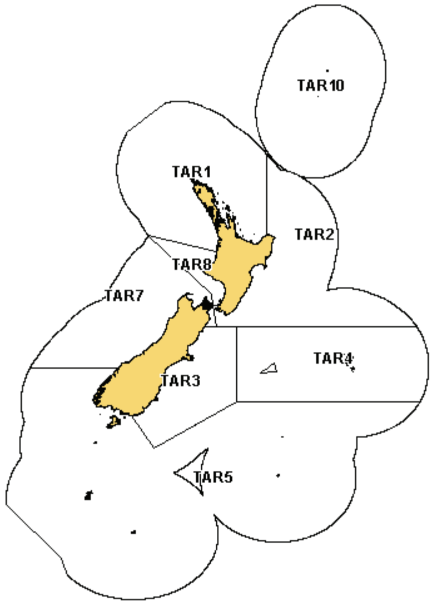
TARAKIHI (TAR)

(*Nemadactylus macropterus*)
Tarakihi



1. FISHERY SUMMARY

1.1 Commercial fisheries

Tarakihi are caught in coastal waters of the North and South Islands, Stewart Island and the Chatham Islands, down to depths of about 250 m. The fishery appears to have been relatively stable since the initial development phase. Between 1968 and 1985 domestic and foreign landings combined ranged between 4082 t and 6444 t, averaging 5042 t per year (Tables 1 and 2). Figure 1 shows the historical landings and TACC values for the main tarakihi stocks. Since the introduction of the QMS, the total landings have fluctuated between 4090 t and 6205 t. Reported landings and actual TACCs are shown in Table 2. From 1st October 2007 the TAC for TAR 1 was increased to 2029t and the TACC was increased from 1399 to 1447 t. Under the new TAC, the allowances for customary non-commercial, recreational and other sources of mortality were increased to 70 t, 470 t, and 20 t respectively.

Table 1: Reported total landings (t) of tarakihi from 1968 to 1982–83.

Year	Landings	Year	Landings	Year	Landings
1968	5 683	1974	5 294	1980–81*	4 990
1969	4 082	1975	4 941	1981–82*	5 193
1970	5 649	1976	4 689	1982–83*	4 666
1971	5 702	1977	6 444		
1972	5 430	1978–79*	4 427		
1973	4 439	1979–80*	4 344		

Source – MAF data.
* Sums of domestic catch for calendar years 1978 to 1982, and foreign and chartered vessel catch for fishing year April 1 to March 31.

Tarakihi are caught by commercial vessels in all areas of New Zealand from the Three Kings Islands in the north to Stewart Island in the south. The main fishing method is trawling. The major target trawl fisheries occur at depths of 100–200 m and tarakihi are taken as a bycatch at other depths as well. The major fishing grounds are west and east Northland (QMA 1), the western Bay of Plenty to Cape Turnagain (QMAs 1 and 2), Cook Strait to the Canterbury Bight (mainly QMA 3), and Jackson Head to Cape Foulwind (QMA 7). Around the North Island 70–80% of the tarakihi catch is targeted. Around the South Island only about 30% of the tarakihi are targeted; much of the remainder is reported as bycatch in target barracouta and red cod bottom trawl fisheries. In addition, there is a small target tarakihi setnet fishery off Kaikoura.

Table 2: Reported landings (t) of tarakihi by Fishstock from 1983–84 to 2007–08 and TACCs (t) from 1986–87 to 2007–08. QMS data from 1986-present.

Fishstock	TAR 1		TAR 2		TAR 3		TAR 4		TAR 5	
FMA (s)	1 & 9		2		3		4		5 & 6	
	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC	Landings	TACC
1983–84*	1 326	–	1 118	–	902	–	287	–	115	–
1984–85*	1 022	–	1 129	–	1 283	–	132	–	100	–
1985–86*	1 038	–	1 318	–	1 147	–	173	–	48	–
1986–87	912	1 210	1 382	1 410	938	970	83	300	42	140
1987–88	1 093	1 286	1 386	1 568	1 024	1 036	227	314	88	142
1988–89	940	1 328	1 412	1 611	758	1 061	182	314	47	147
1989–90	973	1 387	1 374	1 627	1 007	1 107	190	315	60	150
1990–91	1 125	1 387	1 729	1 627	1 070	1 148	367	316	35	153
1991–92	1 415	1 387	1 700	1 627	1 132	1 148	213	316	55	153
1992–93	1 477	1 397	1 654	1 633	813	1 168	45	316	51	153
1993–94	1 431	1 397	1 594	1 633	735	1 169	82	316	65	153
1994–95	1 390	1 398	1 580	1 633	849	1 169	71	316	90	153
1995–96	1 422	1 398	1 551	1 633	1 125	1 169	209	316	73	153
1996–97	1 425	1 398	1 639	1 633	1 088	1 169	133	316	81	153
1997–98	1 509	1 398	1 678	1 633	1 026	1 169	202	316	21	153
1998–99	1 436	1 398	1 594	1 633	1 097	1 169	104	316	51	153
1999–00	1 387	1 398	1 741	1 633	1 260	1 169	98	316	80	153
2000–01	1 403	1 398	1 658	1 633	1 218	1 169	242	316	58	153
2001–02	1 480	1 399	1 742	1 633	1 244	1 169	383	316	75	153
2002–03	1 517	1 399	1 745	1 633	1 156	1 169	218	316	92	153
2003–04	1 541	1 399	1 638	1 633	1 089	1 169	169	316	53	153
2004–05	1 527	1 399	1 692	1 796	905	1 403	262	316	57	153
2005–06	1 409	1 399	1 986	1 796	1 010	1 403	339	316	62	153
2006–07	1 193	1 399	1 729	1 796	1 080	1 403	263	316	93	153
2007–08	1 286	1 447	1 715	1 796	844	1 403	348	316	50	153

Fishstock	TAR 7		TAR 8		TAR 10			Total
FMA (s)	7		8		10			
	Landings	TACC	Landings	TACC	Landings	TACC	Landings§	TACC
1983–84*	896	–	109	–	0	–	5 430	–
1984–85*	609	–	102	–	0	–	4 816	–
1985–86*	519	–	122	–	0	–	5 051	–
1986–87	904	930	185	190	0	10	4 446	5 160
1987–88	840	1 046	197	196	0	10	4 855	5 598
1988–89	630	1 059	121	197	0	10	4 090	5 727
1989–90	793	1 069	114	208	0	10	4 473	5 873
1991–92	710	1 087	190	225	2	10	5 417	5 953
1992–93	929	1 087	189	225	0	10	5 158	5 989
1990–91	629	1 087	131	225	<1	10	5 086	5 953
1993–94	780	1 087	191	225	0	10	4 878	5 990
1994–95	978	1 087	171	225	0	10	5 129	5 991
1995–96	890	1 087	105	225	0	10	5 375	5 991
1996–97	1 013	1 087	133	225	0	10	5 512	5 991
1997–98	685	1 087	153	225	0	10	5 287	5 991
1998–99	1 041	1 087	175	225	0	10	5 501	5 991
1999–00	964	1 087	189	225	0	10	5 719	5 991
2000–01	1 178	1 087	178	225	0	10	5 935	5 991
2001–02	1 000	1 088	223	225	0	10	6 119	5 993
2002–03	1 069	1 088	211	225	0	10	6 008	5 993
2003–04	1 116	1 088	197	225	0	10	5 723	5 993
2004–05	1 056	1 088	184	225	0	10	5 683	6 390
2005–06	1 114	1 088	285	225	0	10	6 205	6 390
2006–07	1 115	1 088	254	225	0	10	5 729	6 390
2007–08	990	1 088	196	225	0	10	5 429	6 438

* FSU data.
§ Includes landings from unknown areas before 1986–87.

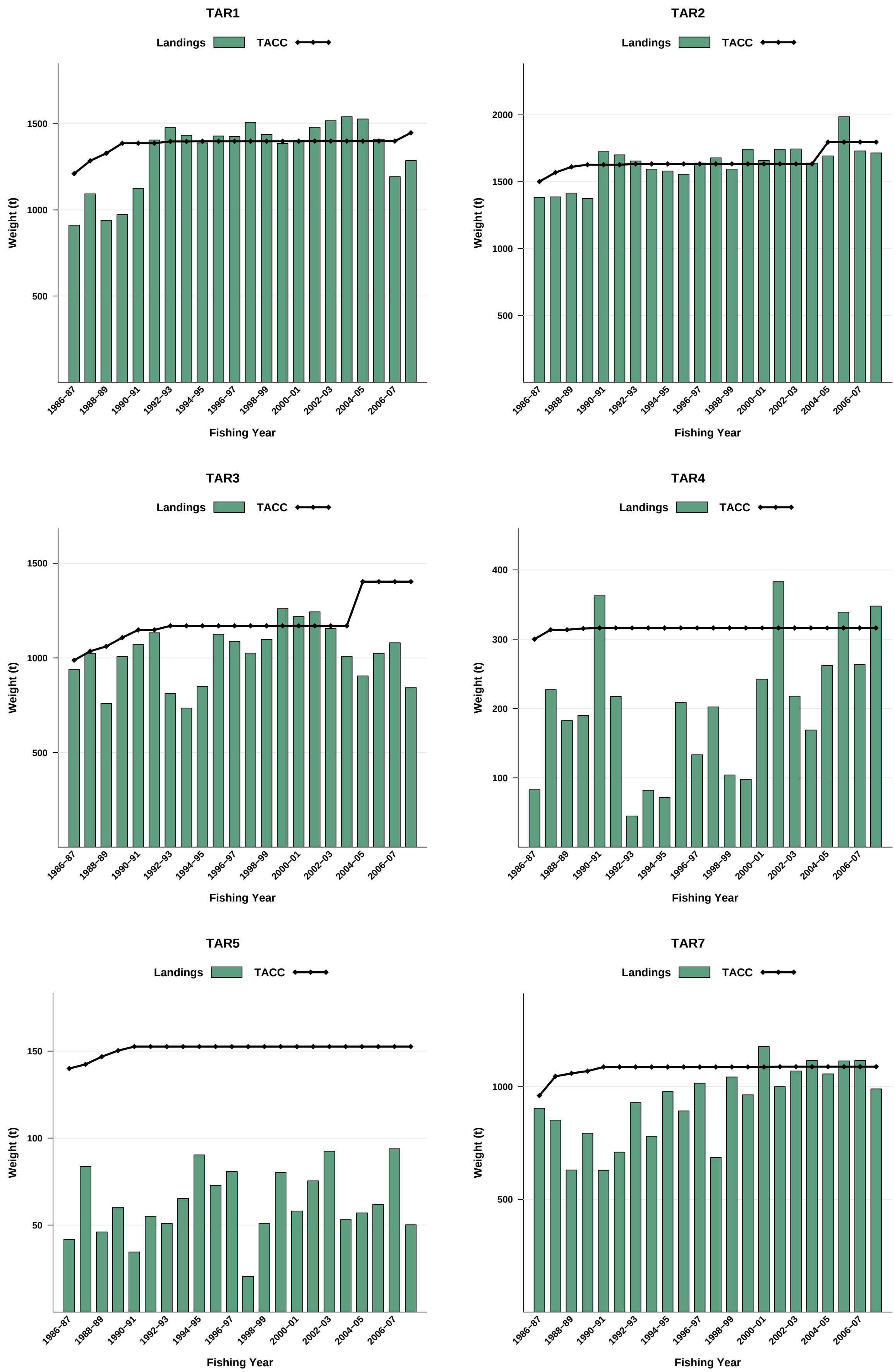


Figure 1: Historical landings and TACC for the seven main TAR stocks. From top left: TAR1 (Auckland), TAR2 (Central East), TAR3 (South East Coast), TAR4 (Chatham Rise), TAR5 (Southland), and TAR7 (Challenger). **[Continued on next page]…**

