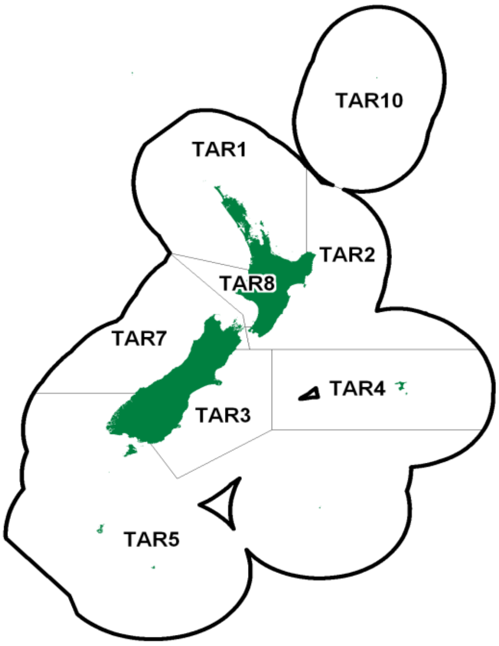
TARAKIHI (TAR)

(*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 1982–83 domestic and foreign landings combined ranged between 4082 t and 6444 t, averaging 5042 t per year (Table 1). Figure 1 shows the historical landings and TACC values for the main tarakihi stocks. Since the introduction of the QMS in 1986, the total landings have fluctuated between 4090 t and 6205 t (Table). From 1 October 2007, the TAC for TAR 1 was increased to 2029 t 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 73 t, 487 t, and 22 t respectively (Table). In October 2001, the TAR 7 TACC was increased to 1088 t but no recreational, customary, or other sources of fishing mortality allocations were made. In October 2004 the TACCs for TAR 2 and TAR 3 were increased to 1796 t and 1403 t respectively. TAR 4, 5, 8, 10 have not been assessed since entering the QMS in October 1986 and therefore the TACC and TACs have remained unchanged.

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 Islands 70–80% of the tarakihi catch is targeted. Around the South Island only about 30% of the tarakihi catch is targeted; with much of the remainder reported as bycatch in target barracouta and red cod bottom trawl fisheries. In addition, there is a small target tarakihi setnet fishery off Kaikoura. The commercial minimum legal size (MLS) for all TAR stocks is 25 cm.

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

Year	TAR 1	TAR 2	TAR 3	TAR 4	Year	TAR 1	TAR 2	TAR 3	TAR 4
1931–32	1146	123	0	0	1957	1423	2200	1150	0
1932–33	588	481	0	0	1958	1300	1952	1400	0
1933–34	534	415	152	0	1959	1697	2464	1315	0
1934–35	691	672	127	0	1960	1489	2867	862	0
1935–36	854	969	284	0	1961	1456	2864	1002	0
1936–37	1165	673	283	0	1962	1266	3126	1073	0
1937–38	1130	758	208	0	1963	1417	2632	968	0
1938–39	1044	788	445	0	1964	1304	2656	1250	0
1939–40	990	780	239	0	1965	1324	3027	1122	0
1940–41	637	674	624	0	1966	1100	2964	1539	0
1941–42	611	779	594	0	1967	1066	2548	657	0
1942–43	791	691	491	0	1968	888	1907	837	0
1943–44	573	477	391	0	1969	863	1727	720	0
1944	923	837	466	0	1970	1129	1932	1120	0
1945	1189	1340	269	0	1971	1125	2006	1153	0
1946	1410	1618	383	0	1972	996	1912	2169	12
1947	1162	1831	970	0	1973	804	1568	1455	0
1948	1075	2129	793	0	1974	687	1889	1913	24
1949	1575	2157	973	0	1975	584	1743	1106	10
1950	1925	2011	743	0	1976	620	1645	1927	21
1951	1948	2097	772	0	1977	849	1994	1648	835
1952	1990	2090	948	0	1978	1059	1718	373	6
1953	2066	2045	809	0	1979	1236	1375	717	362
1954	1697	1529	578	0	1980	1506	1391	1098	246
1955	2124	2039	599	0	1981	1213	1339	1242	137
1956	1850	2312	384	0	1982	1210	1277	953	72

Year	TAR 5	TAR 7	TAR 8	Year	TAR 5	TAR 7	TAR 8
1931–32	0	4	2	1957	12	735	18
1932–33	0	424	2	1958	8	625	20
1933–34	0	215	1	1959	7	666	17
1934–35	0	306	2	1960	10	732	15
1935–36	0	475	2	1961	15	573	23
1936–37	0	555	0	1962	6	759	52
1937–38	0	480	0	1963	8	630	43
1938–39	27	412	0	1964	7	593	61
1939–40	0	480	0	1965	11	470	58
1940–41	31	316	0	1966	24	549	64
1941–42	26	220	0	1967	2	1981	73
1942–43	15	87	0	1968	8	1941	100
1943–44	17	24	0	1969	8	592	173
1944	16	29	0	1970	19	1293	154
1945	1	432	0	1971	25	1192	202
1946	0	545	2	1972	15	741	279
1947	51	643	2	1973	27	747	190
1948	43	688	9	1974	31	1234	192
1949	49	873	13	1975	482	887	237
1950	35	803	8	1976	143	936	287
1951	42	747	7	1977	53	1337	465
1952	44	949	8	1978	54	1021	225
1953	30	896	20	1979	89	1125	109
1954	1	470	72	1980	107	748	109
1955	0	833	84	1981	137	1174	167
1956	0	699	28	1982	117	813	151

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. Data were aggregated to FMA using methods and assumptions described by Francis & Paul (2013).

Table 3: Reported landings (t) of tarakihi by Fishstock from 1983–84 to 2013–14 and TACCs (t) from 1986–87 to 2013–14. 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	94	153
2007–08	1 286	1 447	1 715	1 796	843	1 403	348	316	50	153
2008–09	1 398	1 447	1 901	1 796	1 017	1 403	77	316	45	153
2009–10	1 332	1 447	1 858	1 796	757	1 403	138	316	81	153
2010–11	1 349	1 447	1 660	1 796	1 207	1 403	180	316	135	153
2011–12	1 134	1 447	1 702	1 796	897	1 403	54	316	151	153
2012–13	1 184	1 447	1 900	1 796	1 026	1 403	31	316	144	153
2013–14	1 425	1 447	1 816	1 796	991	1 403	179	316	126	153
2014–15	1 463	1 447	1 947	1 796	1 112	1 403	154	316	136	153

	TAR 7		TAR 8		TAR 10			
FMA (s)	7		8		10			Total
	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	1 116	1 088	254	225	0	10	5 729	6 390
2007–08	990	1 088	196	225	0	10	5 428	6 438
2008–09	977	1 088	169	225	0	10	5 584	6 438
2009–10	1 162	1 088	226	225	0	10	5 553	6 438
2010–11	983	1 088	194	225	0	10	5 708	6 439
2011–12	1 173	1 088	235	225	0	10	5 346	6 439
2012–13	1 058	1 088	209	225	0	10	5 552	6 439
2013–14	1 073	1 088	248	225	0	10	5 857	6 439
2014–15	1 002	1 088	224	225	0	10	6 038	6 439

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

Table 4: Total allowable catches (TAC, t) allowance for customary non-commercial fishing, recreational fishing, and other sources of mortality (t), as well as the total allowable commercial catch (TACC, t) for tarakihi as of 1 October 2011.

Fishstock	TAC	TACC	Customary non-commercial	Recreational	Other Mortality
TAR 1 (FMA 1 & 9)	2 029	1 447	73	487	22
TAR 2	2 082	1 796	100	150	36
TAR 3	1 503	1 403	15	15	70
TAR 4	316	316	0	0	0
TAR 5 (FMA 5 & 6)	153	153	0	0	0
TAR 7	1 088	1088	0	0	0
TAR 8	225	225	0	0	0
TAR 10	10	10	0	0	0

1.2 Recreational fisheries

Tarakihi are taken by recreational fishers using lines and setnets. It is often taken by fishers targeting snapper and blue cod, particularly around the North Island. The allowances within the TAC for each Fishstock are shown in Table 4.

