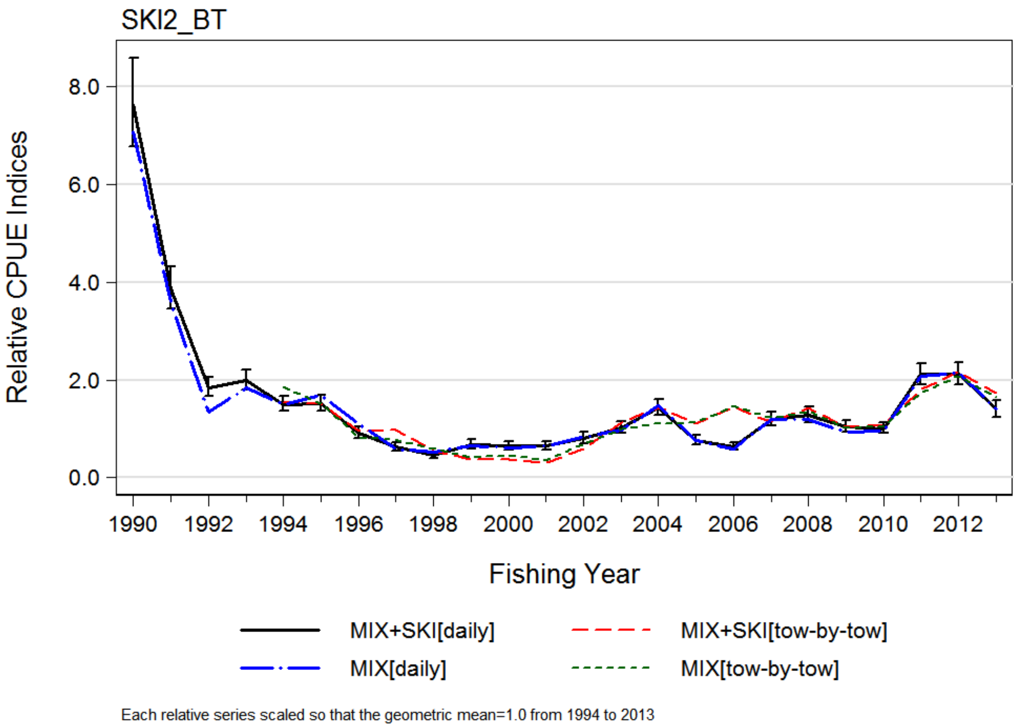


Figure 3: Comparison of the four main combined 2014 SKI 2 CPUE series: a) mixed target species model (including SKI) (daily effort data); b) mixed target species model (without SKI) (daily effort data); b) mixed target species model (including SKI) (tow-by-tow data); b) mixed target species model (without SKI) (tow-by-tow data).