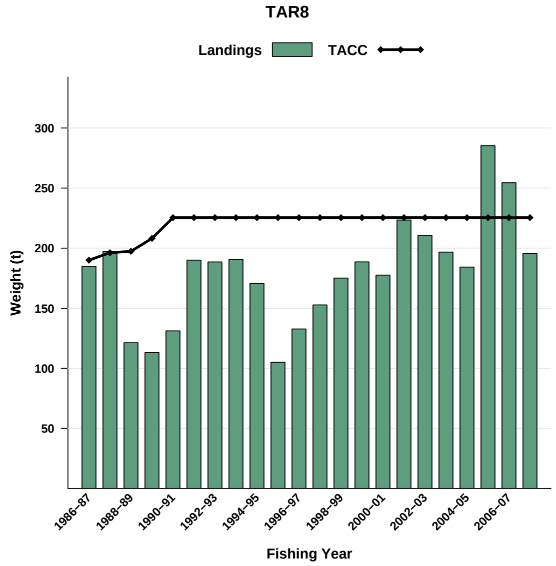


Figure 1 [Continued]: Historical landings and TACC for the seven main TAR stocks. TAR8 (Central Egmont). Note that these figures do not show data prior to entry into the QMS.

1.2 Recreational fisheries

Tarakihi are taken by recreational fishers using lines and setnets. Estimates of recreational catch of tarakihi are given for three separate surveys in Tables 3 and 4. The most recent nationwide recreational survey was undertaken in 2001, but the results are still under review and are not currently available.

Table 3: Estimated number and weight of tarakihi harvested by recreational fishers by Fishstock and survey. Surveys were carried out in different years in the Ministry of Fisheries regions: South in 1991−92, Central in 1992−93 and North in 1993−94 (Teirney *et al.*, 1997).

		Total		
Fishstock	Survey	Number	CV (%)	Survey harvest (t)
TAR 1	North	333 000	15	225–400
TAR 1	Central	18 000	55	10–20
TAR 2	North	7 000	–	0–5
TAR 2	Central	48 000	25	20–40
TAR 3	South	1 000	–	0–5
TAR 5	South	1 000	–	0–5
TAR 7	Central	29 000	25	5–15
TAR 7	South	6 000	33	0–5
TAR 8	Central	10 800	60%	0–10

Table 4: Estimates of annual number and weight of tarakihi harvested by recreational fishers from national diary surveys in 1996 (Bradford 1998) and Dec 1999-Nov 2000 (Boyd & Reilly, 2005). The mean weights used to convert numbers to catch weight are considered the best available estimates. Estimated harvest is also presented as a range to reflect the uncertainty in the point estimates.

Fishstock	Number caught	CV (%)	Estimated harvest range (t)	Point estimate (t)
1996				
TAR 1	498 000	8	280–330	305
TAR 2	114 000	14	55–75	65
TAR 3	3 000	–	–	–
TAR 5	3 000	–	–	–
TAR 7	69 000	13	20–30	24
TAR 8	46 000	17	25–35	28
1999–00				
TAR 1	1 035 000	19	516-755	636
TAR 2	310 000	27	139-243	191
TAR 3	25 000	51	8-23	15
TAR 5	10 000	57	3-9	6
TAR 7	87 000	18	27–39	33
TAR 8	66 000	38	19-42	30

The RTWG 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.

1.3 Customary non-commercial fisheries
No quantitative information on the level of customary non-commercial fishing is available.

1.4 Illegal catch
No quantitative information on the level of illegal tarakihi catch is available.

1.5 Other sources of mortality
No information is available.

2. BIOLOGY

Sexual maturity is reached at 25–35 cm fork length (FL) at an age of 4–6 years, after which the growth rate slows. This species reaches a maximum age of 40+ years.

Tarakihi spawn in summer and autumn in several areas around New Zealand. The three main spawning grounds identified are Cape Runaway to East Cape, Kaikoura to Pegasus Bay, and the west coast of the South Island near Jackson Bay.

Few larval and post-larval tarakihi have been caught and identified. The post-larvae appear to be pelagic, occur in offshore waters, and are found in surface waters at night. Post-larval metamorphosis to the juvenile stage occurs in spring or early summer when the fish are 7–9 cm FL and 7–12 months old.

Several juvenile nursery areas have been identified in shallower, inshore waters, including the southwest coast of the North Island, Tasman Bay, near Kaikoura, northern Pegasus Bay, Canterbury Bight, Otago and the Chatham Islands. Juveniles move out to deeper water at a length of about 25 cm FL at an age of 3–4 years. Only a small proportion of tarakihi found in commercial catches are immature, suggesting that they do not become vulnerable to fishing operations until they reach sexually maturity.

The results of tagging experiments carried out near Kaikoura during 1986 and 1987 indicate that some tarakihi are capable of moving long distances. Fish have been recaptured from as far away as the Kaipara Harbour on the west coast of the North Island, south of Whangarei on the east coast of the North Island, and Timaru on the east coast of the South Island.

The best available estimate of M is a value of 0.10 as determined from the age frequency distribution of unexploited and lightly exploited populations. Estimates of Z for the area near Kaikoura made during 1987 ranged from 0.12–0.16 for fish between 8 and 20 years old. Assuming $M = 0.10$ suggests that F ranged between 0.02–0.06. Estimates of Z for the area near the Chatham Islands made during 1984 were equal to or less than 0.20.

Biological parameters relevant to the stock assessment are shown in Table 5.

Table 5: Estimates of biological parameters of tarakihi.

Fishstock							Estimate	Source
1. Natural mortality (*M*)								
All							0.08–0.15	Annala (1987)
							0.10 considered best estimate for all areas for both sexes	Annala *et al*. (1989, 1990)
2. Weight = a (length)^b (Weight in g, length in cm fork length)								
	Females			Males				
	a		b	a		b		
TAR 3	0.04		2.79	0.0433		2.77		Annala *et al*. (1990)
TAR 4	0.023		2.94	0.017		3.02		Annala *et al*. (1989)
TAR 7	0.015		3.058	0.0141		3.07		Manning (2008)
von Bertalanffy growth parameters								
	Females			Males				
	K	t_0	L_∞	K	t_0	L_∞		
TAR 3	0.2009	– 1.103	44.6	0.2085	– 1.397	42.1		Annala *et al*. (1990)
TAR 4	0.2205	– 1.026	44.6	0.1666	– 2.479	44.7		Annala *et al*. (1989)
TAR 7	0.234	– 0.57	45.6	0.252	– 0.41	42.7		Manning (in prep.)

3. STOCKS AND AREAS

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

The results of tagging experiments have shown that tarakihi are capable of moving large distances around the coasts of the main islands of New Zealand. The long pelagic larval phase of 7–12 months indicates that larvae will also be widely dispersed. Previously these two factors, in addition to the lack of any evidence of genetic isolation, had been used to suggest that tarakihi around the main islands of New Zealand consist of one continuous stock, and for stock assessment purposes they be considered to be one stock. Further it was concluded that because of the large distance between the mainland and the Chatham Islands, and the separation of these two areas by water deeper than that which is usually inhabited by adult tarakihi, the tarakihi around the Chatham Islands are considered to be a separate stock.

In 2008 the Working Group suggested that the tagging programmes have not been designed in such a way to adequately test stock structure hypotheses and the results were not conclusive. Further analysis is necessary before any firm conclusions can be made about the number of stocks around the mainland.

A second species of tarakihi, "king" tarakihi, has recently been described. Catches of this newly described species have been reported as *N. macropterus* in the past.

4. STOCK ASSESSMENT

There are no new data which would alter the yield estimates of TAR 2, 3, and 4 given in the 1996 Plenary Report. The yield estimates are based on commercial landings data. Estimates of fishery parameters are given in Table 6.

An integrated assessment for TAR 7 was updated in 2008 with data that included the commercial catch, trawl survey biomass and proportions-at-age estimates, CPUE indices, and commercial catch proportions-at-age.

4.1 Estimates of fishery parameters and abundance

Stock parameters

Table 6: Estimates of fishery parameters for tarakihi, for TAR 2, 3 and 4.