1.2.1 Management controls

The main methods used to manage recreational harvests of tarakihi are minimum legal size limits (MLS), method restrictions and daily bag limits. Fishers can take up to 20 tarakihi as part of their combined daily bag limit (except in the South-East and Southland fisheries management areas including the Fiordland Marine Recreational Fishing Area where the limit is 15 within a combined daily bag limit of 30 finfish) and the MLS is 25 cm in all areas.

1.2.2 Estimates of recreational harvest

Recreational catch estimates are given in Table 5. There are two broad approaches to estimating recreational fisheries harvest: the use of onsite or access point methods where fishers are surveyed or counted at the point of fishing or access to their fishing activity; and, offsite methods where some form of post-event interview and/or diary are used to collect data from fishers.

The first estimates of recreational harvest for tarakihi were calculated using an offsite approach, the offsite regional telephone and diary survey approach. Estimates for 1996 came from a national telephone and diary survey (Bradford 1998). Another national telephone and diary survey was carried out in 2000 (Boyd & Reilly 2002) and a rolling replacement of diarists in 2001 (Boyd et al 2004 allowed estimates for a further year (population scaling ratios and mean weights were not re-estimated in 2001).

The harvest estimates provided by these telephone diary surveys are no longer considered reliable for various reasons. With the early telephone/diary method, fishers were recruited to fill in diaries by way of a telephone survey that also estimated the proportion of the population that is eligible (likely to fish). A “soft refusal” bias in the eligibility proportion arises if interviewees who do not wish to co-operate falsely state that they never fish. The proportion of eligible fishers in the population (and, hence, the harvest) is thereby under-estimated. Pilot studies for the 2000 telephone/diary survey suggested that this effect could occur when recreational fishing was established as the subject of the interview at the outset. Another equally serious cause of bias in telephone/diary surveys was that diarists who did not immediately record their day’s catch after a trip sometimes overstated their catch or the number of trips made. There is some indirect evidence that this may have occurred in all the telephone/diary surveys (Wright et al 2004).

The recreational harvest estimates provided by the 2000 and 2001 telephone diary surveys are thought to be implausibly high for many species, which led to the development of an alternative maximum count aerial-access onsite method that provides a more direct means of estimating recreational harvests for suitable fisheries. The maximum count aerial-access approach combines data collected concurrently from two sources: a creel survey of recreational fishers returning to a subsample of ramps throughout the day; and an aerial survey count of vessels observed to be fishing at the approximate time of peak fishing effort on the same day. The ratio of the aerial count in a particular area to the number of interviewed parties who claimed to have fished in that area at the time of the overflight was used to scale up harvests observed at surveyed ramps, to estimate harvest taken by all fishers returning to all ramps. The methodology is further described by Hartill et al (2007).

This aerial-access method was first employed and optimised to estimate snapper harvests in the Hauraki Gulf in 2003–04. It was then extended to survey the wider SNA 1 fishery in 2004–05 and to provide estimates for other species, including tarakihi (FMA 1 only for TAR) (Hartill et al 2007). This survey was repeated in 2011–12 (Hartill et al 2013).

In response to the cost and scale challenges associated with onsite methods, in particular the difficulties in sampling other than trailer boat fisheries, offsite approaches to estimating recreational fisheries harvest have been revisited. This led to the development and implementation of a national panel survey for the 2011–12 fishing year. The panel survey used face-to-face interviews of a random sample of 30, 390 New Zealand households to recruit a panel of fishers and non-fishers for a full year. The panel members were contacted regularly about their fishing activities and catch information collected in standardised phone interviews.

The most recent aerial-access survey conducted in QMA 1 in 2011–12 (Hartill et al 2013) provides independent harvest estimates for comparison with those generated from the concurrent national panel survey. Both surveys appear to provide plausible results that corroborate each other for the FMA 1 portion of TAR 1, and are therefore considered to be broadly reliable (Hartill et al 2013). Note that neither of these estimates includes catch taken on recreational charter vessels, or recreational catch taken under s111 general approvals.

Table 5: Recreational harvest estimates for tarakihi stocks ((Bradford 1998, Boyd & Reilly 2002, Boyd et al 2004, Hartill et al 2007, Hartill et al 2013, MPI Unpublished data). The telephone/diary surveys and earlier aerial-access survey ran from December to November but are denoted by the January calendar year. The surveys since 2010 have run through the October to September fishing year but are denoted by the January calendar year. Mean fish weights were obtained from boat ramp surveys (for the telephone/diary and panel survey harvest estimates).

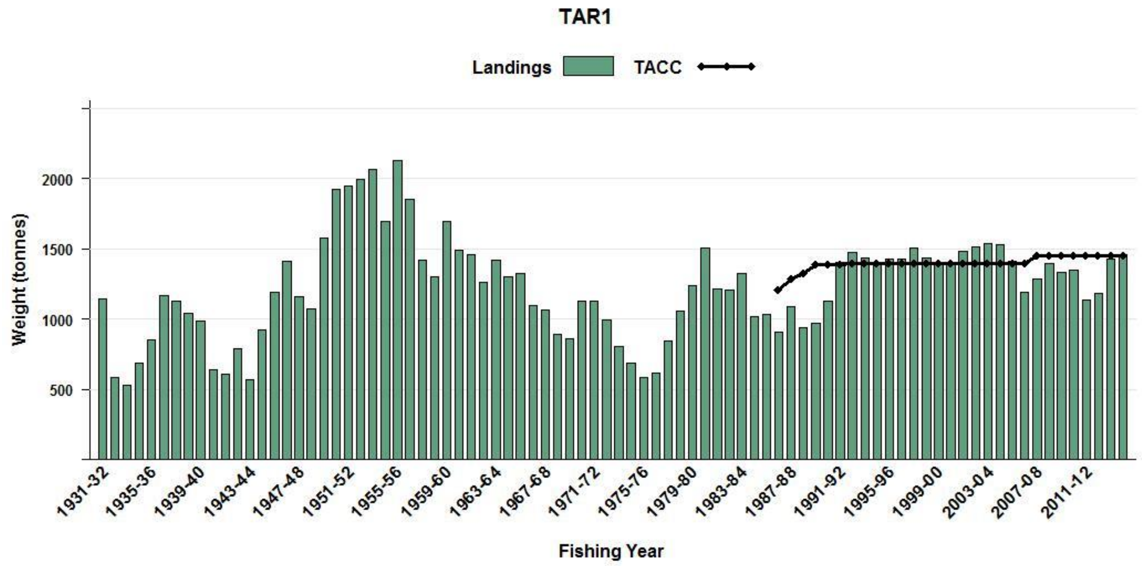
Stock	Year	Method	Number of fish	Total weight (t)	CV
TAR 1	1996	Telephone/diary	498 000	305	0.08
	2000	Telephone/diary	1 035 000	636	0.19
	2001	Telephone/diary	679 000	417	0.16
FMA 1 only	2005	Aerial-access	-	90	0.18
FMA 1 only	2012	Aerial-access	-	67	0.15
FMA 1 only	2012	Panel survey	137 329	97	0.25
TAR 2	1996	Telephone/diary	114 000	65	0.14
	2000	Telephone/diary	310 000	191	0.27
	2001	Telephone/diary	484 000	298	0.18
	2012	Panel survey	107 859	71	0.22
TAR 3	1996	Telephone/diary	3 000	-	-
	2000	Telephone/diary	25 000	15	0.51
	2001	Telephone/diary	7 000	4	0.37
	2012	Panel survey	3 749	3	0.47
TAR 5	1996	Telephone/diary	3 000	-	-
	2000	Telephone/diary	10 000	6	0.57
	2001	Telephone/diary	13 000	7	0.37
TAR 7	1996	Telephone/diary	69 000	24	0.13
	2000	Telephone/diary	87 000	33	0.18
	2001	Telephone/diary	9 000	3	0.15
	2012	Panel survey	47 674	23	0.39
TAR 8	1996	Telephone/diary	46 000	28	0.17
	2000	Telephone/diary	66 000	30	0.38
	2001	Telephone/diary	78 000	36	0.28
	2012	Panel survey	29 940	22	0.31

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.



