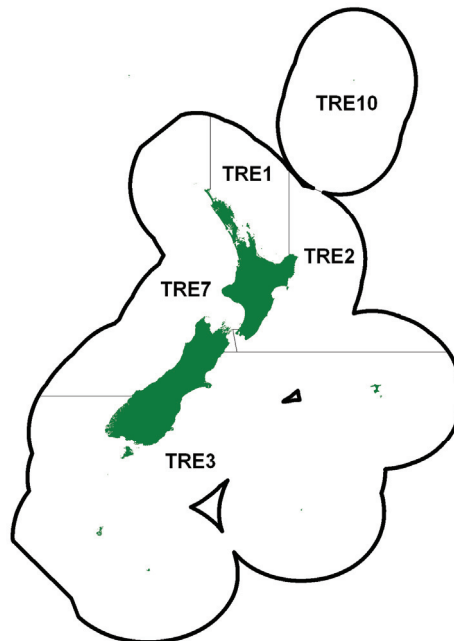


TREVALLY (TRE)*(Pseudocaranx dentex)*

Arara

**1. FISHERY SUMMARY**

Trevally was introduced into the QMS in 1986 with five QMAs. The TAC was set under the provisions of the 1983 Fisheries Act and accordingly refers to only the commercial catch limit. Allowances for customary fishers, recreational fishers and an allowance for others sources of mortality have not yet been set.

1.1 Commercial fisheries

Trevally is caught around the North Island and the north of the South Island, with the main catches from the northern coasts of the North Island. Trevally is taken in the northern coastal mixed trawl fishery, mostly in conjunction with snapper. Since the mid 1970s trevally has been taken by purse seine, mainly in the Bay of Plenty, in variable but often substantial quantities. Setnet fishermen take modest quantities. Recent reported trevally landings and actual TACs are shown in Table 1, while Figure 1 shows the historical landings and TACC values for the main trevally stocks.

Table 1: Reported landings (t) of trevally by Fishstock from 1983 to 2008–09 and actual TACs (t) from 1986–87 to 2008–09. QMS data from 1986-present.

Fishstock QMA (s)	TRE 1		TRE 2		TRE 3		TRE 7		TRE 10	
	Landings	TAC	Landings	TAC	Landings	TAC	Landings	TAC	Landings	TAC
1983*	1 534	–	77	–	3	–	2 165	–	0	–
1984*	1 798	–	335	–	1	–	1 707	–	0	–
1985*	1 887	–	162	–	1	–	1 843	–	0	–
1986*	1 431	–	161	–	3	–	1 830	–	0	–
1986–87	982	1 210	237	190	<1	20	1 626	1 800	0	10
1987–88	1 111	1 210	267	219	<1	20	1 752	1 800	0	10
1988–89	818	1 413	177	235	<1	20	1 665	2 010	0	10
1989–90	1 240	1 493	275	237	18	20	1 589	2 146	0	10
1990–91	1 011	1 495	273	238	8	22	2 016	2 153	0	10
1991–92	1 169	1 498	197	238	<1	22	1 367	2 153	<1	10
1992–93	1 328	1 505	247	241	<1	22	1 796	2 153	<1	10
1993–94	1 162	1 506	230	241	<1	22	2 231	2 153	0	10
1994–95	1 242	1 506	179	241	<1	22	2 138	2 153	0	10
1995–96	1 175	1 506	211	241	<1	22	2 019	2 153	0	10
1996–97	1 174	1 506	317	241	<1	22	1 843	2 153	0	10
1997–98	1 027	1 506	223	241	3	22	2 102	2 153	0	10
1998–99	1 469	1 506	284	241	24	22	2 148	2 153	0	10
1999–00	1 424	1 506	309	241	3	22	2 254	2 153	0	10
2000–01	1 049	1 506	211	241	<1	22	1 888	2 153	0	10
2001–02	1 085	1 506	243	241	<1	22	1 856	2 153	0	10

TREVALLY (TRE)

Table 1 continued:

Fishstock QMA (s)	TRE 1		TRE 2		TRE 3		TRE 7		TRE 10	
	Landings	TAC	Landings	TAC	Landings	TAC	Landings	TAC	Landings	TAC
2002-03	1 014	1 507	270	241	< 1	22	2 029	2 153	0	10
2003-04	1 111	1 507	251	241	< 1	22	2 186	2 153	0	10
2004-05	977	1 507	319	241	< 1	22	1 945	2 153	0	10
2005-06	1 149	1 507	417	241	< 1	22	1 957	2 153	0	10
2006-07	790	1 507	368	241	< 1	22	1 739	2 153	0	10
2007-08	847	1 507	230	241	< 1	22	1 797	2 153	0	10
2008-09	855	1 507	302	241	< 1	22	2 018	2 153	0	10

QMA (s)	Total	
	Landings	TAC
1983*	3 779	-
1984*	3 841	-
1985*	3 893	-
1986*	3 425	-
1986-87	2 845	2 230
1987-88	3 131	3 259
1988-89	2 651	3 688
1989-90	3 122	3 906
1990-91	3 308	3 918
1991-92	2 733	3 921
1992-93	3 371	3 931
1993-94	3 624	3 932
1994-95	3 559	3 932
1995-96	3 405	3 932
1996-97	3 333	3 932
1997-98	3 355	3 932
1998-99	3 925	3 932
1999-00	3 989	3 932
2000-01	3 148	3 932
2001-02	3 185	3 933
2002-03	3 313	3 933
2003-04	3 548	3 933
2004-05	3 241	3 933
2005-06	3 524	3 933
2006-07	2 897	3 933
2007-08	2 875	3 933
2008-09	3 175	3 933

Recent landings from TRE 1 were 847 t and 855 t in 2007-08 and 2008-09 respectively (56 and 57% of the TAC). This is a slight increase since the low catch of 790 t in 2006-07. For TRE 2, catches have exceeded the TAC in seven of the last eight fishing years.