		Fishstock	Estimate	Comments	Source
1. Fishing mortality (F)					
		TAR 3	0.02–0.06	For both sexes during 1987	Annala *et al*. (1990)
		TAR 4	≤0.10	For both sexes during 1984	Annala *et al*. (1989)
2. Total mortality (Z)					
		TAR 3	0.12–0.16	For both sexes during 1987	Annala *et al*. (1990)
		TAR 4	≤0.20	For both sexes during 1984	Annala *et al*. (1989)
3. $F_{0.1}$					
	Females	TAR 3	0.11	With M = 0.10	Annala *et al*. (1990)
		TAR 4	0.11	With M = 0.10	Annala *et al*. (1989)
	Males	TAR 3	0.12	With M = 0.10	Annala *et al*. (1990)
		TAR 4	0.11	With M = 0.10	Annala *et al*. (1989)

Trawl survey indices

Indices of relative biomass are available from recent *Kaharoa* trawl surveys in TAR 2, TAR 3 and TAR 7 (Table 7, Figures 2 & 3). Note that these estimates were revised in 1996 as a result of new doorspread estimates becoming available from SCANMAR measurements. In TAR 2 and TAR 3 no trend is apparent in the biomass estimates. In TAR 7 the biomass estimates declined from 1992 to 2003 with a dramatic increase in 2005, but reducing to slightly higher than previous levels in 2007. Relative biomass indices are currently being used to estimate biomass and yields for TAR 7. The TAR 2 survey was conducted for four consecutive years – 1993-1996 – and then discontinued.

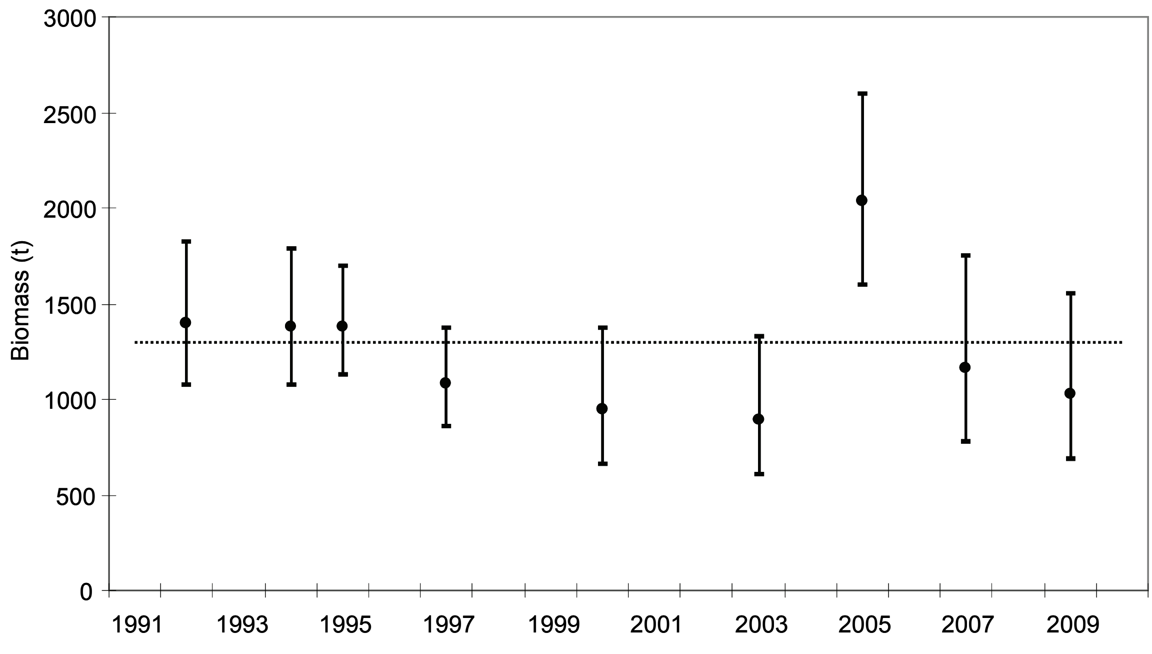


Figure 2: Biomass trends ±95% CI (estimated from survey CV's assuming a lognormal distribution) and the time series mean (dotted line) from the West Coast South Island trawl survey.

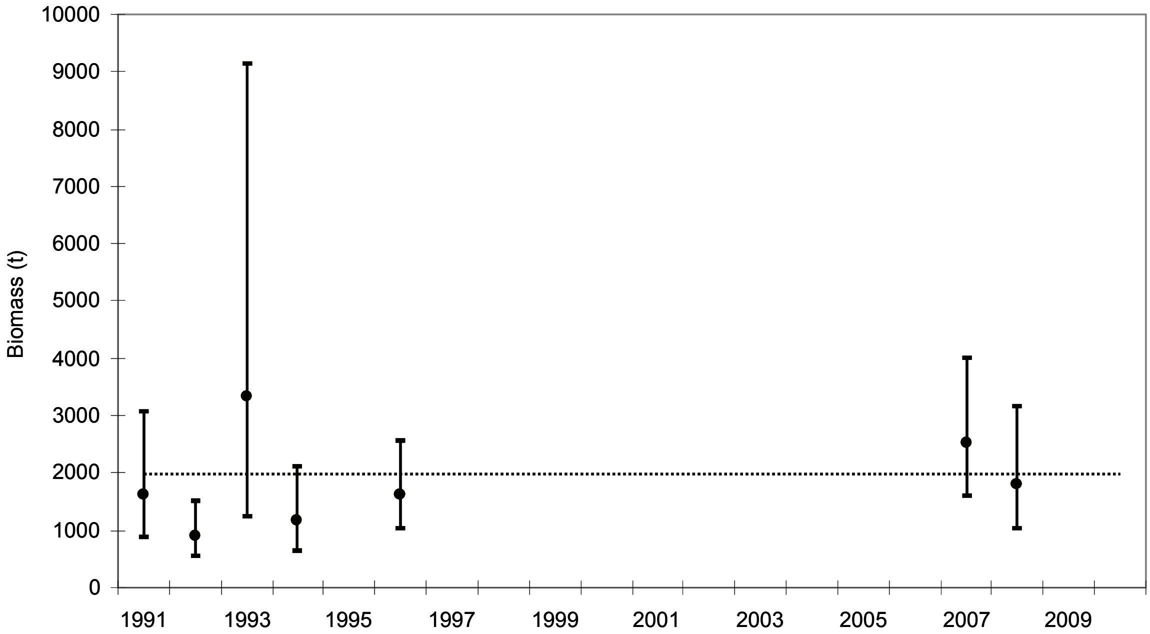


Figure 3: Biomass trends ±95% CI (estimated from survey CV's assuming a lognormal distribution) and the time series mean (dotted line) from the East Coast South Island trawl survey.

Summer surveys in the Bay of Plenty (from Mercury Islands to Cape Runaway) were carried out from 1983 to 1999. The surveys were extended to 250 m, in February 1996 (KAH9601) and 1999 (KAH9902), so that tarakihi depths would be covered. However, the estimates of biomass were low (35 t CV 46% in 1996 and 50 t CV 27% in 1999). Most of the catch in the 1999 survey was taken in 150 to 200 m.

CPUE analysis

TAR 1W, 1E, and 1BP

In 2008, CPUE was updated for the three assumed substocks in TAR 1 (Figures 5-7). In the QMA 1 inshore bottom trawl fishery there has been a systematic switch in reporting from the daily CELR form to the TCEPR tow-by-tow form with consequential effects on catch rates that could potentially confound the year effects. The analyses are therefore done separately by form type and truncated to the years in which they are most relevant.

In each substock the fishery was defined as trips that fished using bottom trawl and landed TAR 1 regardless of fisher-nominated target species. The data for analysis were further restricted to that from a core fleet of vessels with consistent participation in the fishery. Lognormal models were used to standardise positive estimated catches of tarakihi as reported on TCEPR (from 1995–96) and CELR (before 2000–01). For the TCEPR series bottom depth was offered as a proxy for targeting behaviour to de-emphasize the importance of fisher-nominated target species. For the model of CELR data, target was offered with an "other" level for the less common target species.

Log of catch was the dependant variable in all models, the log of tow distance was selected into the TCEPR model and log of number of tows into the CELR models for each substock. Vessel, season, and area also had significant explanatory power in every model.

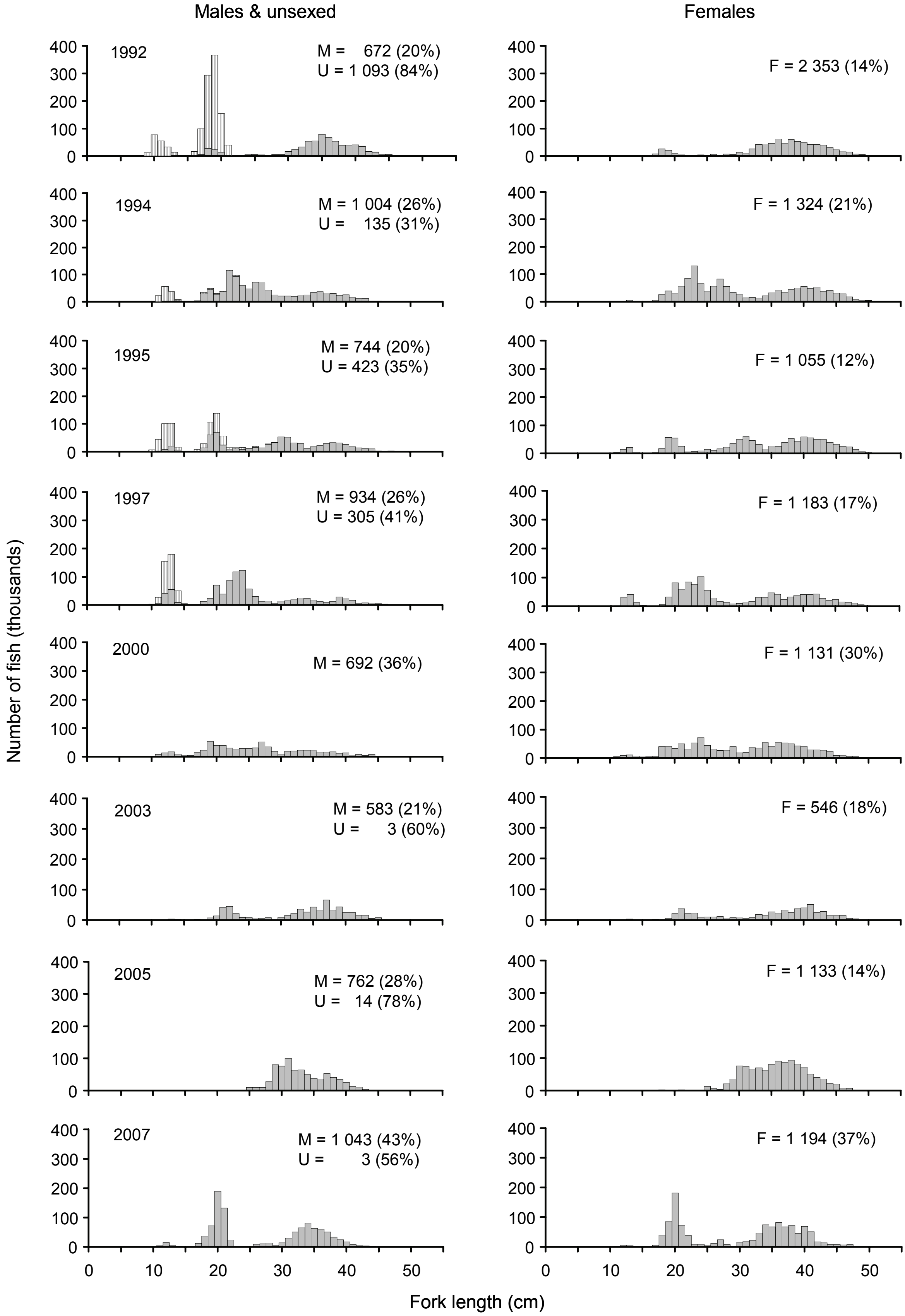


Figure 4: Scaled length frequency distributions for tarakihi in 30–400 m, for WCSI surveys. M, males; F, females; (), CV (Stevenson 2007).