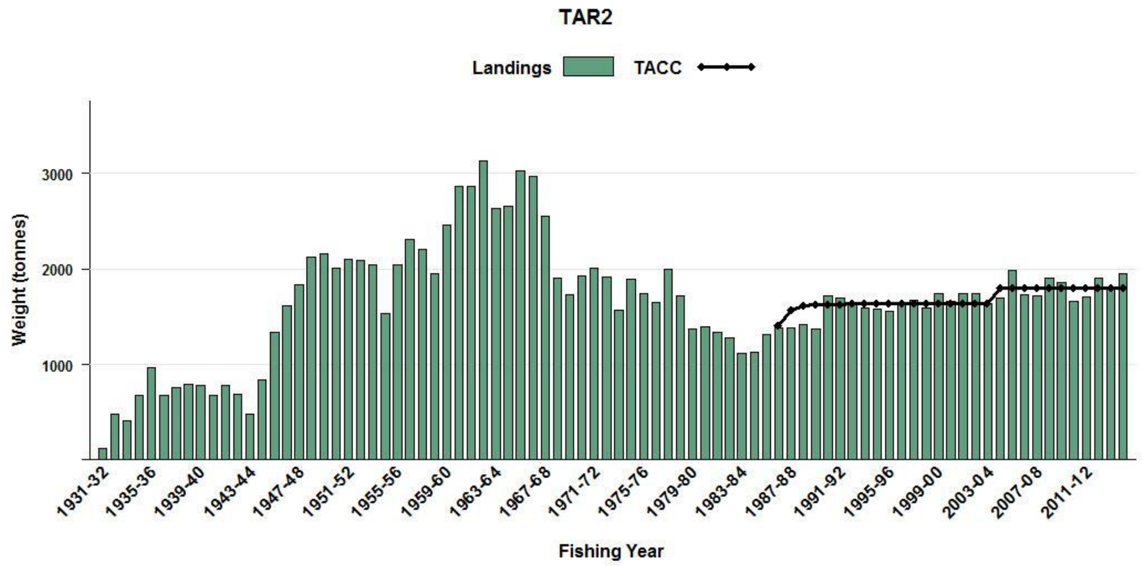
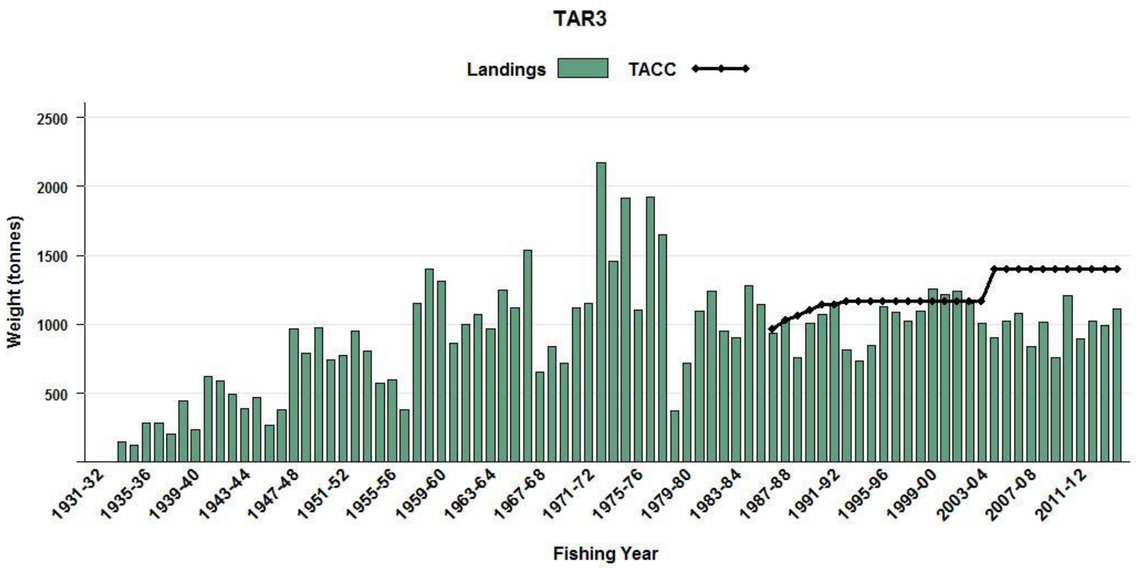


Figure 1: Historical landings and TACCs for the seven main TAR stocks. From top to bottom: TAR 1 (Auckland) and TAR 2 (Central East), TAR 3 (Southeast Coast). [Continued on next page].



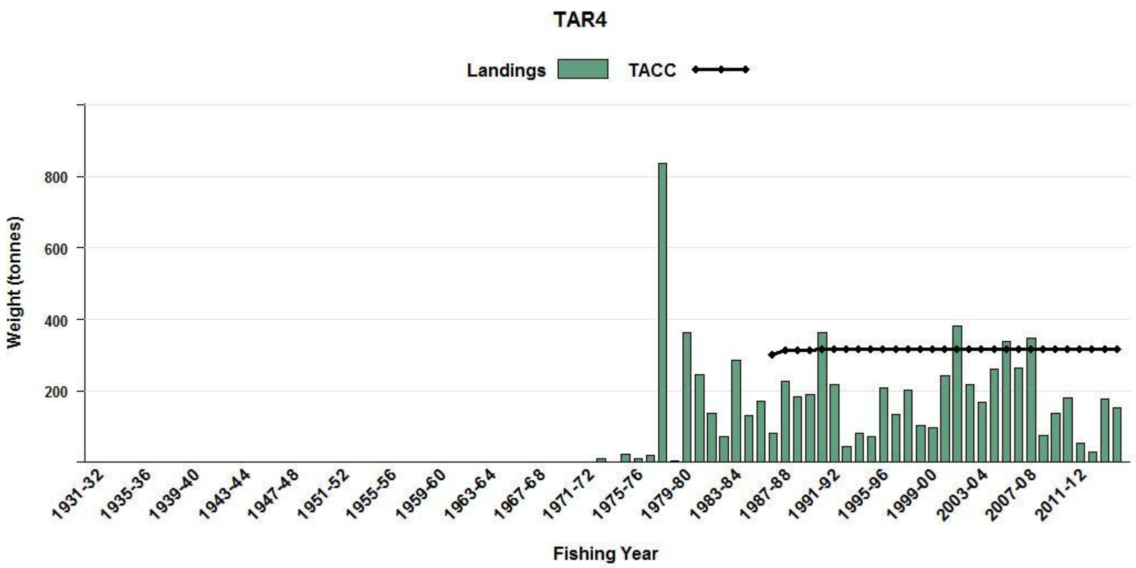
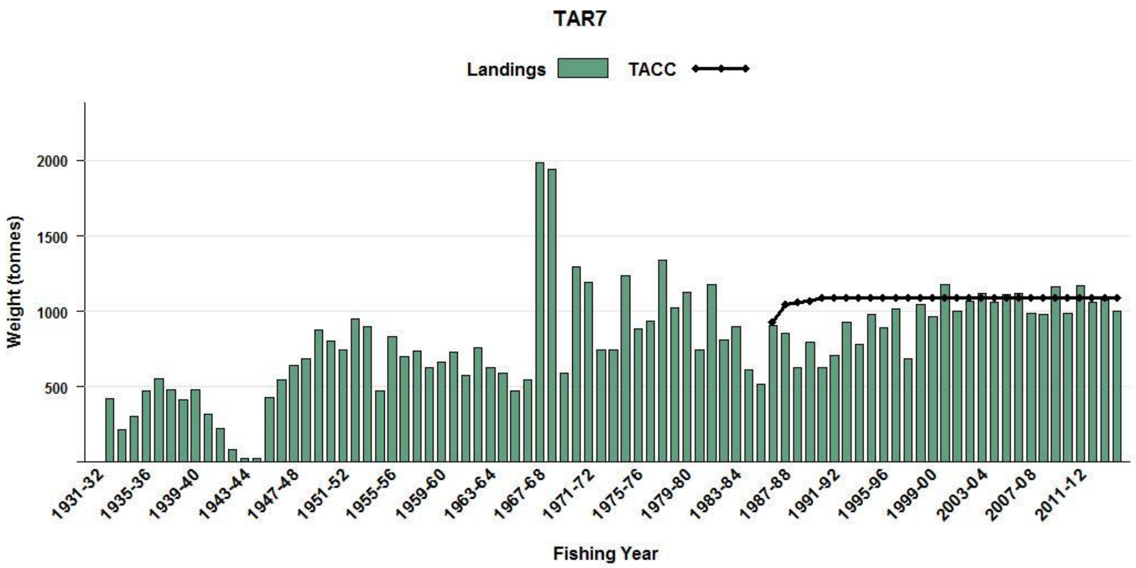


Figure 1 [continued]: Historical landings and TACCs for the seven main TAR stocks. From top to bottom: TAR 1 (Auckland) and TAR 2 (Central East), TAR 3 (Southeast Coast). [Continued on next page].