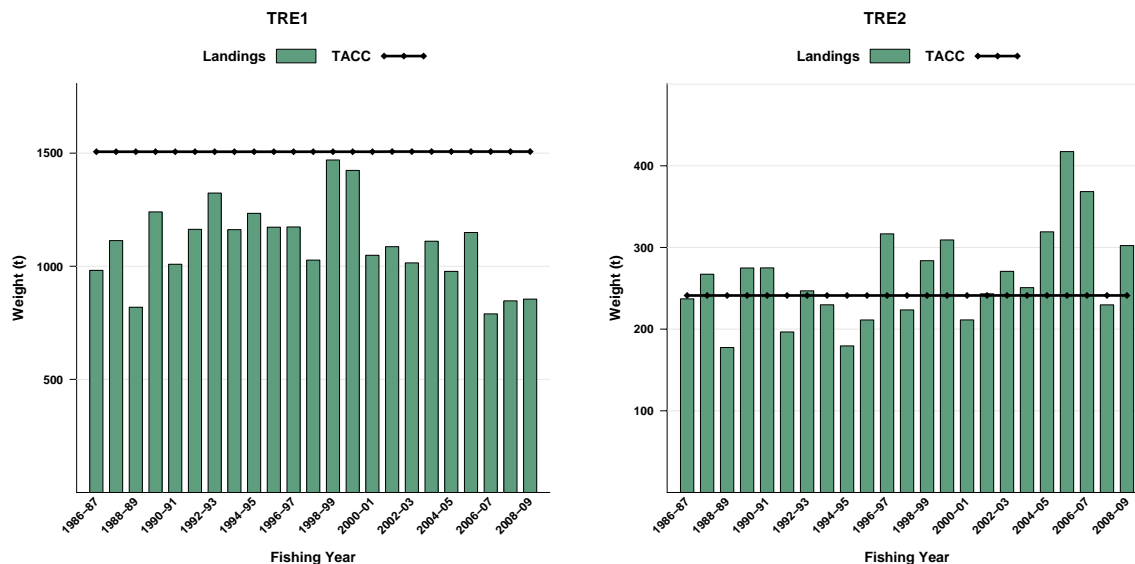


Figure 1: Historical landings and TACC for the three main TRE stocks. Left: TRE1 (Auckland) and Right: TRE2 (Central East). Note that these figures do not show data prior to entry into the QMS. Continued on next page...

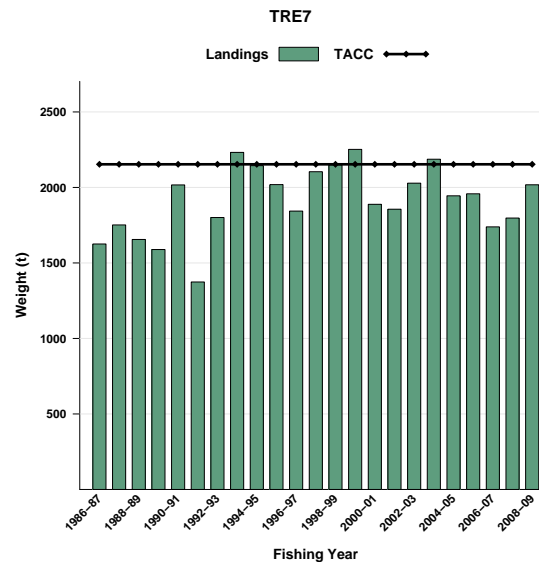


Figure 1 continued: Historical landings and TACC for TRE7 (Challenger). Note that these figures do not show data prior to entry into the QMS.

1.2 Recreational fisheries

Recreational fishers catch trevally by setnet and line. Although highly regarded as a table fish, some trevally may be used as bait. There is some uncertainty with all recreational harvest estimates for trevally as presented in Table 2.

Table 2: Estimated number of trevally harvested by recreational fishers by Fishstock. (Source: Tierney et al. 1997; Bradford, 1997; Bradford, 1998; Boyd & Reilly, 2002; Boyd et al. 2004; Hartill et al. 2008).

Survey Year	TRE 1				TRE 7			
	Number	CV (%)	Range	Estimated Harvest (t)	Number	CV (%)	Range	Estimated Harvest (t)
1992	186 000	-	240-280	260	68 000	-	65-120	92.5
1994	180 000	9	-	228#	62 000	18	-	78.5
1996	194 000	7	215-255	234	67 000	11	60-80	70
2000	701 000	13	5 90.9-764	677.4	69 000	27	58.8-102.6	81
2001	449 000	19	-	434.2	107 000	21	-	124.3
2005		18		104.7				

Survey Year	TRE 2				TRE 3			
	Number	CV (%)	Range	Estimated Harvest (t)	Number	CV (%)	Range	Estimated Harvest (t)
1992	10 000	-	15-25	20	6 000	-	-	7.6#
1994	-	-	-	-	-	-	-	-
1996	9 000	19	10-15	13	2 000	-	-	2.5#
2000	153 000	60	63.2-256.6	160	10 000	45	5.6-14.8	10
2001	32 000	23	-	339	2 000	46	-	1.7

#No harvest estimate available in the survey report, estimate presented is calculated as average fish weight for all years and areas by the number of fish estimated caught.

Recreational harvest estimates by fish stock were obtained from national telephone diary surveys undertaken in 1996 and 2000, with a follow up survey in 2001. Regional telephone diary surveys were undertaken in 1991-92 in the South Region, 1992-93 in the Central Region and in 1993-04 in the North Region.

The Recreational Technical Working Group recommends that the harvest estimates from the diary surveys should be used only with the following qualifications: a) they may be very inaccurate; b) the 1996 and earlier surveys contain a methodological error; and, c) the 2000 and 2001 estimates are implausibly high for many important fisheries. Relative comparisons may be possible between stocks within these surveys.