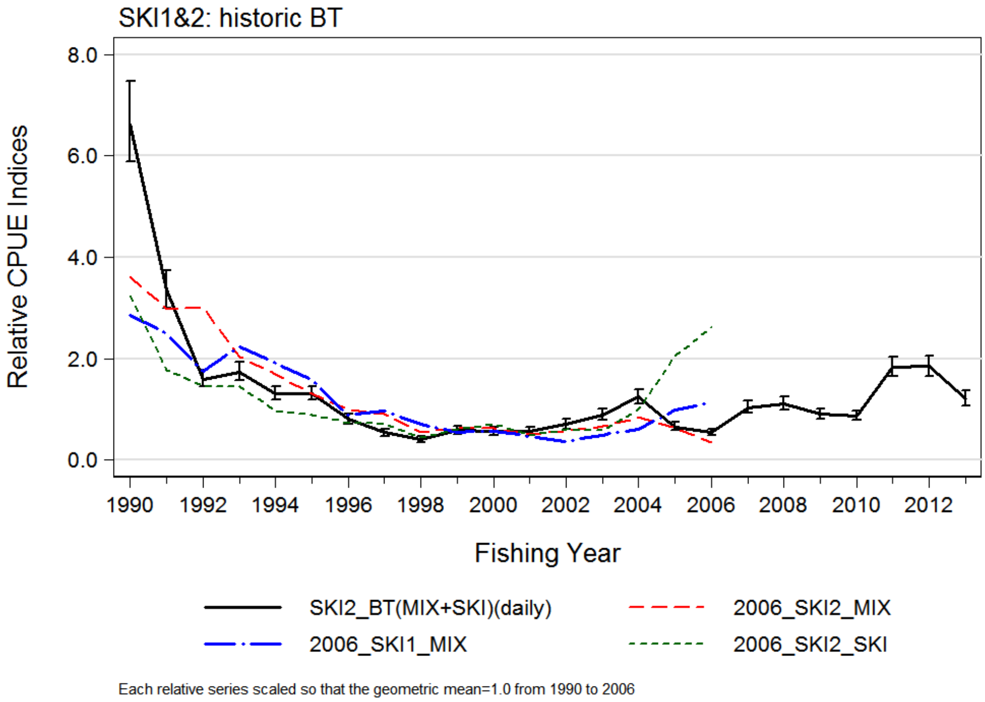


Figure 4: Comparison of the 2014 combined SKI 2 mixed target species model (including SKI) (daily effort data) with three of the 2006 SKI 1&2 CPUE models: SKI 1 mixed target species, SKI 2 mixed target species, SKI 2 target SKI.

Table 7: 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 half 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 separate male and female age-based maturation ogives for SKI 1 and fishing ogives for SKI 2. The SKI 2 fishery was truncated into an early (before 2001) and a late period (after 2002), and separate fishing ogives were used. The SKI 1 fishing ogives were assumed known and were fixed at 1 for all ages.

The age-based fishing ogives for SKI 2 were assumed to be logistic, with male estimated relative to female. The model used logistic migration ogives, one for each sex to determine the rates that fish will mature.

The natural mortality was parameterised by the average of male and female, with the difference estimated within the model. A constant average natural mortality of 0.25 y^{-1} was used. The differential natural mortality, in conjunction with sex-specific fishing ogives were used to account for the between sex difference in proportions at age.

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 CVs, were assumed for all relative biomass and proportions-at-age observations. The CVs 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 CV assumed in the initial model runs for each observation was calculated by adding process error and observation error. The process error added was a CV of 0.14 and 0.20 for the SKI 1 and SKI 2 CPUE series respectively, and 0.48, 0.40, and 0.14 for the SKI 1, SKI 2 early period, and SKI 2 late period proportions-at-age data (run $2006_{YCS2000}$, see Table 9).

Year class strengths were assumed known (and equal to one) for years prior to 1978 and after 2000 (run $2006_{YCS2000}$, see Table 9) 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 8. All priors were intended to be relatively uninformed, and were estimated with wide bounds.

Table 8: The assumed priors assumed for key distributions (when estimated). The parameters are mean (in natural space) and CV for lognormal.

Parameter description	Distribution	Parameters		Bounds	
		Mean	CV	Lower	Upper
B_0	uniform-log	-	-	2 500	250 000
SKI 1 CPUE q	uniform-log	-	-	1×10^{-7}	0.01
SKI 2 CPUE q	uniform-log	-	-	1×10^{-7}	0.01
YCS	lognormal	1	0.9	0.01	10.0
Selectivity	uniform	-	-	0.1	80.0
Maturation	uniform	-	-	1.3	10.0
Difference in M	uniform	-	-	0	0.5
Process error CV.	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).

4.1.4 Results

Estimates of biomass were obtained using the biological parameters and model input described earlier. Three model runs were considered, as there were concerns that the recent SKI 2 catch-at-age samples could be biased due to possible changes in the fishery. Model run "$2006_{YCS2000}$" used data up to 2006 and estimated year class strengths from 1978 to 2000; run "$2006_{YCS2001}$" used the same data but estimated the year class strengths from 1978 to 2001; run "$2007_{YCS2003}$" incorporated data up to 2007, with year class strengths estimated from 1978 to 2003. Table 9 describes the three model runs.

Table 9: Model run labels and descriptions for the base case and sensitivity model runs.