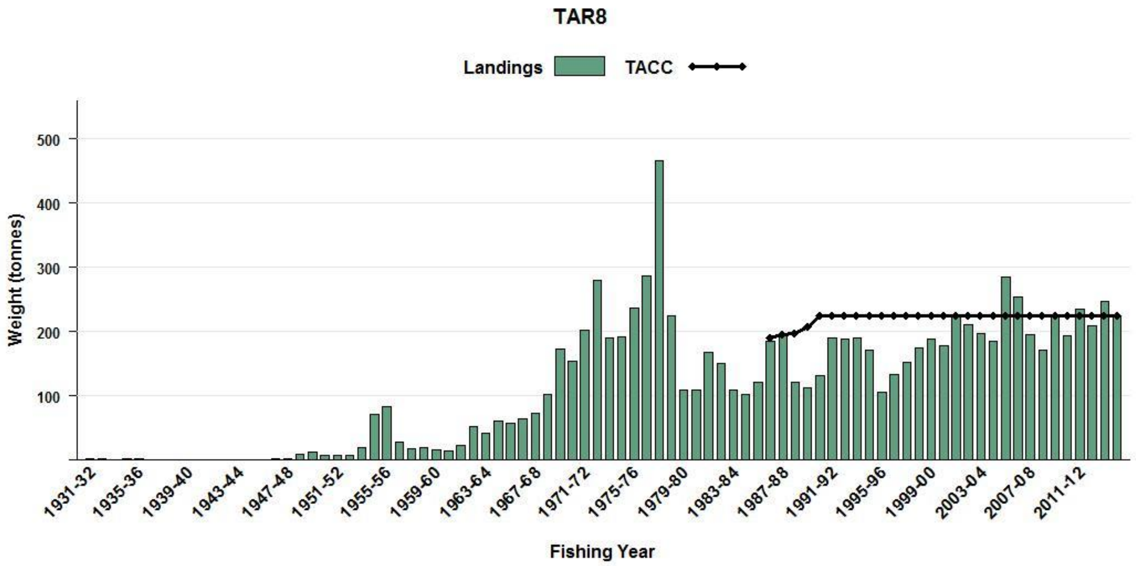


Figure 1 [continued]: Historical landings and TACCs for the seven main TAR stocks. From top to bottom: TAR 1 (Auckland) and TAR 2 (Central East), TAR 3 (Southeast Coast). [Continued on next page].

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. Tarakihi 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, Cape Campbell 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. Recent sampling of the TAR 3 trawl catch revealed that a high proportion of the landed catch is comprised of immature fish. Conversely, TAR 3 set net and TAR 2 trawl landed catches were comprised mainly of mature fish.

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 6.

Table 6: 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 et al (2008)n
3. von Bertalanffy growth parameters							
			Females			Males	
	K	t_0	$L\infty$	*K*	t_0	$L\infty$	
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

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 had been considered to be one stock. Further, 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 were considered to be a separate stock.

In 2008, the Working Group concluded that the tagging programmes had not been designed in such a way as to adequately test stock structure hypotheses and the results were not conclusive. The Working Group suggested that further analysis was necessary before firm conclusions could be made on the number of tarakihi stocks in the North and South Islands.

A 2012 review of tarakihi stock structure along the east coast of mainland New Zealand revealed that recent trends in CPUE in TAR 3 are similar to those from the Bay of Plenty and TAR 2 fisheries. However, the CPUE trend and age structure for East Northland were different from the other east coast areas, suggesting that we cannot link all of the east coast into a single stock.

There are distinct spawning grounds in each of the two main islands (off East Cape in the northern area and off Cape Campbell in the south), but there is a preponderance of juvenile fish in the southern area and low densities of juvenile tarakihi within the Bay of Plenty and TAR 2 fisheries. The long pelagic phase of tarakihi may provide a mechanism for the transfer of larvae to the nursery grounds in Canterbury Bight/Pegasus Bay and they then subsequently recruit to the East Cape area at maturity. This hypothesis is supported by the northward movement of tagged fish from the Kaikoura coast to the Wairarapa, East Cape and Bay of Plenty areas.

These observations are consistent with some mixing between the two fishery areas, with the southern area (TAR 3) representing a source of recruitment to the northern (TAR 2) area. However, it is not possible to assess the extent of mixing and whether or not movement occurs in the opposite direction (from TAR 2 to TAR 3). Thus, there exist a range of potential stock hypotheses which occupy a continuum between the following two extremes: 1) the TAR 2 and TAR 3 fisheries represent discrete stocks or 2) there is substantial mixing of the fish between the two areas. The most plausible working hypothesis is that there is local recruitment in both areas, with the TAR 2 fishery being augmented by additional recruitment from the TAR 3 fishery area. The juvenile tarakihi that settle and reside in the TAR 3 nursery grounds potentially include the progeny of fish spawning in areas outside of TAR 3.
Results from previous tagging studies indicate some connectivity between Kaikoura and the west coast North Island. The TAR 3 fishery may therefore represent a source of recruitment to areas beyond the Bay of Plenty and TAR 2.
Catches of king tarakihi (*Nemadactylus sp.*), have been reported as *N. macropterus* in the past.

4. STOCK ASSESSMENT

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 Trawl Surveys

4.1.1 Relative abundance

Indices of relative biomass are available from *Kaharoa* trawl surveys in TAR 2, TAR 3 and TAR 7 (Table 7, Figure 2, Figure 3 and Figure 4). 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. The TAR 2 survey was conducted for four consecutive years: 1993–1996 and then discontinued.

West Coast South Island Inshore Trawl Survey

For TAR 7, trawl survey biomass estimates for pre-recruit (less than 25 cm F.L.) and recruited (≥25 cm) tarakihi were derived for the west coast South Island and Tasman Bay/Golden Bay (TBGB) areas of the WCSI trawl survey (Figure 2). The TBGB area is considered to be a primary nursery ground for tarakihi in TAR 7. A substantial proportion of the TAR 7 commercial catch is taken from the west coast portion of the survey area. For comparability with the commercial CPUE indices it is appropriate to partition the trawl survey biomass indices by area and size category.

Biomass estimates for the west coast strata of the survey ground are relatively stable through the time series aside from a higher than usual estimate in 2005 (Figure 2). Most of the survey biomass is recruited fish. In contrast, more of the survey biomass in TBGB is comprised of pre-recruited fish. Biomass estimates in TBGB fluctuate more than those for the west coast and the CVs for pre-recruited fish are often high. Throughout the time series, total biomass of the west coast has been substantially greater than for TBGB.

East Coast South Island Trawl Survey

The ECSI winter surveys from 1991 to 1996 (depth range 30–400 m) were replaced by summer trawl surveys (1996–97 to 2000–01) which also included the 10–30 m depth range; but these were discontinued after the fifth in the annual time series, because of the extreme fluctuations in catchability between surveys (Francis et al. 2001). The winter surveys were reinstated in 2007, and this time included strata in the 10–30 m depth range, in order to monitor elephant fish and red gurnard. Only 2007, 2012 and 2014 surveys provide full coverage of the 10–30 m depth range.