Owing to the limitations of diary surveys a combined aerial overflight / boat ramp survey was undertaken in FMA 1 during 2005, primarily targeting snapper (Hartill *et al.* 2007). The TRE 1

TREVALLY (TRE)

recreational harvest was estimated by this survey to be 105t (Hartill *et al.* 2008); which is substantially lower than estimates from diary surveys.

1.3 Customary non-commercial fisheries

Trevally is an important traditional and customary food fish for Maori. No quantitative information is available on the current level of customary non-commercial take.

1.4 Illegal catch

No quantitative information is available on the level of illegal trevally catch. An estimate of historic illegal catch is incorporated in the TRE 7 stock assessment model catch history (see Table 5).

1.5 Other sources of mortality

No quantitative estimates are available regarding the impact of other sources of mortality on trevally stocks. Trevally are known to occur in sheltered harbour and estuarine ecosystems particularly as juveniles. Some of these habitats are known to have suffered substantial environmental degradation.

2. BIOLOGY

Trevally are both pelagic and demersal in behaviour. Juvenile fish up to 2 years old are found in shallow inshore areas including estuaries and harbours. Young fish enter a demersal phase from about 1 year old until they reach sexual maturity. At this stage adult fish move between demersal and pelagic phases. Schools occur at the surface, in mid-water and on the bottom, and are often associated with reefs and rough substrate. Schools are sometimes mixed with other species such as koheru and kahawai. The occurrence of trevally schools at the surface appears to correlate with settled weather conditions rather than with a specific time of year.

Surface schooling trevally feed on planktonic organisms, particularly euphausiids. On the bottom, trevally feed on a wide range of invertebrates.

Trevally are known to reach in excess of 40 years of age. The growth rate is moderate during the first few years, but after sexual maturity at 32 to 37 cm fork length (FL), the growth rate becomes very slow. The largest fish are typically around 60 cm FL and weigh about 4.5 kg, however much larger fish of 6–8 kg are occasionally recorded.

Fecundity is relatively low until females reach about 40 cm FL. They appear to be partial spawners, releasing small batches of eggs over periods of several weeks or months during the summer. Biological parameters relevant to stock assessment are shown in Table 3.

Table 3: Estimates of biological parameters.

Fishstock	Estimate		Source	
1. Natural mortality (M) See section 4.1.4				
2. Weight = $a(\text{length})^b$ (Weight in g, length in cm fork length).	Both sexes			
	a	b	James (1984)	
TRE 1	0.016	3.064		
3. von Bertalanffy growth parameters	Both sexes			
	L_∞	k	t_0	
TRE 1	47.55	0.29	-0.13	Walsh <i>et al.</i> 1999
TRE 7	46.21	0.28	-0.25	

3. STOCKS AND AREAS

There are no new data that would alter the stock boundaries given in previous assessment documents.

4. STOCK ASSESSMENT

A stock assessment was attempted for TRE 1, but was not accepted by the Pelagic Working Group as no reliable abundance index was available. The TRE 7 stock assessment was updated in 2009 (Langley and Maunder 2009).

Estimates of absolute biomass are not available for any stock. Biomass indices are available from *Kaharoa* trawl surveys of the Hauraki Gulf, Bay of Plenty, east Northland, and the west coast of the North Island. These relative indices are unlikely to be directly proportional to true stock abundance due to the following factors: (a) the mixed demersal-pelagic nature of trevally; (b) trawl survey gear efficiency is not optimal for the sampling of trevally; and (c) a direct correlation has been found to exist between sea surface temperature during surveys and relative biomass. These factors are most likely to confound any visible trend in the relative abundance indices for trevally produced from past trawl surveys.

4.1 Challenger, Central West and Auckland West (TRE 7)

4.1.1 CPUE

A standardised CPUE index of abundance was used in the 2009 assessment (Table 4). This was based on positive catches made using single bottom trawls whilst targeting trevally or snapper and covered the period 1989-90 to 2007-08 (Kendrick & Bentley 2009). A second standardized CPUE index - based on data aggregated by month, vessel class and statistical area (Francis *et al.* 1999) was used for an earlier period (1977-78 to 1996-97) in one of the sensitivity runs.

Table 4: Standardised single trawl CPUE indices (relative year effects) with number of vessel days fished from 1989-90 to 2007-08 (Kendrick and Bentley 2009).

Fishing year	Year of relative effect	CPUE index
1989-90	1990	5.94
1990-91	1991	3.79
1991-92	1992	3.06
1992-93	1993	2.22
1993-94	1994	2.51
1994-95	1995	2.29
1995-96	1996	2.48
1996-97	1997	2.56
1997-98	1998	2.36
1998-99	1999	2.88
1999-00	2000	2.57
2000-01	2001	2.34
2001-02	2002	2.62
2002-03	2003	3.05
2003-04	2004	2.86
2004-05	2005	2.43
2005-06	2006	3.05
2006-07	2007	2.42
2007-08	2008	2.73

4.1.2 Catch history

Commercial catch records for TRE 7 date back to 1944. Before that time the stock is assumed to have been lightly exploited and close to its virgin state. It is likely that reported catches prior to 1970 are underestimates of the true catch due to large-scale discarding of fish (James 1984).

Over the period since 1944, there has also been a recreational and customary catch as well as an illegal or non-reported catch. For the purposes of modelling the TRE 7 stock, it is necessary to make allowance for mortality due to discarded fish, recreational catch, customary catch, and non-reported catch. The agreed catch history for the model is given in Table 5.

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Table 5: Catch history (t) for the TRE 7 fishery including total annual reported commercial catch, estimated discarded (D) commercial catch, estimated non-reported commercial catch, recreational catch, and customary catch. (The year denotes the year at the end of the fishing year).