Model run	Description
$2006_{YCS2000}$	Fitting to catch-at-age up to 2006, and CPUE indices based on TCEPR to 2001, and estimating YCSs 1978–00, using an average natural mortality of 0.25 yr^{-1} and separate age-based logistic fishing selectivities for SKI 2 fisheries before and after 2001.
$2006_{YCS2001}$	$2006_{YCS2000}$, but estimated YCS from 1978–2001,
$2007_{YCS2003}$	$2006_{YCS2000}$, but included 2007 SKI 1 and 2 catch and 2007 SKI 2 catch-at-age, and estimated YCSs 1978–2003.

For each model run, MPD fits were obtained and qualitatively evaluated. MPD estimates of biomass trajectories are shown in Figure 5. MCMC estimates of the posterior median and 95% percentile credible intervals for current and virgin biomass are reported in Table 10, and for year class strengths are shown in Figure 6.

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

The between-sex difference in natural mortality was estimated to have a median of 0.02, with a 95% credible interval between 0.01 and 0.03. The median natural mortality was estimated to be about 0.26 for males and 0.24 for female.

The spawning maturation ogives appeared to be poorly estimated; both male and female ogives had broad posterior density estimates. It appears that males were 50% mature at age 6, and females at 7–8 years.

The selectivity ogives for males and females taken by the SKI 2 commercial trawl fishery for the early period were very steep and the 3–4 year-olds had broad posterior density estimates, suggesting considerable uncertainty. The selectivity ogives for the recent period was also steep but had narrow bounds. There were marked differences in the ogives: about 80% and 65% of males were estimated to be fully selected relative to females for the early and recent fishery respectively. There is no information outside the model that allows the shape of the estimated ogives to be verified

Year class strengths were poorly estimated before 1990 when the only data available to determine year class strength were from older fish (see Figure 5). The estimates suggest a period of generally higher than average recruitment during the 1980s, followed by a period of generally lower than average recruitment (1992–2000). For run $2006_{YCS2001}$, the 2001 year class strength was estimated to be weak. For run $2007_{YCS2003}$, recruitment appeared to have improved in 2002 and 2003, but was still below average, and the estimate of 2003 year class strength was very uncertain.

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 lowest level due to increasing exploitation rates combined with a long period of low recruitment since the early 1990s (see Figure 4). For model runs including data up to 2006, the estimated posterior median of B_{2006} was at about 32% of B_0 when the 2001 year class strength was fixed at 1, or 26% of B_0 when this year class was being estimated. More pessimistic estimates of biomass were obtained when 2007 catch-at-data were included, which suggest that the posterior median of B_{2007} was at about 22% of B_0 (see Table 10).

Table 10: Bayesian median and 95% credible intervals of B_0, $B_{current}$, and $B_{current}$ as a percentage of B_0 for the three model runs. $B_{current}$ refers to B_{2006} for run $2006_{YCS2000}$ and $2006_{YCS2001}$, and B_{2007} for run $2007_{YCS2003}$;

Model run	B_0	$B_{current}$	$B_{current}$ (% B_0)
$2006_{YCS2000}$	12 672 (11 398–14 709)	4 007(2 759–5 766)	32(24–40)
$2006_{YCS2001}$	11 691 (10 636–13 283)	3 008(2 024–4 593)	26(19–35)
$2007_{YCS2003}$	10 900 (9 853–12 403)	2 443(1 448–3 924)	22(15–32)

The effect of using a lower and higher value of natural mortality was investigated for run $2007_{YCS2003}$: with the average M set at 0.20, the current biomass is about 16% B_0; with an average M set at 0.30, the current biomass is about 28% B_0. Estimates of other model parameters were relatively insensitive to the assumed value of natural mortality.