For the east coast South Island winter trawl survey core strata (30–400 m) biomass for tarakihi increased by 43% between 2012 and 2014 and in 2014 was 23% above the survey average (1934 t), although this average is inflated by a large biomass estimate with high CV (55%) in 1993, partly the result of a single large catch off Timaru (Table 7, Figure 3). There was no apparent trend in biomass over the time series. Pre-recruit biomass was a major component of tarakihi total biomass estimates on all surveys, ranging from 18–60% of total biomass, and in 2014 it was 34%. Similarly, juvenile biomass (based on length-at-50% maturity) was also a large component of total biomass, but the proportion was relatively constant over the time series, 60–80%, and in 2014 it was 67% (Figure 4). There was virtually no tarakihi caught in the new 10–30 m strata, and hence the addition of the shallow strata in 2007 is of no value for monitoring tarakihi. The distribution of tarakihi hotspots varies, but overall this species is consistently well represented over the entire survey area, most commonly from 30 to about 150 m.

The size distributions of tarakihi in each of the ten ECSI winter trawl surveys were similar and were multi-modal, with smaller modes representing individual cohorts (Beentjes et al. 2015). In 2012, particularly, the 0+, 1+, 2+, and possibly 3+ cohorts were evident, but less clearly defined in 2014. Tarakihi on the ECSI, overall, were generally smaller than those from the west coast South Island and the east coast North Island, suggesting that, as with Tasman/Golden Bays, Pegasus Bay and the Canterbury Bight are important nursery grounds for juvenile tarakihi.

North Island Trawl Surveys

Summer surveys in the Bay of Plenty (from Mercury Islands to Cape Runaway) were carried out from 1983 to 1999. These 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.

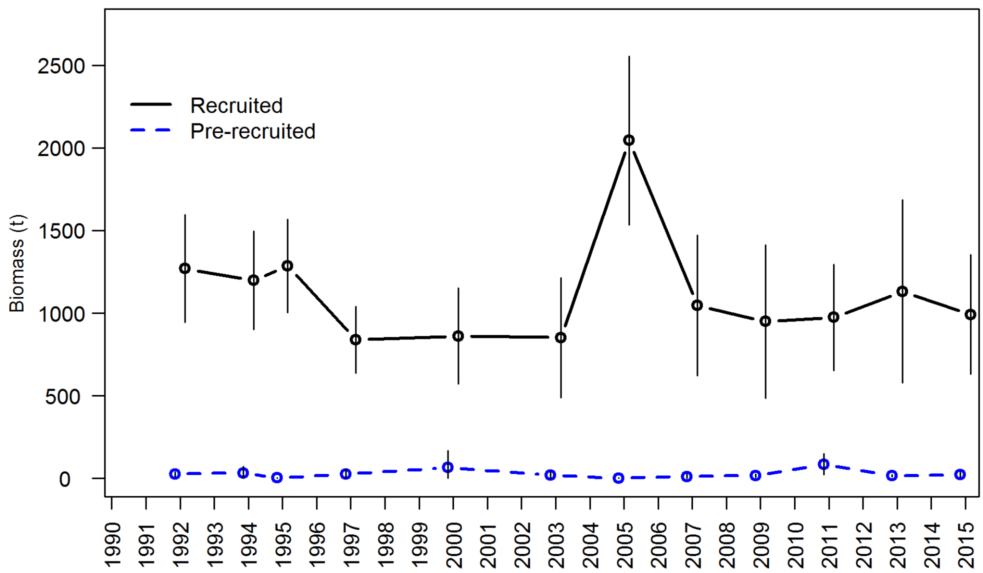


Figure 2: Trawl survey biomass estimates for pre-recruit (< 25 cm FL) and recruited tarakihi (≥ 25 cm FL) for the west coast South Island inshore trawl survey (west coast strata only, Tasman Bay/Golden Bay excluded). Error bars are ± two standard deviations. The 2008 assessment concluded that the stock was at or above B_{MSY} in 2007. [Figure continued on next page].

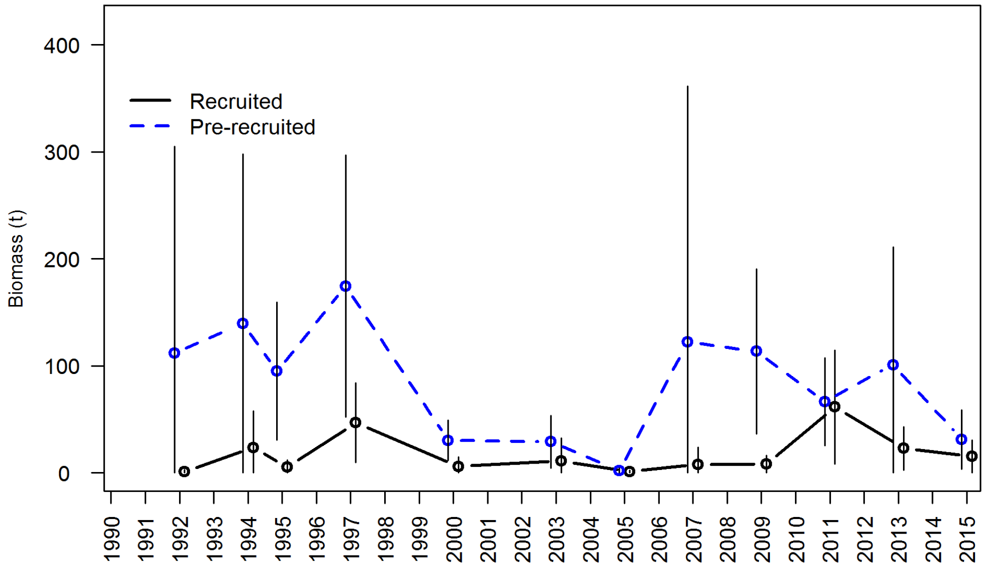


Figure 2 [Continued]: Trawl survey biomass estimates for pre-recruit (< 25 cm FL) and recruited tarakihi (≥ 25 cm FL) for the west coast South Island inshore trawl survey (Tasman Bay/Golden Bay strata only, west coast excluded). Error bars are ± two standard deviations.

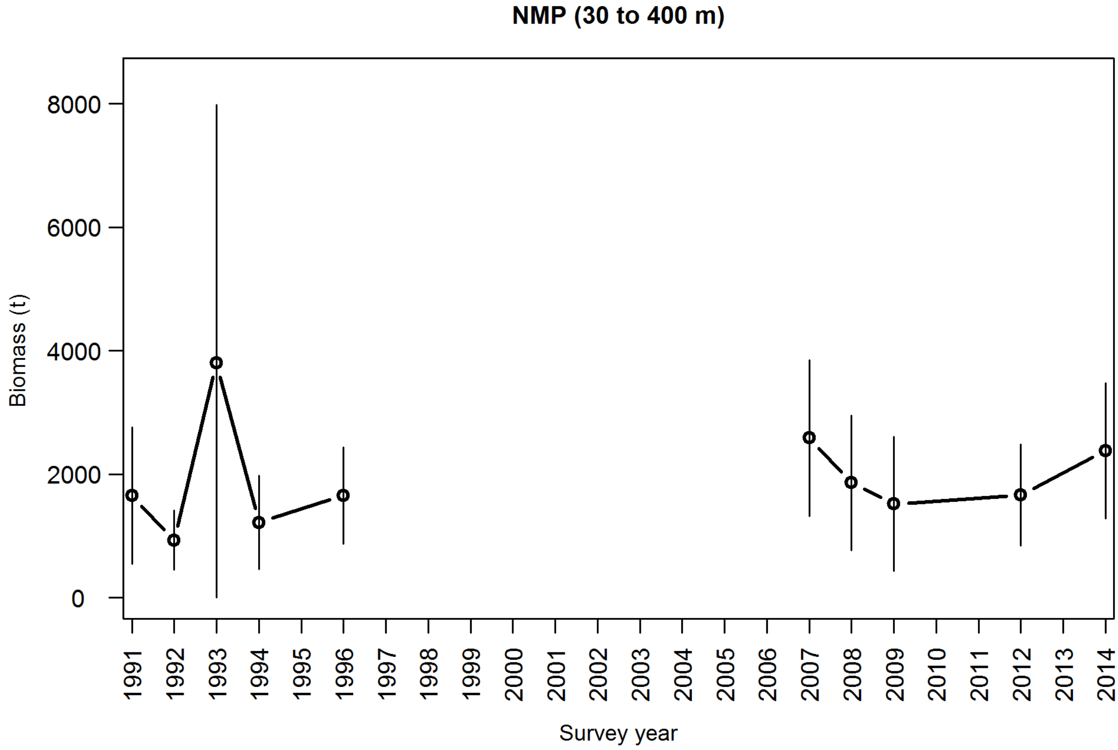


Figure 3: Tarakihi total biomass and 95% confidence intervals for the all ECSI winter surveys in core strata (30–400 m).