Year	Reported landings	D	Under-reported catch	Rec. catch	Cust. catch	Total	Year	Reported landings	D	Under-reported catch	Rec. catch	Cust. catch	Total
1944	3	2	1	14	15	34	1960	595	128	119	48	10	900
1945	3	2	1	16	15	36	1961	471	101	94	51	10	727
1946	3	2	1	18	15	38	1962	543	116	109	53	10	831
1947	14	7	3	20	15	59	1963	662	142	132	55	10	1 001
1948	8	4	2	23	15	52	1964	534	114	107	57	10	822
1949	7	4	1	25	15	52	1965	544	117	109	59	10	839
1950	15	8	3	27	15	68	1966	1 080	60	216	61	10	1 427
1951	36	18	7	29	15	105	1967	1 493	83	299	64	10	1 949
1952	31	16	6	31	15	99	1968	1 515	84	303	66	10	1 978
1953	103	52	21	33	15	223	1969	1 322	73	264	68	10	1 737
1954	78	39	16	36	15	184	1970	1 682	0	336	70	10	2 098
1955	138	69	28	38	15	288	1971	2 037	0	407	70	10	2 524
1956	130	65	26	40	15	276	1972	2 226	0	445	70	10	2 751
1957	296	148	59	42	15	560	1973	2 320	0	464	70	10	2 864
1958	343	172	69	44	15	642	1974	2 024	0	405	70	10	2 509
1959	351	176	70	46	15	658	1975	1 598	0	320	70	10	1 998

Year	Reported landings	D	Under-reported catch	Rec. catch	Cust. catch	Total	Year	Reported landings	D	Under-reported catch	Rec. catch	Cust. catch	Total
1976	1 894	0	379	70	10	2 353	1993	1796	0	72	70	12	1950
1977	2 113	0	423	70	10	2 616	1994	2231	0	67	70	12	2380
1978	2 322	0	464	70	10	2 866	1995	2138	0	43	70	12	2263
1979	2 600	0	520	70	10	3 200	1996	2019	0	20	70	12	2121
1980	2 493	0	499	70	12	3 074	1997	1844	0	18	70	12	1944
1981	2 844	0	569	70	12	3 495	1998	2103	0	21	70	12	2206
1982	2 497	0	499	70	12	3 078	1999	2148	0	21	70	12	2251
1983	2 165	0	433	70	12	2 680	2000	2254	0	23	70	12	2359
1984	1 707	0	341	70	12	2 130	2001	1888	0	19	70	12	1989
1985	1 843	0	369	70	12	2 294	2002	1810	0	18	70	12	1910
1986	1 678	0	336	70	12	2 095	2003	2050	0	21	70	12	2153
1987	1 626	0	163	70	12	1 871	2004	2156	0	22	70	12	2260
1988	1752	0	158	70	12	1992	2005	1945	0	19	70	12	2046
1989	1665	0	133	70	12	1880	2006	1957	0	20	70	12	2059
1990	1589	0	111	70	12	1782	2007	1739	0	17	70	12	1838
1991	2016	0	121	70	12	2219	2008	1739	0	17	70	12	1838
1992	1367	0	68	70	12	1517							

4.1.3 Catch at age

A time series of age frequency distributions is available from the target TRE 7 single trawl fishery from 1997–98 to 2008–09. There are also some age frequency samples for the pair trawl method. Previous comparisons found no significant difference between the age composition of catches made by pair and single trawl methods (Hanchet 1999).

In addition, two sources of age frequency data are available from the 1970s: (1) a series covering the years 1971–74 derived from research sampling carried out by the vessel *James Cook*, and (2) a series derived from market sampling carried out in the 1974–76 and 1978–79 fishing years. These data were incorporated in the assessment, but further exploration is required with respect to the sampling protocols, data validation, and the weighting given to the data.

4.1.4 Estimate of natural mortality (M)

Initial model runs fixed the value of natural mortality at 0.10, the value used in previous assessments. A likelihood profile for the parameter indicated that 0.10 was at the upper range of the plausible values for M , given the observational data and the structural assumptions of the model, and two alternative values of M were considered: the most likely value ($M=0.087$) and a lower value corresponding to a relative likelihood of 0.05 ($M=0.075$) (Langley and Maunder 2009).

Estimates of current biomass and stock status were highly sensitive to the assumed value of natural mortality. This was due to the lack of contrast in the CPUE indices which allows the model considerable freedom to fit the age frequency data. These data include a relatively large proportion in

the accumulated oldest age class. Alternative assumptions regarding M substantially influence the time series of recruitment estimates, particularly over the last 20 years, to attain the best fit to the age frequency distributions.

4.1.5 Model structure

The age structured population model encompasses the 1944–2008 period. The model structure includes two sexes, 1–20 year age classes and an accumulating age class for older fish (20+ years). The age structure of the population at the start of the model is assumed to be in an unexploited, equilibrium state. The biological parameters are equivalent to those used in previous assessments and equivalent for the two sexes (see Table 3). For the initial model, natural mortality was invariant with age at a value of 0.1. A Beverton-Holt spawning stock – recruitment relationship (SRR) was assumed with steepness (h) fixed at 0.75 and the standard deviation of the natural logarithm of recruitment (σ_R) was fixed at 0.6. Recruitment deviates were estimated for the 1960–2006 years.

Primary differences in the models used in the previous (2005) and current (2009) assessments are as follows:

- Additional data, including three years catch-at-age and an updated CPUE index.
- Refinement of the assumed level of unreported catch since 1986.
- Change in model software from CASAL to Stock Synthesis. This was demonstrated to have minimal effect on the model results.
- A change in the definition of adult biomass with knife-edge maturity at 5 years old (it was previously assumed that all fish were mature).
- Estimation of separate selectivities for the periods pre and post 1986 to account for an increase in trawl mesh size associated with the introduction of a minimum legal size.

The model was fitted to: (a) a combined (either trevally or snapper targeted) CPUE index for the years 1990 to 2008, (b) a research sampling proportions-at-age series for 1971 to 1974, (c) a market sampling proportions-at-age series covering 1974 to 1976 and 1978 to 1979 (d) a commercial proportions-at-age series for 1997 to 2008. A range of sensitivity analyses were conducted to examine the key structural assumptions of the model.