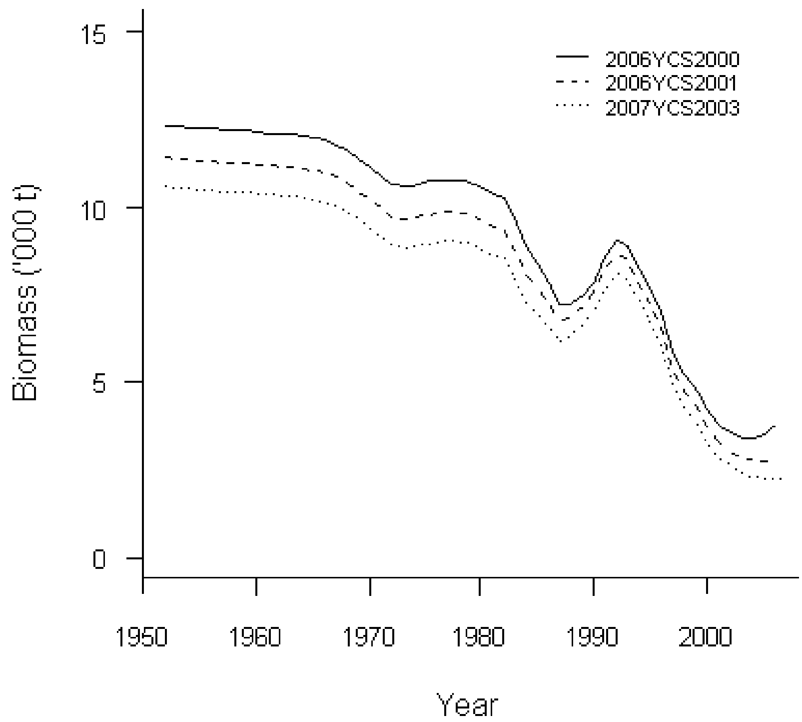


Figure 5: MPD biomass trajectories for the three model runs: *2006YCS2000*, *2006YCS2001*, and *2007YCS2003*.

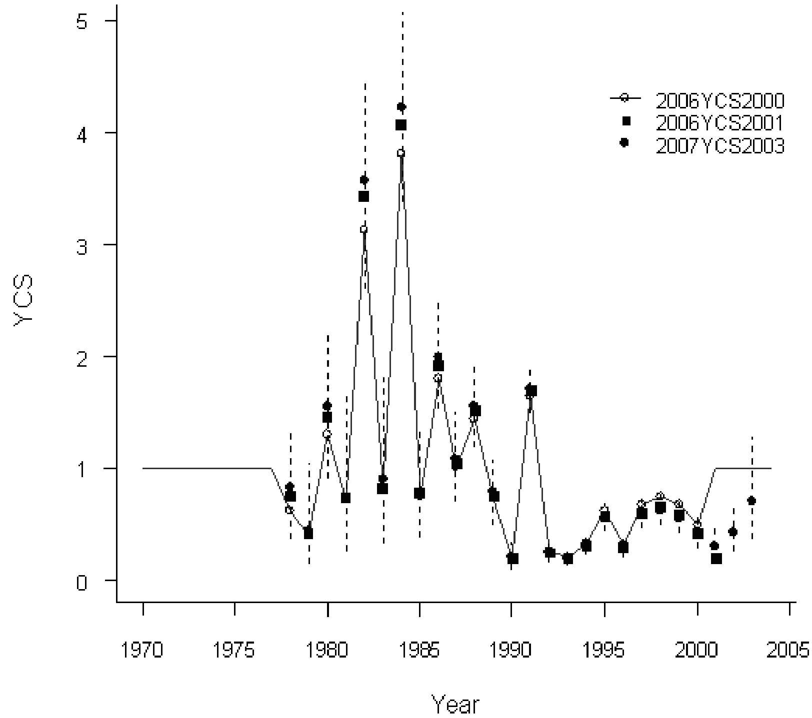


Figure 6: Bayesian median of year class strength for the three model runs *2006YCS2000*, *2006YCS2001*, and *2007YCS2003*. Dotted lines are the 95% credible intervals for run *2007YCS2003*.

4.1.5 Discussion of model results

This assessment updated the 2003 assessment using a similar model structure, revised catch history, revised CPUE indices, and addition of catch-at-age data. The model used sex-specific fishing selectivities and differential natural mortality to account for the sex ratio bias in the data, and the SKI 2 fishery was split into an early and a recent period to account for a possible change in selectivity. Several model runs were carried out, in consideration of the uncertainty of the most recent recruitment, arising from the possible bias in the catch-at-age data in the last few years. Model estimates of the state of the northern gemfish stock show that the current biomass is about 32% of virgin level if recruitments since 2001 were assumed to be average, or 22% of virgin level if more recent recruitments were estimated using the additional catch-at-age data in 2007.