Table 7: Relative biomass estimates (t) and coefficients of variation (CV) for tarakihi available from trawl survey data.

QMA	Area	Year	Trip Code	Biomass (t)	CV (%)
TAR 2	Cape Runaway to Cook Strait	1993	KAH9304	885	27
		1994	KAH9402	1 128	20
		1995	KAH9502	791	23
		1996	KAH9602	943	15
TAR 3	Pegasus Bay to Canterbury Bight	1991 W	KAH9105	1 657	33
		1992 W	KAH9205	932	26
		1993 W	KAH9306	3 805	55
		1994 W	KAH9406	2 050	41
		1996 W	KAH9606	1 656	24
		2007 W	KAH0705	2 589	24
		1996 S	KAH9618	3 818	21
		1997 S	KAH9704	2 036	24
		1998 S	KAH9809	4 277	24
		1999 S	KAH9917	2 606	15
		2000 S	KAH0014	1 510	13
		2007		2589	24
		2008		1863	29
TAR 7	Tasman Bay to Haast	1992	KAH9204	1 409	14
		1994	KAH9404	1 420	14
		1995	KAH9504	1 389	11
		1997	KAH9701	1 087	12
		2000	KAH0004	964	19
		2003	KAH0304	912	20
		2005	KAH0503	2 050	12
		2007	KAH0704	1 093	20
		2009	KAH09xx	1 051[1]	21

S = summer and W = winter survey (Note: because trawl survey biomass estimates are indices, comparisons between different seasons e.g. summer and winter in the same area are not strictly valid). [1] Preliminary figure still to be presented to the Working Group.

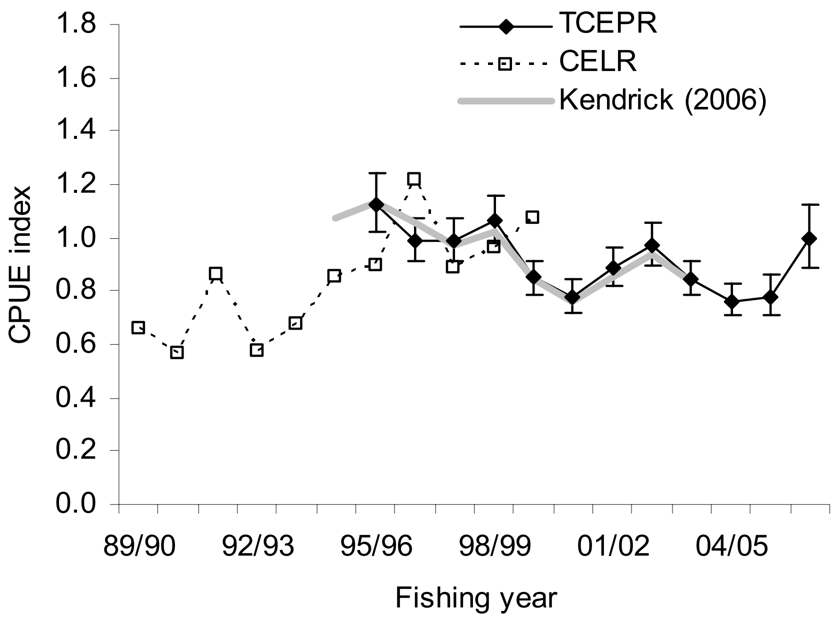


Figure 5: Comparison of indices for the west coast substock of TAR 1 (TAR 1W); Lognormal indices for the earlier series based on CELR format data, the lognormal series based on TCEPR format data, and the previously presented series (based on TCEPR data) overlaid.

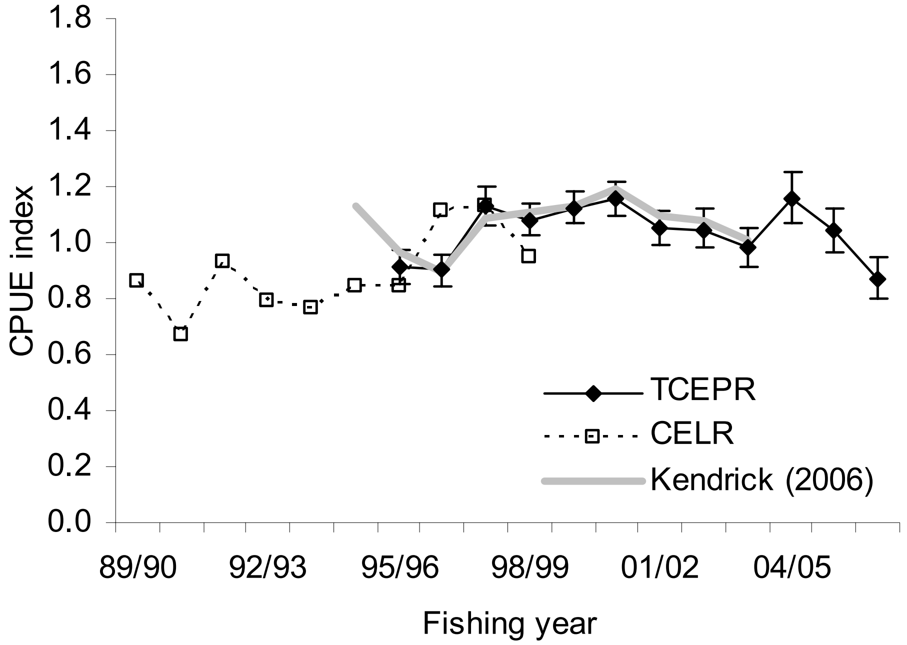


Figure 6: Comparison of indices for the east Northland substock of TAR 1 (TAR 1 EN); Lognormal indices for the earlier series based on CELR format data, the lognormal series based on TCEPR format data, and the previously presented series (based on TCEPR data) overlaid.

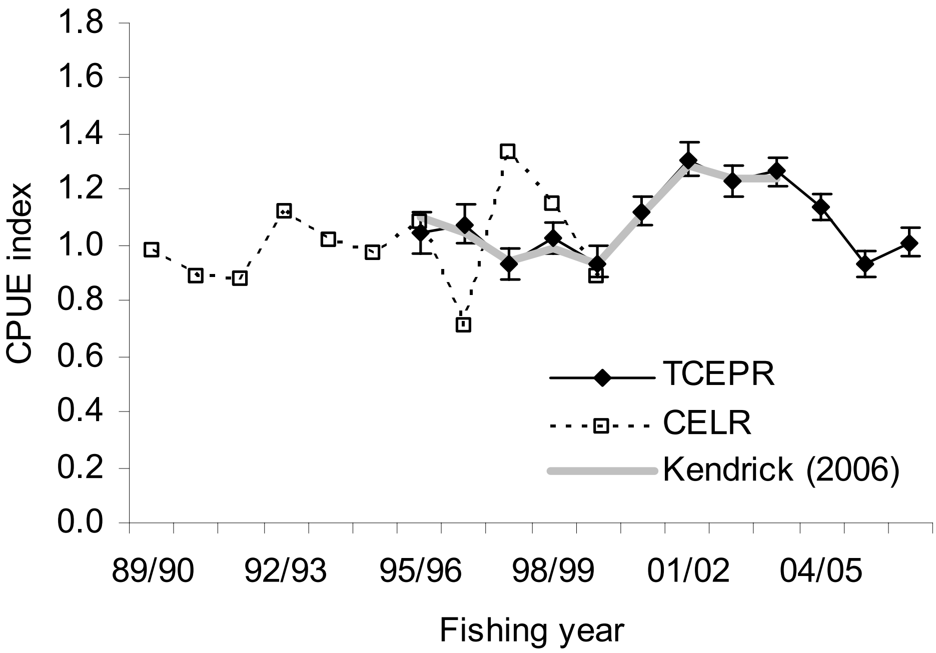


Figure 7: Comparison of indices for the Bay of Plenty coast substock of TAR 1 (TAR 1 BP); Lognormal indices for the earlier series based on CELR format data, the lognormal series based on TCEPR format data, and the previously presented series (based on TCEPR data) overlaid.

In all areas recent CPUE was within the range estimated over the period 1989–90 to 2006–07 and there have been no strong trends in CPUE. This suggests that there have been no large changes in abundance (Figures 5-7). When compared to the time of the last CPUE analysis, CPUE in the west coast is slightly up and that in east Northland and the Bay of Plenty is slightly down.

TAR 3, 7

In TAR 3 and 7, tarakihi are mainly reported as bycatch of the red cod and barracouta fisheries. This partly reflects the mixed species nature of these fisheries, but also the target species nominated to allow the bycatch trade. The standardised trawl CPUE for TAR 3 increased steadily from 1992–93, until 1999–00, before declining steadily until 2005–06, although equivalent estimates for the setnet fishery have been fairly stable. The Working Group considered that the CPUE indices calculated for TAR 7 were not monitoring tarakihi abundance in the area, and rejected them as indices of abundance.