Model projections were conducted with annual catches assumed equivalent to the TAC plus an allowance for customary, recreational, and non-reported commercial catch (of total catch of 2257t). In the projection period, recruitment variation was incorporated in the model with the recruitment deviates simply constrained by the assumed variation in the deviates ($\sigma_R = 0.60$). Parameter uncertainty was incorporated using a Markov chain Monte Carlo (MCMC) approach.

4.1.6 Results

The assessment indicated that the spawning biomass gradually declined during the 1940s and 1950s. The rate of decline increased in the 1960s and 1970s consistent with the increase in the total annual catch. In the MPD runs, the spawning biomass trajectory from the early 1980s was sensitive to the assumed value of M , but was relatively insensitive to the range of other alternative structural assumptions investigated.

An MCMC approach was applied to estimate model uncertainty for the models with different values of natural mortality. Reasonable results were attained for the two higher values of natural mortality (0.087 and 0.10); however, problems were encountered for the lower value of natural mortality (0.075) with MCMC parameter values being constrained by the bounds of key parameters (particularly selectivity parameters), thereby, resulting in biased estimates of stock status. On this basis, the MCMC results for the lower value of natural mortality were rejected and it was concluded that the lower value of natural mortality was less plausible than the other two values. The female spawning biomass trajectories for runs with $M=0.1$ and $M=0.087$ are presented in Figures 2 and 3 respectively. Female spawning biomass is predicted to have remained stable ($M=0.087$) or to have increased ($M=0.1$) since the 1980s, with moderate-high probability that the current biomass is above the B_{MSY} level (61% and 100%, respectively)

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Table 6: Probability (*Pr*) of the TRE 7 stock falling below key reference points in 2008, using model runs with the two plausible estimates of *M*. B_{2008} is the mid-year female spawning biomass in 2008. Estimates are derived from MCMC analysis

	$Pr(B_{2008} < B_{MSY})$	$Pr(B_{2008} < 0.2B_0)$	$Pr(B_{2008} < 0.1B_0)$
$M = 0.10$	0	0	0
$M = 0.087$	0.39	0.05	0

Table 7: Biomass estimates (medians, with 95% confidence intervals in parentheses) for model runs with the two plausible estimates of *M*. B_{2008} is the mid-year female spawning biomass in 2008. Estimates are derived from MCMC analysis.

	B_0	B_{2008}	B_{MSY}	MSY	B_{MSY} / B_0	B_{2008} / B_0	B_{2008} / B_{MSY}
$M = 0.10$	31,968 (29,177–38,119)	16,889 (11,067–24,506)	8,956 (8,172– 10,683)	2,461 (2,246– 2,924)	0.280 (0.279–0.281)	0.53 (0.38–0.67)	1.87 (1.34–2.38)
$M = 0.087$	30,729 (28,223–33,736)	9,171 (5,121–14,613)	8,619 (7,914– 9,468)	2,106 (1,932– 2,309)	0.280 (0.279–0.281)	0.30 (0.18–0.44)	1.07 (0.64–1.55)

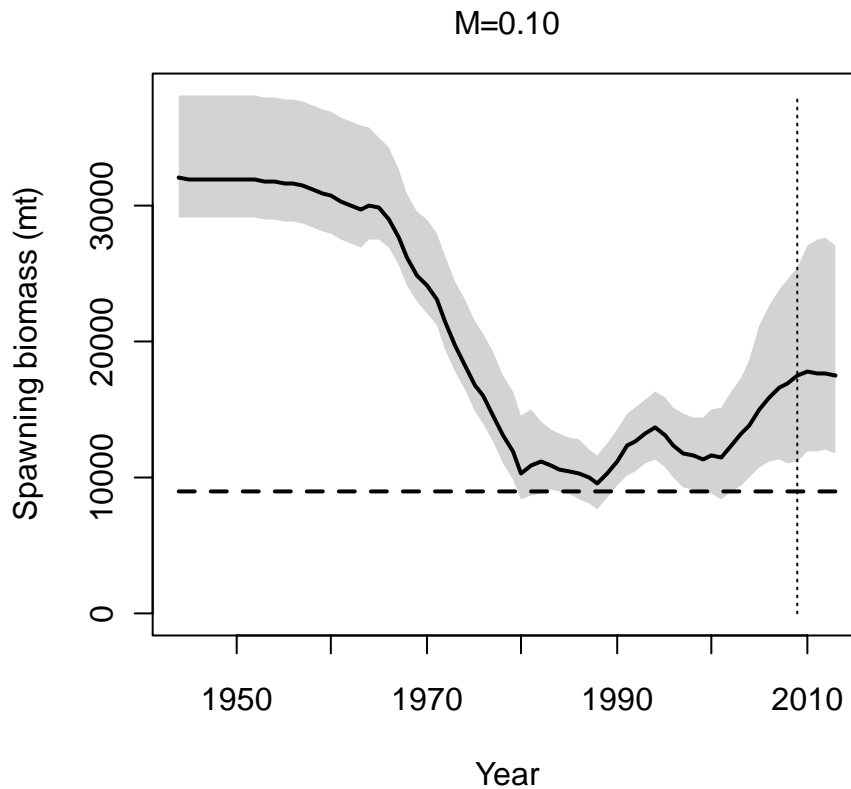


Figure 2: Spawning biomass (female only) trajectory (median of MCMCs) for the model run with natural mortality at 0.10. 95% confidence intervals were derived from MCMC. The horizontal line represents the B_{MSY} and dashed vertical line represents the first year of the projection period (2009).