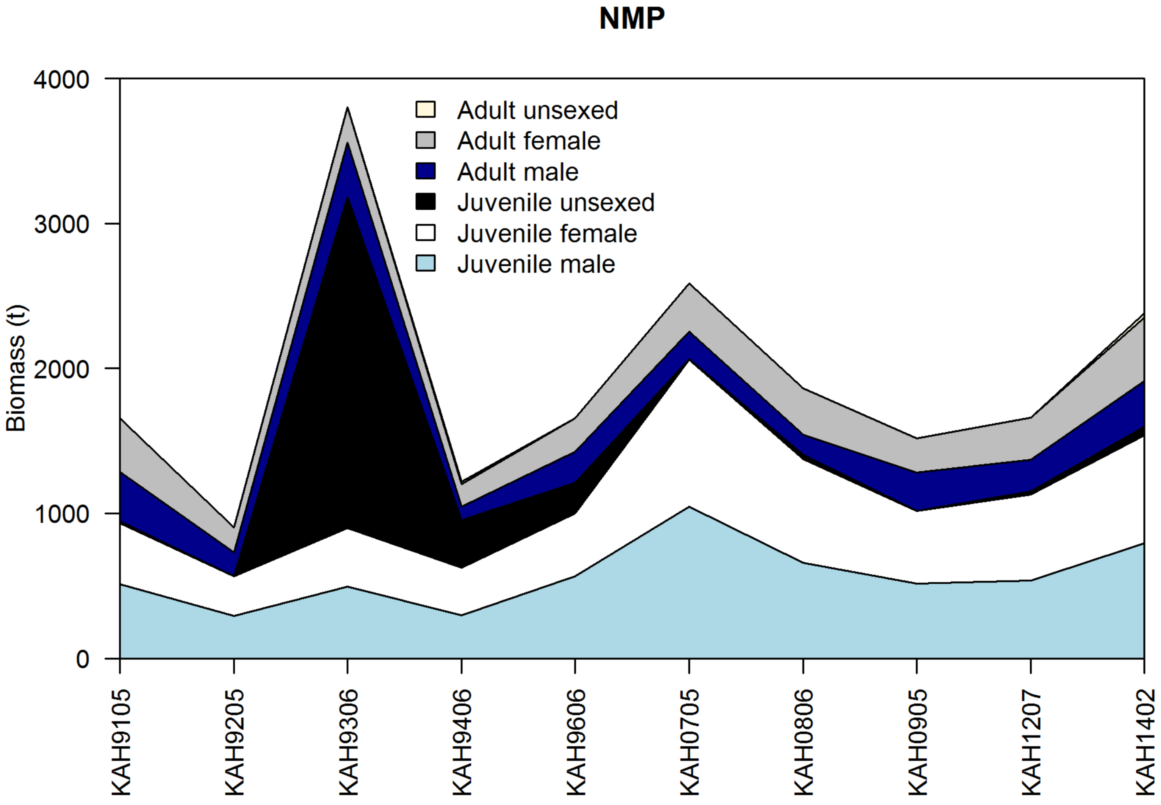


Figure 4: Tarakihi juvenile and adult biomass for ECSI winter surveys in core strata (30–400 m), where juvenile is below and adult is equal to or above the length at which 50% of fish are mature.

Table 7: Relative biomass indices (t) and coefficients of variation (CV) for tarakihi for Cape Runaway to Cook Strait, ECSI – summer and winter, and Tasman Bay to Haast survey areas*. Biomass estimates for ECSI in 1991 have been adjusted to allow for non-sampled strata (7 and 9 equivalent to current strata 13, 16 and 17). The sum of pre-recruit and recruited biomass values do not always match the total biomass for the earlier surveys because at several stations length frequencies were not measured, affecting the biomass calculations for length intervals. – , not measured; NA, not applicable. Recruited is defined as the size-at-recruitment to the fishery (25 cm).

Region	Fishstock	Year	Trip number	Total Biomass estimate	CV (%)	Total Biomass estimate	CV (%)	Pre-recruit	CV (%)	Pre-recruit	CV (%)	Recruited	CV (%)	Recruited	CV (%)
Cape Runaway to Cook Strait	TAR 2	1991	KAH9304	885	27	-	-	-	-	-	-	-	-	-	-
		1992	KAH9402	1 128	20	-	-	-	-	-	-	-	-	-	-
		1993	KAH9502	791	23	-	-	-	-	-	-	-	-	-	-
		1994	KAH9602	943	15	-	-	-	-	-	-	-	-	-	-
ECSI (winter)	TAR 3			30–400 m		10–400m		30–400m		10–400m		30–400m		10–400m	
		1991	KAH9105	1 712	33	-	-	305	38	-	-	1 414	33	-	-
		1992	KAH9205	932	26	-	-	288	26	-	-	614	28	-	-
		1993	KAH9306	3 805	55	-	-	2 282	62	-	-	1522	46	-	-
		1994	KAH9406	1 219	41	-	-	494	31	-	-	725	35	-	-
		1996	KAH9606	1 656	24	-	-	519	30	-	-	1137	27	-	-
		2007	KAH0705	2 589	24	-	-	822	30	-	-	1766	24	-	-
		2008	KAH0806	1 863	29	-	-	739	44	-	-	1123	25	-	-
		2009	KAH0905	1 519	36	-	-	525	42	-	-	994	42	-	-
		2012	KAH1207	1 661	25	-	-	584	34	-	-	1077	29	-	-
		2014	KAH1402	2 380	23	-	-	818	26	-	-	1562	26		
ECSI (summer)	TAR 3	1996	KAH9618	3 818	21	-	-	-	-	-	-	-	-	-	-
		1997	KAH9704	2 036	24										
		1998	KAH9809	4 277	24	-	-	-	-	-	-	-	-	-	-
		1999	KAH9917	2 606	15	-	-	-	-	-	-	-	-	-	-
		2000	KAH0014	1 510	13	-	-	-	-	-	-	-	-	-	-
Tasman Bay to Haast	TAR 7	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	1 089	21	-	-	-	-	-	-	-	-	-	-
		2009	KAH0904	1 088	22	-	-	-	-	-	-	-	-	-	-
		2011	KAH1104	1 188	15	-	-	-	-	-	-	-	-	-	-
		2013	KAH1305	1 272	22	-	-	-	-	-	-	-	-	-	-
		2015	KAH1503	1 058	17	-	-	-	-	-	-	-	-	-	-

*Assuming areal availability, vertical availability and vulnerability equal 1.0. Biomass is only estimated outside 10 m depth except for COM9901 and CMP0001. Note: because trawl survey biomass estimates are indices, comparisons between different seasons (e.g., summer and winter ECSI) are not strictly valid.

4.2 CPUE analyses

4.2.1 East Coast and West Coast North Island CPUE analyses

CPUE indices for all TAR QMAs, except for TAR 7 (west coast South Island), were reviewed in 2012 for use in a planned east coast North and South Islands tarakihi stock assessment. The Working Group did not accept this stock assessment because the available data were inadequate to differentiate between a range of movement and stock hypotheses, as well as requiring strong unsubstantiated assumptions when fitting the data (see discussion below in Section 4.2). In lieu of a stock assessment, the Working Group agreed to present the accepted CPUE series as the best available indicators of tarakahi abundance.