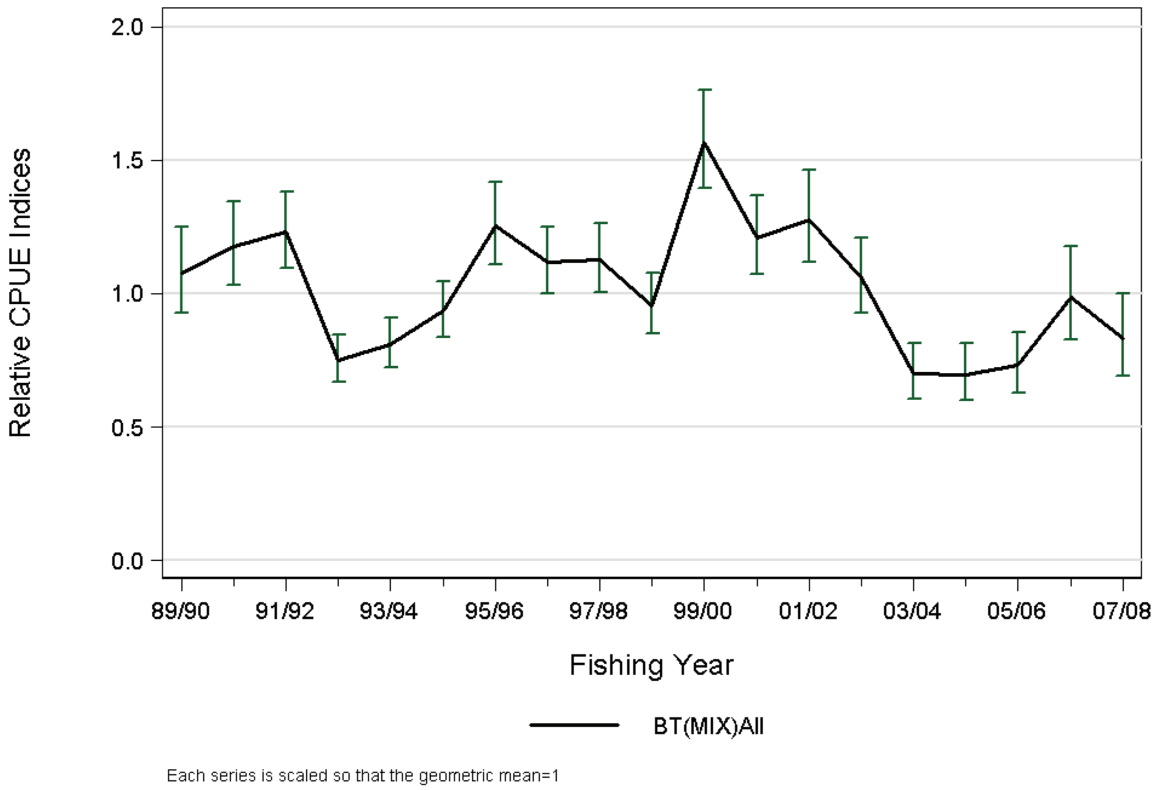


Figure 8: Lognormal indices for accepted TAR 3 CPUE series: target RCO, BAR, TAR bottom trawl [BT(MIX)]from combined Pegasus Bay (Area 020) and Canterbury Bight (Area 022). Starr *et al.* 2009.

4.2 Biomass estimates

TAR 2, 3, and 4

Estimates of current absolute biomass for TAR 2, 3, and 4 are not available.

TAR 7

An integrated statistical catch-at-age stock assessment for TAR 7 was carried out in 2008 for data up to the end of the 2006-07 fishing year (Manning, in prep.). The model partitioned by age (0–45 years) and sex was fitted to the trawl survey relative abundance indices (1992–07), survey proportions-at-age data (1995–07), and WCSI fishery catch-at-age data (2005–2007). The stock boundary assumed in the model included the west coast of the South Island, Tasman and Golden Bays, but not eastern Cook Strait (a catch history was compiled for the model stock that excluded eastern Cook Strait). A summary of the model's annual cycle is given in Table 6. The base case model (R4.1) was fit to trawl survey biomass indices (lognormal likelihood) and proportion at age data (multinomial likelihood), U_{max} was set at 0.8, steepness was assumed to be 0.75, and M was fixed at 0.1. The base case model assumed an equilibrium biomass at the beginning of the population reconstruction in 1940. One sensitivity R4.5 was the same as R4.1 but was also fit to the CPUE data (lognormal likelihood). The other sensitivity (R4.6) also included the CPUE data; however, the model was started in 1985 from a non-equilibrium start. Model run 4.5 was very similar to the base case (4.1) in terms of biomass trajectory and stock status, but sensitivity 4.6 was more pessimistic in terms of stock status (Table 7). None of the three runs reported in Table 7 estimate a mean or median stock status that is below B_{MSY} and the stock is expected to rebuild, on average, for all three runs under current levels of removals and with average recruitment (Figure 9).

Table 6: The TAR 7 model's annual cycle (Manning in prep.). Processes within each time step are listed in the time step in which they occur in particular order (e.g., in time step 3, new recruits enter the model partition first followed by the application of natural and fishing mortality to the partition). M, the proportion of natural mortality assumed during each time step. F, the nominal amount of fishing mortality assumed during each time step as a proportion of the total catch in the stock area. Age, the proportion of fish growth that occurs during each time step in each model year

			Proportions			
Time step	Duration	Process applied	*M*	*F*	Age	Observations
1	Oct-Apr	Mortality (*M, F*)	0.58	0.74	0.90	Survey relative biomass (KAH) Survey proportions-at-age (KAH) Survey proportions-at-age (JCO) Survey proportions-at-length (KAH) Fishery catch-at-age Fishery relative abundance (CPUE
2	May (instantaneous)	Spawning Age incrementation	0.00	0.00	0.00	NIL
3	May-Sept	Recruitment Mortality (*M, F*)	0.42	0.26	0.10	Fishery catch-at-age

Table 7: MCMC initial and current biomass estimates for the TAR 7 model runs R4.1, 4.5, and 4.6. B_0, virgin or unfished biomass; B_{2007}, mid-year biomass in 2007 (current biomass); (B_0 / B_{2007}) %, B_0 as a percentage of B_{2007}; Min, minimum; Max, maximum; Qi, ith quantile. The interval ($Q_{0.025}$, $Q_{0.975}$) is a Bayesian credibility interval (a Bayesian analogue of frequentist confidence intervals).

		R4.1			R4.5	
	B_0	B_{2007}	(B_0 / B_{2007}) %	B_0	B_{2007}	(B_0 / B_{2007}) %
Min	13 010	4 340	33.4	12 810	4 180	32.6
$Q_{0.025}$	14 290	6 060	42.3	13 780	5 350	39.1
Median	16 440	9 010	54.7	15 640	7 880	50.4
Mean	16 570	9 180	54.9	15 730	8 020	50.6
$Q_{0.975}$	19 630	13 410	68.3	18310	11500	63.0
Max	22 030	16 510	75.0	21 430	15 420	72.0
		R4.6				
Min	14 660	4 150	28.3			
$Q_{0.025}$	18 350	6 490	34.7			
Median	24 540	10 190	41.6			
Mean	25 680	10 940	41.9			
$Q_{0.975}$	40 600	19 890	50.5			
Max	63 300	34 700	58.3			

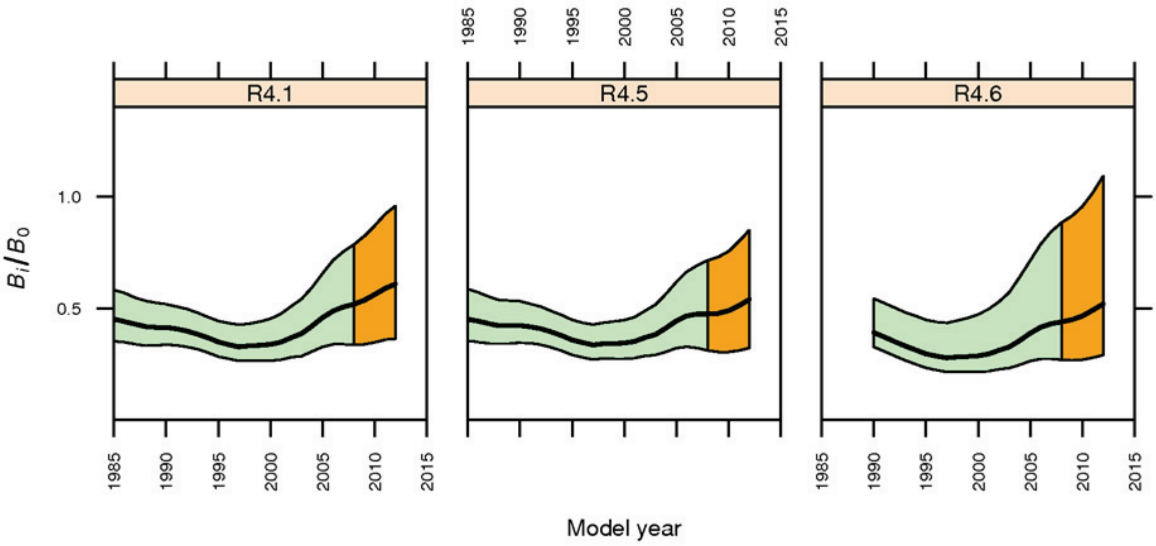


Figure 9: Relative SSB trajectories (green) and projected status assuming a future constant catch equal to the current catch (orange) calculated from the MCMC runs for model runs 4.1, 4.5, and 4.6 in the quantitative stock assessment of TAR 7. The shaded region indicates the 95% credibility region about median SSB (dotted lines) calculated from each model's SSB posterior distribution.

4.3 Estimation of Maximum Constant Yield (MCY)

North and South Islands (all areas except TAR 4 & 10)
MCY was estimated using the equation MCY = cY_{AV} (Method 4). Y_{AV} was the average of the combined domestic and foreign landings from 1968 to 1985 (5042 t). This period was one of comparative stability following the developmental phase of the fishery, and fishing mortality and effort were assumed to be relatively constant. Natural mortality is low (0.08 to 0.15), the species is long lived (40+ years), and there are generally at least 10 year classes in the fishery. Recruitment is not known to vary much. The value of c was set at 0.9 based on the estimate of $M = 0.10$.

$$MCY = 0.9 * 5042 \text{ t} = 4538 \text{ t (rounded to 4540 t)}.$$

The MCY estimate has not changed since 1989.