The CPUE indices were only used up to 2001, as the recent indices were considered to be unlikely to track abundance. The fits to the CPUE indices were reasonable, though the SKI 2 indices declined slightly more than those predicted by the model. 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.

The fits to the catch at age data were reasonable and diagnostics showed no great departure from the assumption of normality for all model runs. The models explained most of the between-sex difference for the early and recent SKI 2 catch at age. The main outliers were the SKI 2 female observations in 2005, and it is possible that a larger proportion of female fish have been selected by the trawl. There appear to be some structures in the residuals of the older age classes for the SKI 1 catch at age as there are very few observed 14 and 15+ year old fish from 1989 to 1994.

The additional year class strengths estimated for run $2007_{YCS2003}$ show improvement of recruitment since 2001, which appears to be corroborated by the increase in the abundance indices of the last five years. However, the representativeness of the more recent SKI 2 catch-at-age data needs to be further examined (few age 3 males were observed in 2005, but the 2002 year class was one of the dominant year classes at age five in the 2007 catch at age data). More reliable abundance indices for SKI 1 and 2 fisheries need to be developed in order to obtain better estimates of the recent recruitment.

4.1.6 Yield estimates and projections

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 2008). 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. 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. For all model runs, the current stock status was at or below the estimated B_{MAY} (Table 10).

Table 11: Yield estimates (*MCY* and *CAY*) and associated parameters for the three model runs where simulations were based on recruits resampled from the entire period in which year class strengths were estimated.

Model run	B_{MCY} (t)	B_{MCY} (%B_0)	*MCY* (t)	B_{MAY} (t)	B_{MAY} (%B_0)	*MAY* (t)	*CAY* (t)
$2006_{YCS2000}$	6 698	53	995	4 117	32	1 404	1 305
$2006_{YCS2001}$	6 304	54	865	3 934	34	1 270	925
$2007_{YCS2003}$	5 928	48	816	3 676	34	1 194	755

4.1.7 Projections

The projections were estimated for five years under four scenarios (two alternative recruitment assumptions and two alternative catch levels). Recruitment was randomly resampled from the entire period in which the year class strengths were estimated, or only the recent period (e.g., 1992 to 2000 for run $2006_{YCS2000}$, 1992 to 2001 for run $2006_{YCS2001}$, and 1992 to 2003 for run $2007_{YCS2003}$). Future catches were set equal to the current TACC or the estimated *CAY* (see Table 11).

For all model runs, projections with recruitment resampled from the longer period suggest that the stock is likely to increase when future catches are assumed to be the current TAC, and is likely to decrease slightly when future catches are assumed to be the estimated *CAY*; projections with recruitment resampled from the recent period suggest that the future biomass is likely to decrease under the TAC, and is likely to decrease quickly under the estimated *CAY* (Table 12).

Table 12: Bayesian median and 95% credible intervals of projected biomass B_{PROJ}, B_{PROJ} as a percentage of B_0, and $B_{PROJ}/B_{CURRENT}$(%) for the three model runs where future catches were fixed at either TAC or estimated *CAY*, and future recruitments were randomly sampled from the long period or from the recent period. B_{PROJ} and $B_{CURRENT}$ refer to B_{2011} and B_{2006} for run $2006_{YCS2000}$ and $2006_{YCS2001}$, and B_{2012} and B_{2006} for run $2007_{YCS2003}$;