Six CPUE series (Table 8) were reviewed and accepted by the Working Group in 2012. All but one of these series were extensions of series already accepted by the Working Group, developed through MPI research projects or through the AMP. The only new series accepted by the Working Group was the ECNI mixed target species bottom trawl series, which previously had been restricted to tows targeting TAR only. The Working Group agreed to widening the target species definition in this series to include additional target species to conform with existing practice with respect to CPUE analyses, where a broader definition of target species allows for greater comparability across years and form types, as well as guarding against hyperstability in the series confined to a single species definition.

Table 8: Names and descriptions of the six tarakihi CPUE series accepted by the WG in 2012. Also shown is the error distribution that had the best fit to the distribution of standardised residuals for the fitted model.

Name	Code	QMA	Method	Statistical areas	Target species	Best distribution
West coast North Island	WCNI-BT	TAR 1	BT	041, 042, 045, 046, 047, 048	TAR, SNA, TRE	Weibull
East Northland	EN-BT	TAR 1	BT	002, 003, 004, 005, 006, 007	TAR, SNA, TRE, BAR, JDO, GUR	Weibull
Bay of Plenty	BoP-BT	TAR 1	BT	008, 009, 010	TAR, SNA, TRE, SKI, JDO, GUR	Weibull
East coast North Island	ECNI-BT	TAR 2	BT	011, 012, 013, 014, 015, 016	TAR, SNA, BAR, SKI, WAR, GUR	Weibull
East coast South Island	ECSI-BT	TAR 3	BT	017, 018, 020, 022, 024, 026	TAR, BAR, RCO, WAR, GUR	Lognormal
Area 18 target setnet	ECSI-SN	TAR 3	SN	018	TAR	Weibull

All six analyses (Table 8) were based on data which had been amalgamated into “trip-strata” (Starr 2007), defined as the sum of the catch and effort within a trip characterised by unique statistical areas, target species and method of capture. This approach loses much of the detailed information available in tow-by-tow records, but reduces all data to a common level of stratification, allowing the calculation of linked year coefficients for use in the stock assessment model and obviating the necessity of estimating multiple scaling [q] parameters in the stock assessment model.

A problem with the “trip-stratum” approach is that it ignores problems associated with shifts in reporting behaviour associated with changes in form type requirements, while relying on the model parameterisation to adjust for potential biases. This represents a change in approach for the three models for WCNI, EN and BoP, which previously had handled the form change issue by calculating independent indices for each form type. The Working Group agreed that calculating a single series across all years was a better approach for stock assessment modelling in the face of limited data, but requested that future tarakihi CPUE analyses continue to investigate the effect of the form type change on the estimated annual coefficients and to return, when justified, to analyses which were restricted to form types which collected data at equivalent resolution. As well, the Working Group reviewed analyses which investigated the effects of form type changes in these models and concluded that the models had been reasonably successful in accounting for potential biases.

Each series was modelled in the same manner, with log(catch) offered as the dependent variable and a range of explanatory variables offered, including duration and number of tows (length of net set in the setnet analysis) as continuous polynomials, and statistical area, target species, vessel and month as categorical explanatory variables. In every case, year was forced into the model as the first variable and was considered to be a proxy for relative annual abundance. Data were restricted to vessels which had participated for a specified number of years at a minimum level of participation (expressed as number of trips in a year). This filtering of the data was done to reduce the number of vessels in the data set without overly reducing the amount of catch represented in the model.

Trial models based on five alternative distributional assumptions were fit to a reduced set of explanatory variables, with the distribution giving the best log-likelihood fit selected for the final stepwise model fit. Table 8 lists the distribution giving the best fit for each model. A logit model which modelled the probability of success was also fit to the same data using a binomial distribution. This model was generated as a diagnostic but is not presented.

TAR 1: Three standardised CPUE models (Table 8) are used to track the abundance of tarakihi populations in TAR 1, because of the wide area covered by this QMA and the divergence in trends between the three areas. The WCNI model showed almost no trend, fluctuating around the long-term mean with fairly wide error bars, indicating that the model is not well determined (Figure 5). The East Northland series dropped sharply after the first year, which is likely to be due to data issues in the first year of operation (Figure 6). After that drop, the series showed a long gradual declining trend beginning towards the end of the 1990s. This decline appears to have stabilised at about 60% of the long-term mean since 2006–07. Finally the Bay of Plenty series shows no long-term trend, with current levels near to the levels observed at the beginning of the series, interrupted by about 5 years of increased CPUE in the early 2000s (Figure 7).

TAR 2: Only one standardised CPUE series is used to monitor the east coast of the North Island tarakihi (Table 8). This series closely resembles the Bay of Plenty series with no strong long-term trend over the full 22 years, except that the recent (4 to 5 years) indices appear to lie slightly below the indices at the beginning of the series (Figure 8). This series also shows an elevated period in the early 2000s that mirrors the Bay of Plenty indices. The close similarity between these two series is taken as evidence that there is a linkage between the tarakihi populations in these two areas.

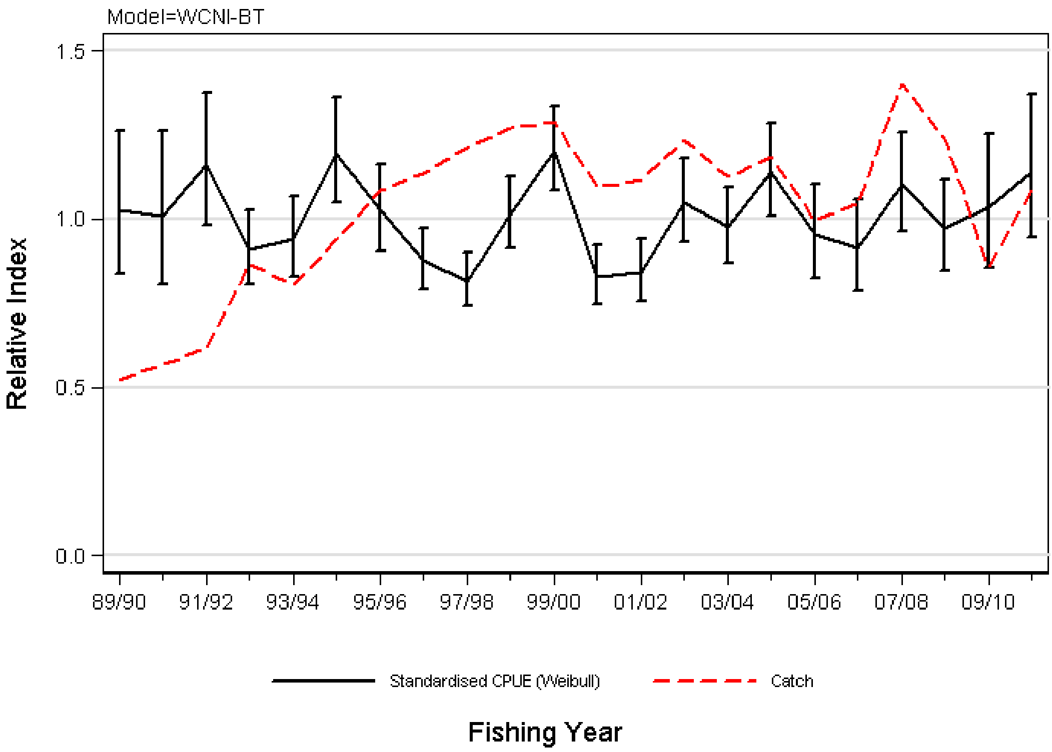


Figure 5: **Standardised CPUE index for the west coast substock of TAR 1 (Table 8) plotted along with the annual sum of catches from the series statistical areas listed in Table 8. Both series have been normalised to a geometric mean =1.0. Error bars show ±97.5% confidence intervals.**