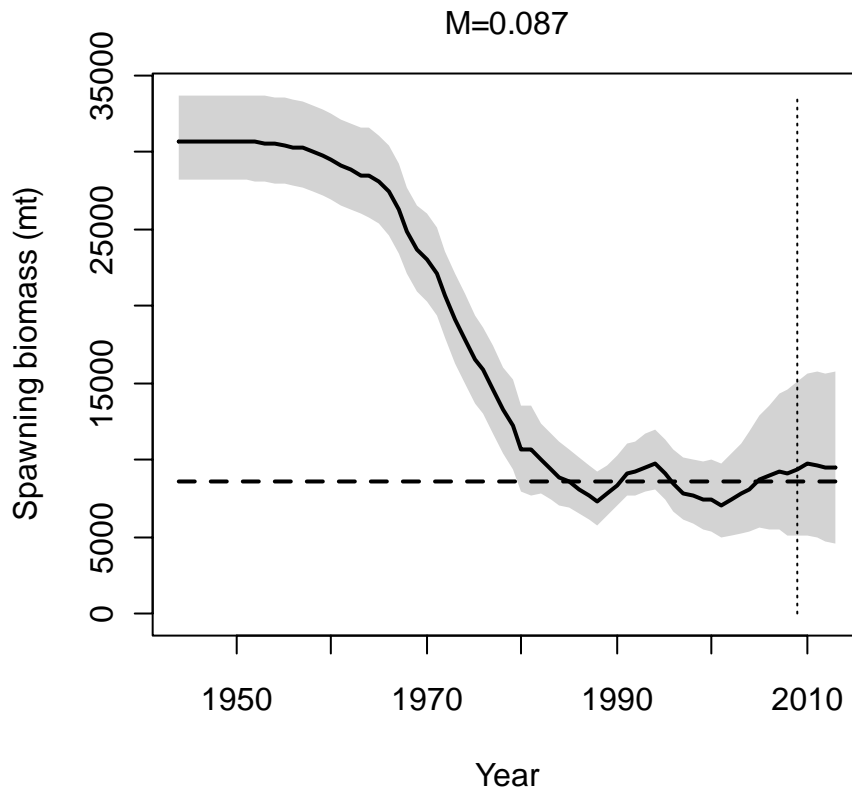


Figure 3: Spawning biomass (female only) trajectory (median of MCMCs) for the model run with natural mortality at 0.087. 95% confidence intervals were derived from MCMC. The horizontal line represents the B_{MSY} and dashed vertical line represents the first year of the projection period (2009).

Stock projections, for a five-year period, were conducted for the two accepted models ($M=0.087$ and $M=0.10$). The projections assumed a constant catch based on the TAC and an allowance for recreational and customary catch. For both models, the stock size is predicted to remain at about the current level over the next five years, and remain at or above the B_{MSY} level (probability of 61% and 100% for natural mortality of 0.087 and 0.10, respectively) with a high probability (95% and 100%, respectively) that the biomass will remain above 20% of the unexploited level (B_0). For both models the stock was virtually certain to remain above 10% of B_0 (Probability of 100% in both cases).

Table 8: Biomass estimates (medians, with 95% confidence intervals in parentheses) for model runs with the two plausible estimates of M . B_{2013} is the mid-year female spawning biomass in 2013. Estimates are derived from MCMC analysis. Probability (Pr) of the spawning biomass remaining above default reference points is also given.

	B_{2013} / B_{MSY}	B_{2013} / B_0	$Pr(B_{2013} > B_{msy})$	$Pr(B_{2013} > 0.2B_0)$	$Pr(B_{2013} > 0.1B_0)$
$M = 0.10$	1.95 (1.43–2.60)	0.55 (0.40–0.73)	1.00	1.00	1.00
$M = 0.087$	1.08 (0.55–1.68)	0.31 (0.15–0.47)	0.61	0.95	1.00

4.2 Yield estimates

There are no new data that would alter the yield estimates given in the 1999 Plenary Report for the TRE 1, 2, and 3. The TRE 1 yield estimates are based on commercial landings data and the results of a historical stock reduction analysis. Yield estimates for TRE 2 and TRE 3 were derived from commercial landings data.

4.2.1 Estimation of Maximum Constant Yield (MCY)

The estimates of MCY are summarised in Table 8 and detailed in the following sections for each stock. The level of risk to the stock by harvesting the population at the estimated MCY value has not been determined.

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TRE 1

An estimate of current surplus production (CSP) is available from a stock reduction analysis of the Bay of Plenty fishery using data from 1973 to 1983. The stock was estimated to have fallen to between 0.3 and 0.7 of its initial size in the period. Using a modified estimate of absolute stock size from a tagging experiment in 1977 and conservative net stock productivity values ($0.02-0.06 \text{ y}^{-1}$) the estimate for CSP in 1984 was 600 t. No new information has become available to permit updating the stock reduction analysis estimate of CSP made in 1984. Although not an estimate of equilibrium surplus production, this value for CSP was used to estimate MCY using the equation $\text{MCY} = 2/3 \text{ CSP}$ (Method 3). This is believed to be a conservative estimate of MCY.

$$\text{MCY} = 2/3 * 600 \text{ t} = 400 \text{ t.}$$

MCY was estimated using the equation $\text{MCY} = cY_{AV}$ (Method 4) for the Hauraki Gulf and North east coast sub-areas. Y_{AV} was set equal to the mean annual commercial landings for the decade 1977–86 and equalled 924 t. Based on an estimate of $M = 0.1$, c was set equal to 0.9.

$$\text{MCY} = 0.9 * 924 \text{ t} = 830 \text{ t.}$$

These MCY values were combined to provide the overall MCY estimate for TRE 1 of 1230 t. This estimate of MCY has not changed since the 1992 Plenary Report.

TRE 2 and TRE 3

MCY estimates using the equation $\text{MCY} = cY_{AV}$ (Method 4) with mean annual commercial landings for the decade 1977–86 and the natural variability factor c , set equal to 0.9 for these areas, has not changed since the 1989 Plenary Report.

4.2.2 Other yield estimates and stock assessment results

TRE 7

Estimates of MSY derived from the 2009 TRE 7 assessment were 2,461 t (2,246-2,924) for $M=0.1$ and 2,106t (1,932–2,309) for $M=0.087$. The current commercial allowance is 2153 t.