Model run	Catch (t)	Recruitment	B_{PROJ}	B_{PROJ} (%B_0)	$B_{PROJ}/B_{CURRENT}$ (%)
$2006_{YCS2000}$	450	1978–2000	6 060 (3 242–12 075)	47 (27–92)	151 (94–264)
	450	1992–2000	3 815 (2 128–6 071)	30 (18–44)	98 (74–122)
	1 305	1978–2000	3 472 (595–8 535)	27 (5–65)	85 (17–200)
	1 305	1992–2000	1 195 (135–3 414)	9 (1–24)	31 (5–66)
$2006_{YCS2001}$	450	1978–2001	4 263 (2 010–8 844)	36 (18–74)	140 (76–286)
	450	1992–2001	2 436 (1 257–4 136)	21 (11–32)	81 (57–107)
	1 305	1978–2001	2 809 (630–7 744)	23 (6–64)	91 (24–235)
	1 305	1992–2001	999 (100–2 863)	9 (1–22)	34 (5–68)
$2007_{YCS2003}$	450	1978–2003	3 580 (1 531–6 990)	33 (15–62)	139 (82–280)
	450	1992–2003	2 361 (1 019–4 509)	21 (10–38)	96 (62–137)
	755	1978–2003	2 497 (692–6 200)	23 (7–54)	99 (36–233)
	755	1992–2003	1 476 (199–3 481)	14 (2–29)	59 (13–105)

The projections suggest that unless recruitment improves and the catch remains at moderately low levels, the biomass is unlikely to increase in the short term.

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

4.2.1 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 (CV) from trawl surveys (assuming area availability, vertical availability and vulnerability = 1).

Fishstock	Area	Vessel	Trip code	Date	Biomass	% CV
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