Chatham Islands (TAR 4)
MCY cannot be determined.

4.4 Estimation of Current Annual Yield (CAY)
Estimates of current biomass are not available and CAY cannot be determined.

Yield estimates are summarised in Tables 8 and 9.

Table 8: Yield estimates (t) of tarakihi.

Parameter	Fishstock	Estimate
MCY	All except TAR 4, 7, & 10	4 540
CAY	All except TAR 4,7, & 10	Cannot be determined

Table 9: Yield estimates (t) of tarakihi (TAR 7)

			Run
Parameter	4.1	4.5	4.6
MCY	549	522	755
B_{MCY}	18237	16233	18620
CAY	1588	1361	1682
F_{CAY}	0.1685	0.1661	0.1508
MAY	1086	976	1203
B_{MAY}	6350	5790	7865

5. ANALYSIS OF ADAPTIVE MANAGEMENT PROGRAMMES (AMP)

The Ministry of Fisheries revised the AMP framework in December 2000. The AMP framework is intended to apply to all proposals for a TAC or TACC increase, with the exception of fisheries for which there is a robust stock assessment. In March 2002, the first meeting of the new Adaptive Management Programme Working Group was held. Two changes to the AMP were adopted:

- a new checklist was implemented with more attention being made to the environmental impacts of any new proposal;
- the annual review process was replaced with an annual review of the monitoring requirements only. Full analysis of information is required a minimum of twice during the 5 year AMP.

TAR 2
A full review of the TAR 2 AMP was undertaken in April 2008.

AMP History

- The tarakihi fishery dates back to about 1933 (Annala 1987). Data available from 1968 show that New Zealand wide total landings were between 4 000 t and 6 444 t over the period 1968 to 1985. In TAR 2, landings increased from 1 118 t in 1984 to 1 318 t in 1986, prior to entry into the QMS.
- TAR 2 entered the QMS in 1986–87 with an initial TACC of 1410 t, which was almost reached with a catch of 1 382 t in that fishing year. The TACC rose to 1 633 t by 1992–93 due to quota appeals, at which level it remained through to 2003–04. Catches initially lagged behind the TACC until 1989–90, but have remained close to the TACC thereafter, averaging 1 660 t from 1990–91 to 2003–04.
- TAR 2 entered an AMP in 2004–05, with a TACC increase to 1 796 t. After entry into an AMP, catches increased to a peak of 1 986 t in 2005–06, and have since dropped back to 1 729 t in 2006-07, slightly below the TACC. The first mid-term review of TAR 2 was conducted in 2007, at which time the AMP Working Group requested that certain aspects of the CPUE analyses be repeated. The review conducted in 2008 was therefore a repeat of the 2007 review, to allow an evaluation of the revised analyses.

Fishery Characterization

- Over 99% of TAR 2 catches are taken by bottom trawl (BT) and the annual proportion of catch by bottom trawl has remained stable since 1989–90. Although inshore fisheries in FMA 2 have caught more than 90 species since 1989–90, 82% of TAR 2 is taken in the TAR targeted bottom trawl fishery. Bycatches of tarakihi are low in most other target bottom trawl fisheries, with significant quantities only being caught in the GUR (7%), and SKI (4%) targeted fisheries.
- In contrast, most TAR caught in the mid-water trawl (MWT) and setnet (SN) fisheries are caught while targeting other species such as SKI, GUR, HOK and WAR. Statistical areas 011, 012 and 013 have together contributed 78% of the total TAR 2 catch since 1989–90. Area 013 has been the most important area for bottom trawling, but catches from this area have been decreasing for the last 5 to 6 fishing years, while catches from areas 011 and 014 have increased.
- There is no clear historic seasonal pattern in the TAR 2 fishery, although more catch was landed from February to July in 2006–07.
- Tarakihi are caught by bottom trawl over a wide depth range from 50 m to >400 m, depending on target, but with an overall median of 140 m, and with the TAR targeted BT fishery mostly operating somewhat shallower than this. The mid-water trawl fishery catches TAR from 80 m to 800 m, with an overall median depth of 300 m, but again with TAR with targeted tows shallower than 150 m.

CPUE Analysis

- Following initial increases from 1989–90 to 1991–92, the number of hours fished declined slightly, and has remained fairly stable since about 1996–97. In contrast, the number of vessels participating in this fishery has declined steadily from a peak of around 80 vessels in 1994–95 to 40 vessels in 2006–07.
- CPUE standardisations were done for two fisheries where defined based on method, target species, and/or region (Figure 10):
    - BT.TAR: bottom trawling targeting TAR. This is considered to be The BT.TAR index is considered to be the more reliable index for TAR 2, as it represents 82% of the catch and more than 90% of records have positive catches.
    - BT.OTH: bottom trawling not targeting TAR - an index for the bycatch fishery, representing < 18% of the catch.

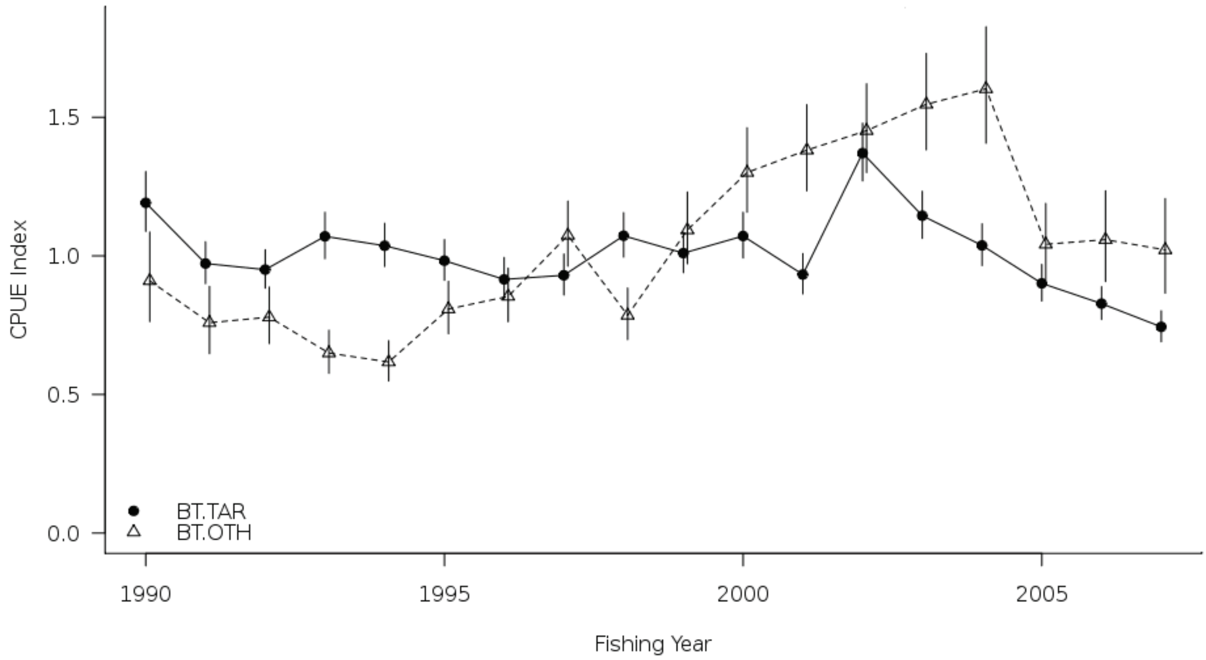


Figure 10: Standardised CPUE indices from the target bottom trawl (BT.TAR) and bottom trawl not targeting TAR (BT.OTH) fisheries.

- Prior to 2003–04, the BT.TAR index was relatively stable, rising to a peak in 2001–02, and then declining steadily. In contrast, the BT.OTH index increases steadily from 1993–94 to a peak in 2003–04, with a decline back to levels consistent with the late 1990s in 2004–05, and flat thereafter. Both indices show a decline from 2003–04 onwards, but have not dropped much below their geometric means over the history of the fishery. In 2006–07, the BT.TAR index was at its lowest level since the start of the series at 0.74, whereas the BT.OTH index was at 1.02.
- The effects of standardisation differ between these two series. Standardisation has the effect of converting a slow increase in the BT.TAR index over 1989–90 to 2000–01 into a flat trend. The decline has steepened since 2001–02, primarily as a result of correcting for an increasing number of tows in recent years, and a strong, increasing trend in vessel effect over the history of the fishery, as newer vessels with better catch rates have replaced less efficient vessels.
- Standardisation of the BT.OTH index dampens fluctuations in the series to 2003–04, and converts a decline in the last three years to a flat trend. Primarily correcting a declining trend in effect of targeting, as targeting has shifted to SNA and FLA, as well as effects of vessel and tow duration.

Logbook Programme

- There has been no logbook coverage of the TAR 2 fishery.
- The Working Group noted that the lack of biological data from TAR 2 was a concern, and that QMA 2 had the worst record of performance with regard to implementation of logbook programmes under AMP's.

Effects of Fishing

- Almost all of the catch in TAR 2 is landed whole, thereby reducing the seabird interactions that might otherwise result from offal discharge. From 2005–06 to 2007–08, observers have recorded one fur seal mortality, five seabird mortalities and nine live-releases of seabirds in FMA 2. However, observer coverage in the inshore fisheries has been low, with no coverage prior to 2005–06.
- Starting in July 2008, a Department of Conservation project will investigate protected species interactions in QMA 2. This project intends to assess risks, promote the new Protected Species Non-Fish Bycatch Form and improve reporting, mitigation measures and monitoring of protected species interactions and environmental effects of fishing.

AMP Review Checklist

1. The TAR 2 targeted fishery has a long history of participation by many vessels which take 82% of the TAR 2 catch, and covers a high proportion of the area. The TAR targeted bottom trawl (BT.TAR) CPUE index is therefore considered to probably be a reasonable and representative index of abundance of TAR 2.

2. All attempts to date to establish a logbook programme for TAR 2 (and BNS 2) have been unsuccessful, and no biological information has been collected from this fishery. The Working Group emphasised the importance of implementing appropriate programmes (whether logbooks, observers or shed sampling) for collection of spatially and temporally representative biological information for TAR 2.

3. Additional analyses recommended by the Working Group included:
   - For future analyses, rather than excluding certain data from the initial extract based on target species (such as ORH, OEO or CDL), data for all trips that caught or targeted TAR 2 and other associated species should be extracted. Data for some targeted fisheries that catch negligible quantities of TAR (such as SCI) can then be excluded after initial inspection of the data.