4.2.3 Other factors

Trevally are caught by trawling, together with other species such as snapper, red gurnard and John dory. Mismatches between the proportions of quota held for these species in any year for individual quota holders may affect landings in any one year. As a result of the interaction between snapper and trevally in the TRE 7 trawl fishery, the trevally catch is sometimes constrained by the availability of snapper quota.

Catch sampling of the TRE 1 purse seine catch was carried out annually from 1997–98 to 2002–03. Catch-at-age sampling of TRE 1 caught by single trawl gear was reinstated during the 2006-07 fishing year (Walsh *et al.* 2009). Prior to this the TRE 1 single trawl fishery was last sampled in 1999-2000. The 1999-2000 single trawl samples had a broad range of age classes and a relatively strong 20+ aggregate year class (mean age 8.4 years). There were proportionally fewer older age classes in the 2006-07 single trawl samples and the 20+ aggregate year class was significantly smaller (mean age 6.9 years). In contrast, the age composition of TRE 1 purse seine catches sampled in 1999-00 and 2006-07 showed very little difference in age distribution (mean age 1999-00 9.6 years; mean age 2006-07 10.4 years). The purse seine method appears to select a narrow range of lengths and ages while single trawl catch probably provides better representation of “true” age structure of the stock (Walsh *et al.* 2009).

The 2006-07 TRE 7 catch-at-age study sampled catches from three spatial areas (90 mile beach; Kaipara Manukau; South Taranaki Bight). This was the first time area specific age information had been collected from TRE 7. Strong evidence of spatial heterogeneity in age structure was seen in the catch sampling results. Both 90 mile beach and Kaipara-Manukau sub-areas had a broad range of age classes but 90 mile beach was unique in having relatively high numbers of 3 and 4 year old fish. The Southern Taranaki Bight age composition differed markedly from the two northern areas having a

very large proportion of fish older than 20 years and very few fish aged 3 and 4 years (Walsh *et al.* 2009). This pattern may have implications for stock assessment (if it is observed to be persistent) and is currently being investigated with additional catch-at-age programmes and CPUE analysis.

5. STATUS OF THE STOCKS

TRE 1

The assessment for TRE 1 undertaken in 2006 was not accepted by the Pelagic Working Group due to the lack of a reliable abundance index. Recent catches reported for TRE 1 are less than the estimated MCY levels and below the TACC. Reduced proportions of older age classes in the single bottom trawl catch between 1999-00 and 2006-07 combined with the strong drops in landings in 2006-07 and 2007-08 may indicate that stock abundance is declining at current catch levels.

TRE 2

From 2002-03 to 2006-07 reported catches for TRE 2 were substantially larger (average 325t) than the TACC (241t) but fell to the level of the TACC in 2007-08. It is not known if these recent catches are sustainable.