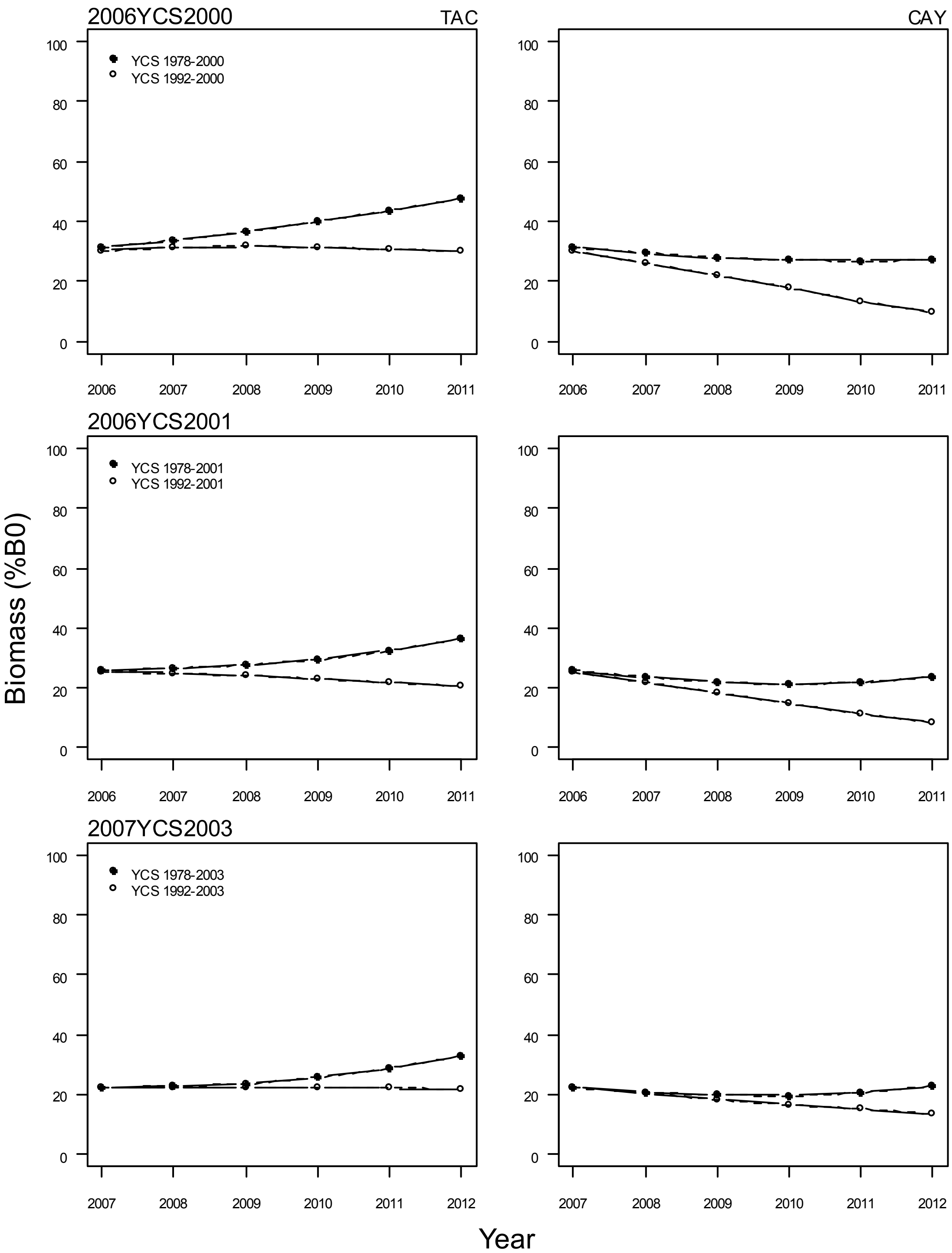


Figure 7: Bayesian median of projected biomass (% B_0) for the three model runs, with future catch fixed at TAC or estimated *CAY*, and future recruitment randomly resampled from the long period or the recent period.

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*		

4.2.2 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).

4.2.3 Yield estimates and projections
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.

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

Stock Structure Assumptions
Gemfish are assessed as two biological stocks, based on spawning migration and timing and the location of spawning grounds. These stocks are managed and assessed separately and are assumed to be non-mixing. The SKI 1&2 stock is based on the east coast North Island, migrating north to spawn north of the North Island during May–June. The SKI 3&7 stock occurs in the south of New Zealand and migrates to the west coast South Island to spawn in August–September.

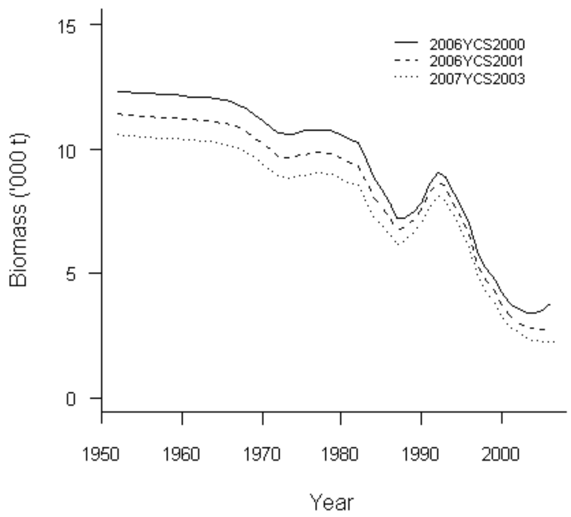
A new stock assessment was completed for SKI 1 & 2 in 2008.

SKI 1&2

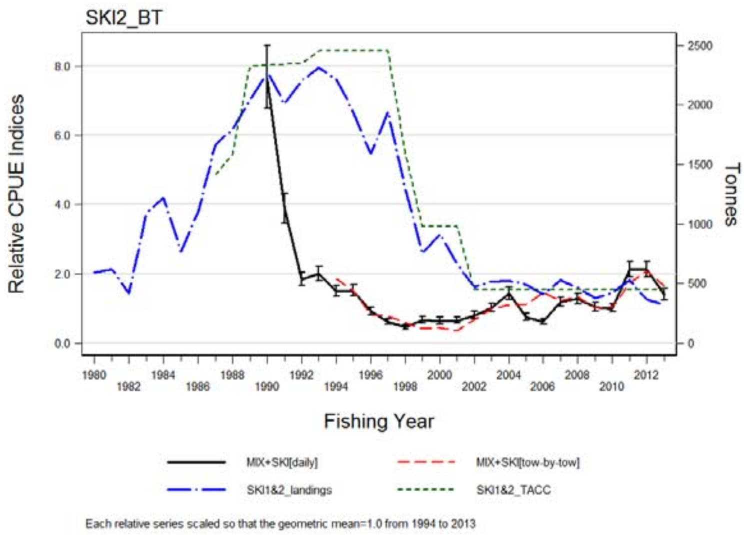
Stock Status	
Year of Most Recent Assessment	2008: Stock Assessment 2014: CPUE update
Assessment Runs Presented	Stock Assessment Three cases are presented. There was no single preferred model. CPUE Update Combined (lognormal + binomial) model based on mixed target species (including SKI) using daily effort data for statistical areas 11-19
Reference Points	Management Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: -
Status in relation to Target	B_{2006} was estimated at 32% B_0 ($2006_{YCS2000}$) and 26% B_0 ($2006_{YCS2001}$), and B_{2007} at 22% B_0 ($2007_{YCS2003}$) in the three models Unlikely (< 40%) to be at or above the target in 2006 The 2014 CPUE analysis indicates that relative abundance increased by 119% from the mean for 2005–2007 to the mean for 2011–13. Although biomass is increasing, it is not known whether the stock has reached the target