4. The TAR 2 fishery has provided fairly stable harvests of over 1 000t since the 1950s, and catches around 1 600t to 1 700t since the 1970s. Current catches (1 729t in 2006–07) are most likely sustainable. However, CPUE should be monitored to see whether the CPUE decline observed in the target fishery index over the past six years continues to significantly lower levels.

5. The state of the TAR 2 stock in relation to B_{MSY} is not known. Long periods of sustained catches around 1 600t to 1 700t indicate a flat yield curve for the stock, and suggest that the stock is probably close to B_{MSY}.

6. Observer coverage levels of the inshore trawl fisheries are low, and the effects of fishing are not currently adequately monitored. Introduction of the '*Non-fish/Protected Species Catch Return*' into the suite of regulated MFish forms from 1 October 2008, may provide a credible source of information on the level of protected species bycatch. However, observer coverage will still be required to validate fisher reporting rates.

7. Given the low observer coverage in this fishery, rates of non fish bycatch are not known with any confidence, and it is not known whether rates of bycatch are acceptable.

8. This stock does not need to be referred to the Plenary for review.

TAR 2 - Discussion of CPUE Trends in 2009

TAR Stock Structure

Although not scheduled for review in 2009, marked similarity between the SN(TAR) index for Kaikoura and trawl indices for TAR 2 led to discussion of relationships between TAR caught off Kaikoura and the ECNI Wairarapa coast (TAR 2).

The Kaikoura area was previously considered by the WG to be a spawning area for South Island (TAR 3) stock, but this now seems unlikely. Close similarity in CPUE trends between the BT(TAR2) and SN(TAR3) indices, results of historical tagging work and industry views on stock structure, all indicate that TAR caught off Kaikoura, north of Point Gibson, are probably related to the TAR 2 stock, and not the TAR 3 stock.

CPUE Analysis

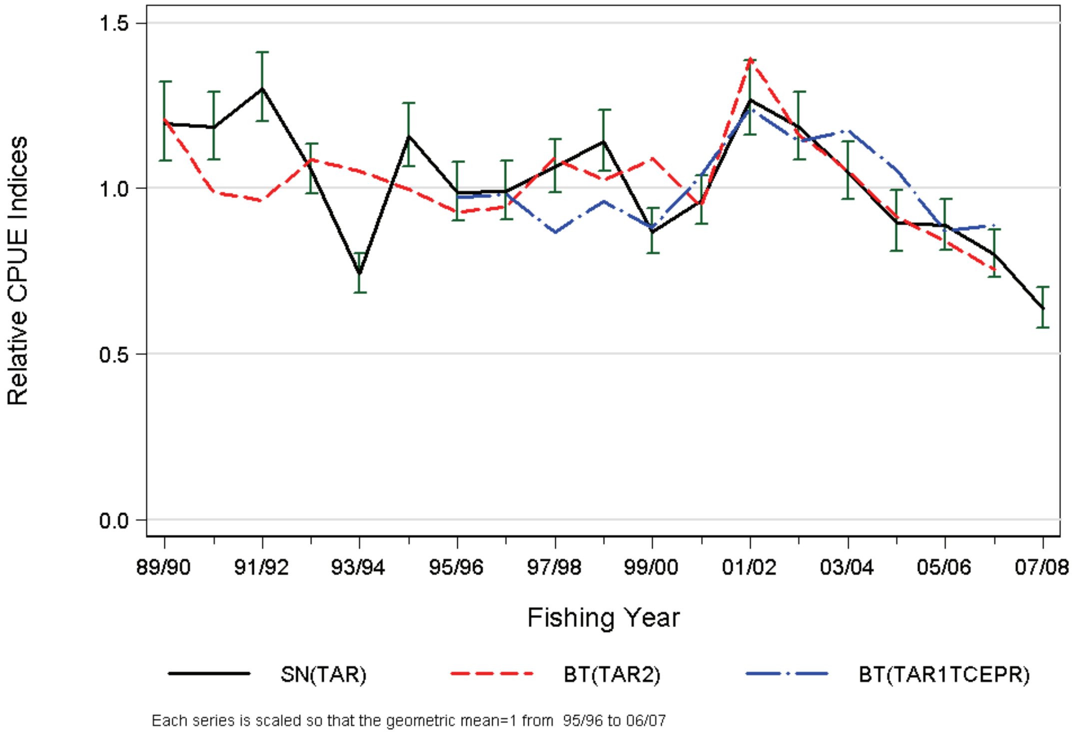


Figure 11: Comparison of the lognormal indices from three independent CPUE series for east coast tarakihi; a) [SN(TAR)]: Kaikoura target tarakihi setnet fishery (Starr et al. 2009); b) [BT(TAR2)]: bottom trawl, target tarakihi, east coast North Island (Bentley et al. 2008); c) [BT(TAR1TCEPR)]: Bay of Islands mixed target species bottom trawl fishery based on tow-by-tow data using the TCEPR form type (Kendrick 2009)

- To investigate the possibility that the Kaikoura setnet fish are related to a TAR 2 stock, the SN(TAR2) index was compared to the previously calculated BT(TAR2) index (Bentley *et al.*) (Figure 11). There is very close coincidence between these indices, particularly in the marked steady and ongoing decline from 2001-02 onwards.
- Comparison was extended to investigate the correspondence with the TAR 1 index for the Bay of Plenty region, developed using TCEPR data. This index also corresponds closely with the other two (Figure 11), suggesting that a single ECNI TAR stock may extend from Kaikoura around to Bay of Plenty.
- These three indices all indicate a period of stable abundance from 1989-90 fluctuating at or above the long-term average level, followed by an almost 60% steady and ongoing decline in all three indices, down to lowest historical levels by 2007-08 for the SN(TAR) index of the Kaikoura target tarakihi setnet fishery.

TAR 3
The TAR 3 TACC by 20%, from 1169 t to 1403 t, under AMP management, on 1 October 2004.

TAR 3 - Three Yearly Review (AMP WG/09/08)
Catch History

- The tarakihi fishery has a long history, being the third most important species in domestic catches until the mid-1970s. Past reporting areas differ from current QMA boundary definitions, but an approximate reconstructed catch history for TAR3 estimates that catches doubled after 1945 from ~1000t/year to about 2000t/year, around which catches fluctuated until the mid 1960s. Average annual reported catches over the 22 year period from 1945 - 1966 have been about 1,760t.
- Catches dropped sharply back to the 1,000t/year level in 1967, primarily as a result of many east coast fishing vessels departing to participate in the Chatham Islands rock lobster fishery at the

time. Subsequent catches over the period 1970 to 1986 fluctuated between about 650t to 1350t/year, although it is likely that foreign catches during the 1970s were under-reported.

- The TACC for TAR 3 was set at 970t when the stock first entered the QMA in 1986-87. This was sequentially raised in response to appeals to 1,169t by 1993/94. The TACC was increased from 1,169t to 1,403t by 20% in October 2004 when it entered the AMP programme. An additional allowance for recreational and customary catches brought the total TAC to 1,503t.
- TAR3 catches fluctuated from 750t to 1,200t/year until 1998-99, and then exceeded the TACC from 1999-00 to 2001-02, prompting the request for entry into an AMP. However, catches declined to 1,009t by 2003-04, 905t by 2004-05, and remained around 1,000t to 2006-07. In 2007-08, TAR 3 catches declined further to 843t, the lowest reported catch since 1993-94.
- Estimates of recreational tarakihi catch are highly uncertain, but the recreational catch is thought unlikely to exceed 10t per year.

Fishery Characterization

- 70% of the QMA3 tarakihi catch has been taken in the bottom trawl fisheries targeting red cod, tarakihi, barracouta and flatfish. There is a high level of targeting, and 50% of the total TAR3 catch is taken in effort targeted at tarakihi in the trawl and a setnet fishery. A small proportion of TAR is taken in TAR targeted sets in the Danish seine fishery which has developed since 2003-04.
- The remaining 30% of the total catch is nearly all taken in the TAR targeted setnet fishery in Area 18 off Kaikoura. During this review it was concluded that these fish probably constitute part of a stock centred in TAR 2 and possibly extending around into TAR 1.
- Roughly half the trawl catch is taken in each of Area 020 (Pegasus Bay) and Area 022 (Canterbury Bight), with < 10% of the landings coming from the lower half of the South Island in most years.
- The bottom trawl fishery takes tarakihi throughout the year.
- 90% of the bottom trawl landings of the TAR 3 are made up by fisheries targeting tarakihi, red cod, barracouta and flatfish, with about 30% coming from TAR targeted trawls.
- Tarakihi are caught over a wide depth range, depending on fishery. They are mainly caught between 40m - 100m in the main BAR, RCO, TAR and FLA fisheries, up to 200m in the SQU and SWA fisheries, with minor catches up to 400m deep in the HOK fishery.
- Two fishery definitions have been used since 2003 to assess TAR 3 CPUE: a BT(MIX)All mixed target trawl fishery on the ECSI; and the SN(TAR) fishery off Kaikoura. In 2007, differences between these indices suggested they may be tracking different components of the stock, and it was recommended that BT analyses be divided north and south of Banks Peninsula.
- Results confirmed that the SN(TAR) index showed substantially different trends, but that the BT(MIX)CB and BT(MIX)PB indices were similar. Industry participants noted that the industry had always considered the setnet-caught fish off Kaikoura to be different from those caught south of Point Gibson, and that the Kaikoura fish are probably related to the TAR 2 stock.
- Early tagging work by Annala (unpublished) also indicates that TAR caught off Kaikoura are probably related to those caught off the Wairarapa coast in TAR 2. Subsequent comparison of the SN(TAR) index for Kaikoura and recent bottom trawl index for TAR 2 (Bentley *et al.*) showed remarkable similarity.
- Further comparisons showed that the BT(TAR1)TCEPR index (which applies to the mixed target bottom trawl fishery in the Bay of Plenty) is also very similar to the TAR 2 and Kaikoura TAR 3 indices, suggesting a single ECNI stock extending from Kaikoura around to the Bay of Plenty. In view of the close coincidence and steadily declining trends in these three northern TAR indices, it was recommended that the Northern Inshore and AMP WGs urgently consider possible research and assessment proposals for the 'TAR 2' stock for 2009-10.
- The only remaining index for TAR 3 was the BT(MIX) index, which was applicable to the east coast South Island south of Kaikoura (Figure 10). The WG noted that this BT fishery is thought to catch smaller fish than the Kaikoura setnet fishery, and may be partially dependant on recruitment.