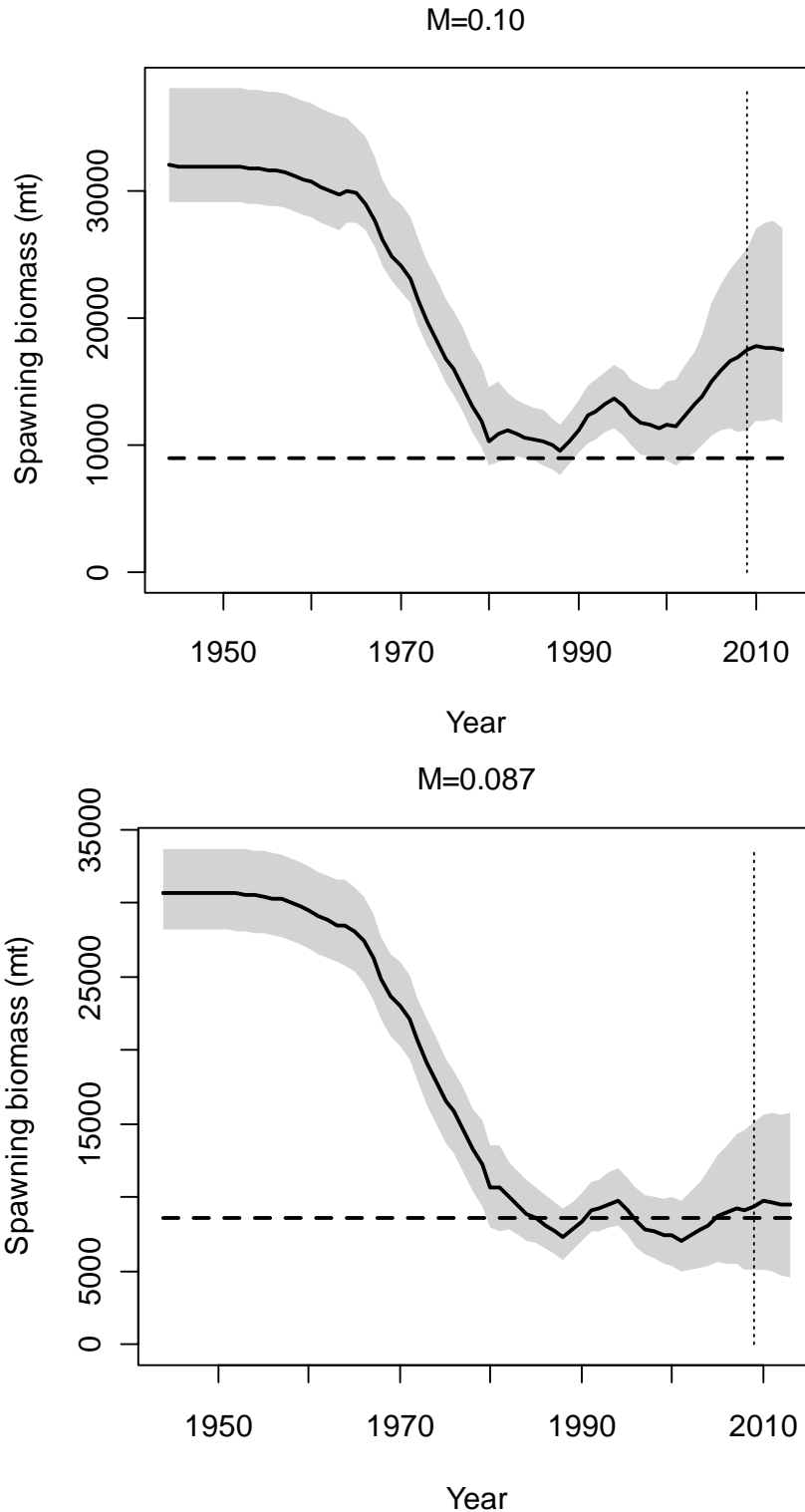
TRE 7

Stock Structure Assumptions

Trevally occurring along the west coast of the North Island are believed to comprise a single stock.

Stock Status	
Year of Most Recent Assessment	2009
Assessment Runs Presented	Two alternate model runs, one with $M=0.1$ and the other with $M=0.087$, were used to evaluate TRE 7 status.
Reference Points ³ (Note: These have not actually been set by fisheries managers yet)	Target: Not established but B_{MSY} (28% B_0) assumed. Soft Limit: Not established but assumed to be 20% B_0 Hard Limit: Not established but assumed to be 10% B_0
Status in relation to Target	<u>Model run $M=0.1$:</u> B_{2008} estimated to be 38% - 67% B_0 (median = 53% B_0); Very Likely (> 90%) to be at or above the target <u>Model Run $M=0.087$:</u> B_{2008} estimated to be 18% - 44% B_0 (median = 30% B_0); Likely (> 60%) to be at or above the target.
Status in relation to Limits	<u>Model Run $M=0.1$:</u> B_{2008} Very Unlikely (< 10%) to be below the Soft and Hard Limits. <u>Model Run 0.087</u> B_{2008} Very Unlikely (< 10%) to be below the Soft Limit and Very Unlikely (< 10%) to be below Hard Limit.

Historical Stock Status Trajectory and Current Status



Spawning biomass (female only) trajectories (median of MCMCs) for the model runs with natural mortality at 0.10 and 0.087. 95% confidence intervals were derived from MCMC. The horizontal line represents the B_{MSY} and dashed vertical line represents the first year of the projection period (2009).

Fishery and Stock Trends

Recent Trend in Biomass or Proxy

Spawning Biomass is estimated to have declined gradually during the 1940s and 1950s. The rate of decline increased in the 1960s and 1970s consistent with the increase in the total annual catch. Since 1980 spawning biomass appears to have remained fairly stable (M=0.087), or to have increased to 2008 (M=0.1).

Recent Trend in Fishing Mortality or Proxy	-
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	Relatively large proportions of fish >10 years, including a healthy 20+ age group (as evidenced by the age structure of the commercial catch) suggest that TRE 7 have not been heavily exploited.

Projections and Prognosis	
Stock Projections or Prognosis	Model projections indicate that the biomass of TRE 7 stock is About as Likely as Not to remain stable over the next 5 years and the probability of the stock going below B_{MSY} in 2013 is estimated at 0% (M=0.1) and 38% (M=0.087).
Probability of Current Catch or TACC causing decline below Limits (5 years)	<u>Model Run M=0.1:</u> B ₂₀₁₃ Very Unlikely (< 10%) to decline below Soft and Hard Limits. <u>Model Run 0.087:</u> B ₂₀₁₃ Very Unlikely (< 10%) to decline below Soft Limit and Very Unlikely (< 10%) to decline below Hard Limit.

Assessment Methodology	
Assessment Type	Level 1 – Quantitative stock assessment
Assessment Method	Age-structured Stock Synthesis model with Bayesian estimation of posterior distributions.
Main data inputs	- Proportions at age data from the commercial fisheries and historic trawl surveys. - Estimates of biological parameters. - Standardized CPUE index of abundance
Period of Assessment	Latest assessment: 2009 Next assessment: 2013
Changes to Model Structure and Assumptions ¹⁰	Primary differences in the models used in the previous (2005) and current (2009) assessments are as follows: <ul style="list-style-type: none"> • Additional data, including three years catch-at-age and an updated CPUE index. • Refinement of the assumed level of unreported catch since 1986. • Change in model software from CASAL to Stock Synthesis. This was demonstrated to have minimal effect on the model results. • A change in the definition of adult biomass with knife-edge maturity at 5 years old (it was previously assumed that all fish were mature). • Estimation of separate selectivities for the periods pre and post 1986 to account for an increase in trawl mesh size associated with the introduction of a minimum legal size.
Major Sources of Uncertainty	The model allows only a narrow range of plausible M, which does not reflect real uncertainty in this parameter.

Qualifying Comments
Analysis of the age structure of commercial bottom trawl catches in 2006/07 suggest there may be some spatial structure within TRE 7 stock. Future TRE 7 assessments may need to be spatially structured.

Fishery Interactions
Main QMS bycatch species are snapper, red gurnard, John dory and tarakihi.

Yield estimates, TACCs and reported landings by Fishstock are summarized in Table 9.

TREVALLY (TRE)

Table 9: Summary of yields (t), TACCs (t) and reported landings (t) of trevally for the most recent fishing year.

Fishstock	QMA		MCY	2008–09 Actual TACC	2008–09 Commercial landings
TRE 1	Auckland (East)	1	1 230	1 507	855
TRE 2	Central (East)	2	310	241	302
TRE 3	South–East, Chatham, Southland and Sub–Antarctic	3, 4, 5, 6	5	22	< 1
TRE 7	Auckland (West), Central (West), Challenger	7, 8, 9	*see assessment	2 153	2 018
TRE 10	Kermadec	10	0	10	0
Total				3 933	3 175

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