Status in relation to Limits	B_{2006} was estimated to be Unlikely (< 40%) to be below both the Soft Limit and the Hard Limit
Status in relation to Overfishing	-

Historical Stock Status Trajectory and Current Status



MPD biomass trajectories for the three model runs: *2006$_{YCS2000}$*, *2006$_{YCS2001}$*, and *2007$_{YCS2003}$*.



Historical CPUE Trajectory with combined SKI 1&2 landings and TACC (t)

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Standardised CPUE has increased steadily since the late 1990s.
Recent Trend in Fishing Mortality or Proxy	Fishing pressure has declined with the decrease in TACC since 1999–2000.
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	One strong year class was estimated to have occurred in 1991. Recruitment in recent years appears lower than seen previously.

Projections and Prognosis		
Stock Projections or Prognosis	With catches at the current TACC the stock is projected to increase if recruitment returns to the 1978–2000 average level, but decline slightly if recent (1992–2000) recruitment continues.	
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Soft Limit: Very Unlikely (< 10%) Hard Limit: Very Unlikely (< 10%)	
Probability of Current Catch or TACC causing Overfishing to continue or to commence	-	
Assessment Methodology and Evaluation		
Assessment Type	Type 1 – Quantitative Stock Assessment (to 2006) Type 2 – Partial Quantitative Stock Assessment (2014)	
Assessment Method	Age-structured CASAL model with Bayesian estimation of posterior distributions	
Assessment Dates	Latest assessment: 2007 CPUE update: 2014	Next assessment: Unknown next CPUE update: 2017
Overall assessment quality rank	-	
Main data inputs (rank)	Stock Assessment Updated from previous assessment: - Catch history - CPUE abundance indices - Proportions-at-age data (1 year SKI 1, 4 years SKI 2) CPUE Analysis MPI catch and effort data	
Data not used (rank)	-	
Changes to Model Structure and Assumptions	Incorporation of: - Age based selectivities - Differential natural mortality - Additional year of age data	
Major Sources of Uncertainty	Stock Assessment Uncertainty in recent recruitment necessitated the development of multiple models, however, without more reliable abundance indices to estimate recent recruitment it is unwise to prefer a single model. CPUE Steep decline in first two years of series and sustained high catches suggest the first two data points may not reliably reflect abundance.	

Qualifying Comments
-

Fishery Interactions

Gemfish are common bycatch in the hoki, tarakihi, scampi and squid target fisheries, although some gemfish target fisheries do exist. Bycatch is variable but includes hoki, tarakihi, silver warehou and bluenose. Bycatch of concern includes fur seals and seabirds.

SKI 3 & 7

The assessment of the southern gemfish stock has not been updated since 1997. Landings from SKI 7 increased from 2000 to be a level over twice the TACC in 2004–05, but have decreased since then.

Table 16: Summary of yields (t) from base case assessments, TACCs (t) and reported landings (t) for gemfish for the most recent fishing year.

Fishstock	QMA	FMAs	*MCY*	*CAY*	2014–15 Actual TACC	2014–15 Reported landings
SKI 1	Auckland (East) (West)	1 & 9 }			210	83
SKI 2	Central (East)	2 }	816	-	240	168
SKI 3	South-East (Coast) (Chatham), Southland, Sub-Antarctic	3, 4, 5, & 6 }			300	21
SKI 7	Challenger, Central (West)	7 & 8 }	990–2 770	-	300	231
SKI 10	Kermadec	10	-	-	10	0
Total					1 060	503

6. FOR FURTHER INFORMATION

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