CPUE Analysis

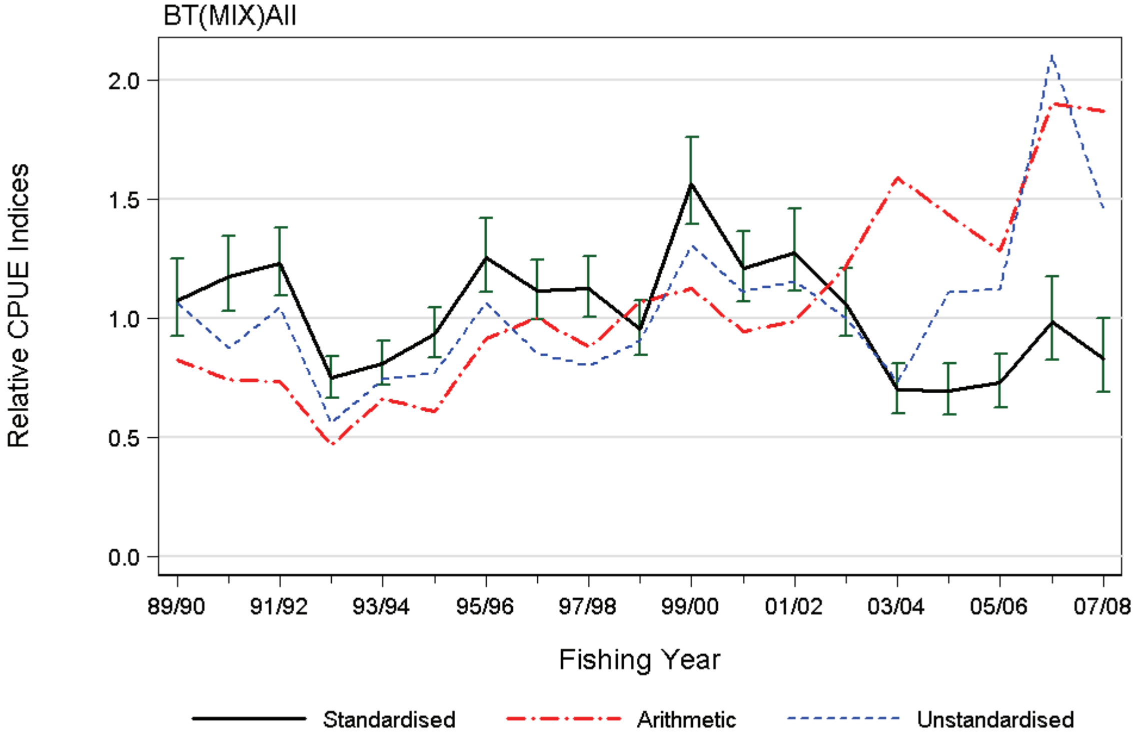


Figure 11: TAR 3 CPUE analysis based on mixed target species bottom trawl data for Statistical Areas 020, 022, 024 and 026 stratified by trip, target species and statistical area standardised with respect to fishing year, vessel, duration of tow, and target species. Indices from two unstandardised analyses are presented for comparison: a) "arithmetic", the annual sum of landings divided by the total annual sum of hours fished; and b) "unstandardised", the geometric mean of landings per hour fished by trip-stratum.

- There has been a substantial increase in targeting of TAR over the past 5 to 10 years and the strongest effect of standardisation of the BT(MIX) index is target, then duration of trawl and vessel effects. Correction for these results in strong depression of the index in from 2002-03 onwards, converting an increasing arithmetic mean to a declining standardised index.
- The standardised BT(MIX) index fluctuates without trend around the long term average from 1989-90 to 1998-99, and then rises to a historical maximum 50% above the average in 199-00. This is followed by a decline to historically lowest levels by 2003-04 over the period of increasing targeting.
- Since 2003-04 the index has remained stable, or slowly increasing, at this lower level.

Trawl Surveys

- Indices of tarakihi abundance were produced by the five ECSI winter trawl surveys from 1991 - 1996 and TAR was one of the species for which the ECSI winter trawl surveys were optimised when these resumed in 2007.
- There is reasonable agreement between BT(MIX) trawl index and winter east coast South Island trawl survey. The trawl survey index suggest that abundance has been relatively stable, but may be declining since the early 2000s. The large number of small tarakihi observed in the 2008 winter trawl survey suggests that there may be a pulse of recruitment pending. However, the trawl survey indices are highly imprecise even though tarakihi is one of the target species for this survey.

Status of the Stock

Analysis Recommendations

The following analyses were conducted or recommended during the 2009 review:

- Following conclusion that the Kaikoura setnet appears to catch fish which are related to the TAR 2 stock, it was recommended that this index be abandoned for TAR 3, and the BT(MIX) trawl index be re-calculated for all areas excluding Area 18. The index presented in Figure 4 follows this recommendation. Future indices for TAR 3 and TAR 2 should be separated at Point Gibson.
- There are suggestions that the apparent increase in reported TAR targeting in 1998 - 2001 related more to bycatch trading FLA target for TAR bycatch quotas. This emphasises the importance of trying to understand and correct for the effect of change in meaning of target over this period by looking at residuals by target and year or using a target*year interaction to detect false targeting effects

Abundance Indices

The BT(MIX) mixed species targeted index, excluding data from statistical area 18, appears to be the most appropriate abundance index for TAR 3. Noting the steady decline in CPUE since 2001-02 to lowest historical levels, this index should continue to be monitored to see whether abundance recovers to long term average levels, or continues to decline.

The TAR 3 fishery is based on small fish and consequently fewer year classes, so catch rates are expected to respond quickly to recruitment strength, and to fluctuate more rapidly. Discards resulting from the minimum legal size for this species may be as high in the trawl fishery south of the Banks Peninsula and there are concerns that this may distort the abundance index.

Sustainability of Current Catches

Current catches south of Point Gibson, excluding catches off Kaikoura, are likely sustainable at current levels of around 700t. Catches have been well below the TACC since 2003-04 and are currently only 60% of the TACC. Catches in the southern area at levels near to or at the current TACC, may lead to declines in biomass.

Stock Status

The state of the stock in relation to B_{MSY} is unknown. Abundance appeared to reach its lowest historical level over 2003-04 to 2005-06, at about 70% of the long-term average, having declined steadily from a peak in 1999-00. Abundance may be increasing back to average levels again.

6. STATUS OF THE STOCKS

TAR 1

CPUE indices for the three substocks within TAR 1 were calculated using data through to the end of the 2006–07 fishing year. The indices remain stable suggesting that current catches and the TACC for TAR 1 are sustainable. In 2002 the Inshore WG concluded that TAR 1 was likely to be above B_{MSY}. There is no evidence from the CPUE analyses to suggest any major changes in abundance since this time.

TAR 2

The TAR 2 fishery has provided fairly stable harvests of over 1 000t since the 1950s, and catches around 1 600t to 1 700t since the 1970s. Current catches (1 729t in 2006–07) are most likely sustainable. However, CPUE should be monitored to see whether the recent declines in CPUE from the target fishery continue.

The state of the TAR 2 stock in relation to B_{MSY} is not known. Long periods of sustained catches around 1 600t to 1 700t indicate a flat yield curve for the stock, and suggest that the stock is probably close to B_{MSY}.

TAR 3

The TAR 3 stock is believed to be separated from the TAR 2 stock at Point Gibson, south of Kaikoura. Tarakihi caught off Kaikoura are considered to form part of the TAR 2 stock, and the Kaikoura setnet index is no longer considered an appropriate index for the TAR 3 stock. The standardised BT(MIX) mixed species targeted bottom trawl CPUE index, excluding data from statistical area 18, appears to be the most appropriate abundance index to monitor TAR 3 abundance. This index fluctuates without trend around the long term average from 1989-90 to 1998-99, rises to a historical maximum 50% above the average in 1999-00, and then declines to the lowest levels over the data series by 2003-04 as a consequence of increased TAR targeting. The index is broadly consistent with trends observed in the ECSI winter trawl survey index, although the trawl survey is considered to be more an index of recruitment than population abundance.

Current catches south of Point Gibson are likely sustainable at current levels of around 700t. Catches have been well below the TACC since 2003-04 and are currently only 60% of the TACC. Catches in the southern area at levels of the current TACC, may lead to declines in biomass.

The state of the stock in relation to B_{MSY} is unknown. Abundance appeared to reach its lowest historical level over 2003-04 to 2005-06, at about 70% of the long-term average, having declined steadily from a peak in 1999-00. Abundance may be increasing back to average levels again, although a decline was again noted in 2007-08.

TAR 4

For TAR 4, the fishery around the Chatham Islands has generally been lightly fished and the stock can probably support higher catch levels for the next few years.

TAR 7

The range of model results for TAR 7 west coast stock assessment suggests that, given the assumptions about recruitment, the stock size on average should increase under current catch levels and suggests that the stock size is Likely to be above B_{MSY}.

TAR 8

Overall, landings from the North and South Islands have remained relatively stable, since at least the late 1960s, despite changes in effort and methods of fishing. Given the long, stable catch history of this fishery, current catch levels and TACCs are thought to be sustainable.

Yield estimates, TACCs and reported landings for the 2007–08 fishing year are summarised in Table 10.

Table 10: Summary of yield estimates (t), TACCs (t) and reported landings (t) of tarakihi for the most recent fishing year.

Fishstock	QMA		MCY	2007–08 Actual TACC	2007–08 Reported landings
TAR 1	Auckland (East) (West)	1 & 9		1 447	1 286
TAR 2	Central (East)	2		1 796	1 715
TAR 3	South–East (Coast)	3	4 540	1 403	844
TAR 4	South–East (Chatham)	4	–	316	348
TAR 5	Southland and Sub–Antarctic	5 & 6		153	50
TAR 7	Challenger	7		1 088	990
TAR 8	Central (West)	8		225	196
TAR 10	Kermadec	10	–	10	0
Total				6 390	5 429

7. FOR FURTHER INFORMATION

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