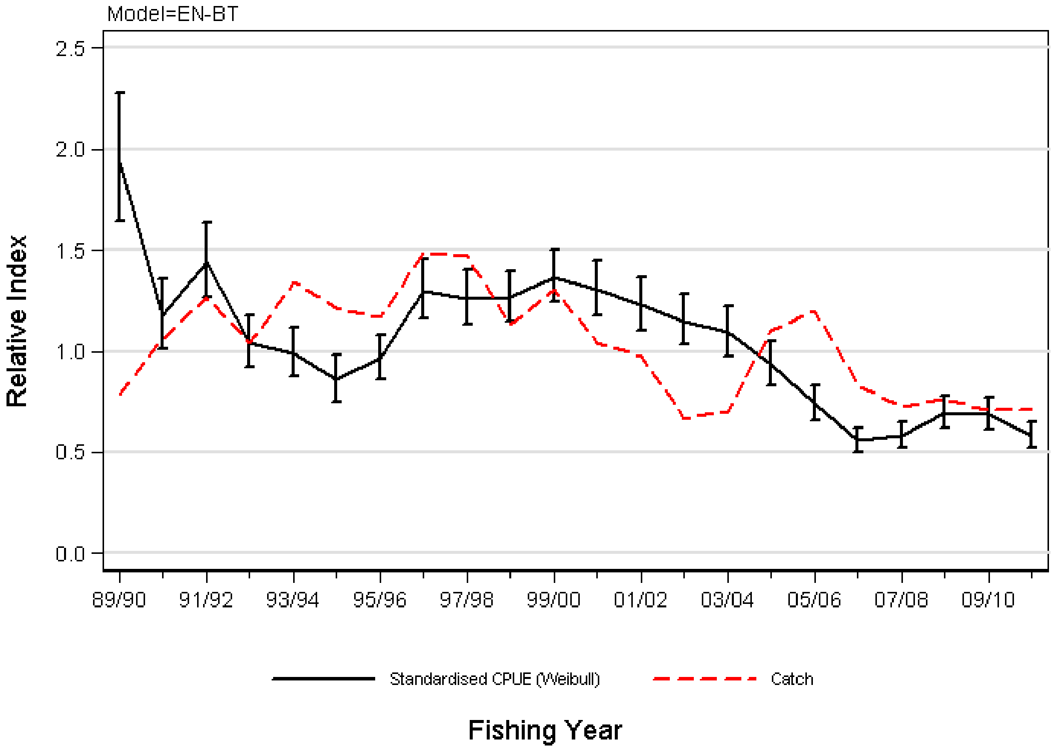


Figure 6: **Standardised CPUE index for the East Northland substock of TAR 1 (Table 8) plotted along with the annual sum of catches from the series statistical areas listed in Table 8. Both series have been normalised to a geometric mean =1.0. Error bars show ±97.5% confidence intervals.**

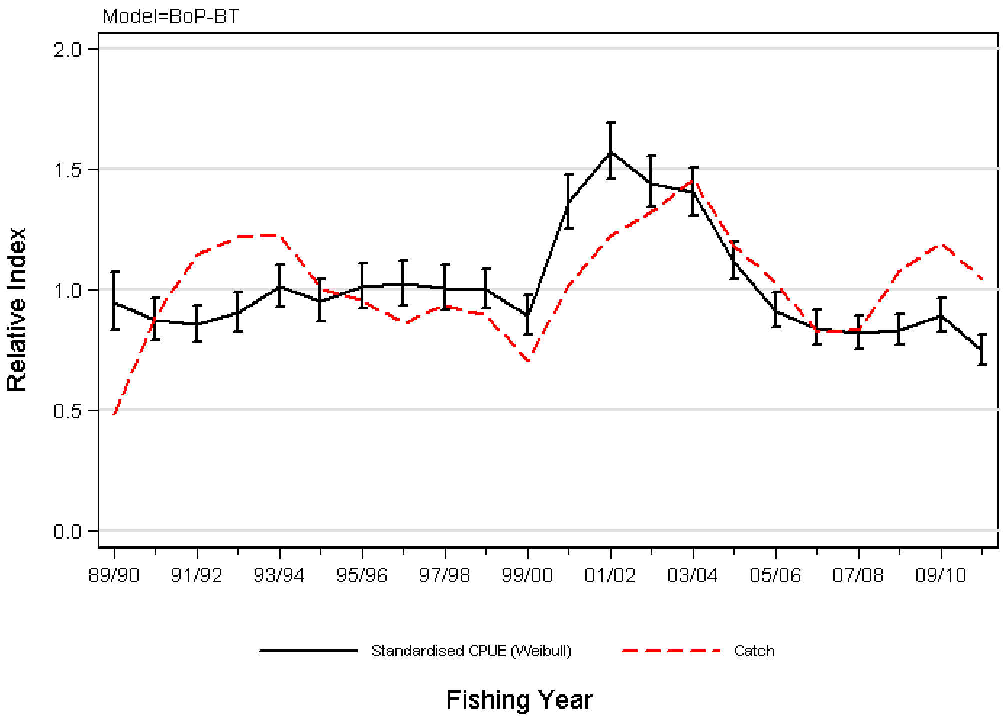


Figure 7: **Standardised CPUE index for the Bay of Plenty substock of TAR 1 (Table 8) plotted along with the annual sum of catches from the series statistical areas listed in Table 8. Both series have been normalised to a geometric mean =1.0. Error bars show ±97.5% confidence intervals.**

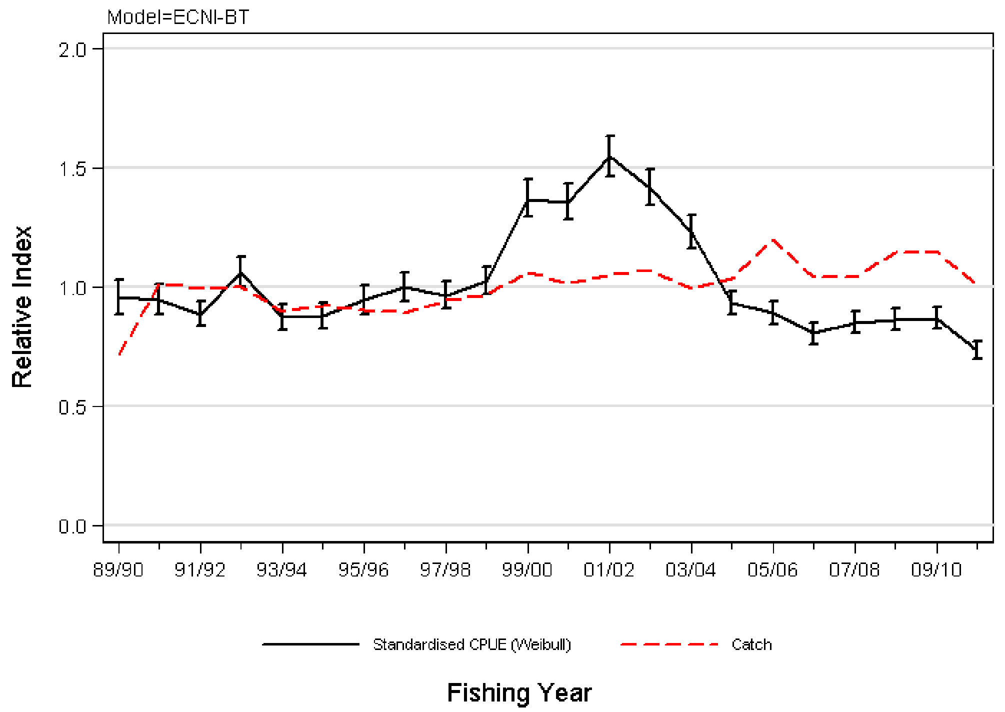


Figure 8: **Standardised CPUE index for the east coast North Island bottom trawl (TAR 2;Table 8) plotted along with the annual sum of catches from the series statistical areas listed in Table 8. Both series have been normalised to a geometric mean =1.0. Error bars show ±97.5% confidence intervals.**

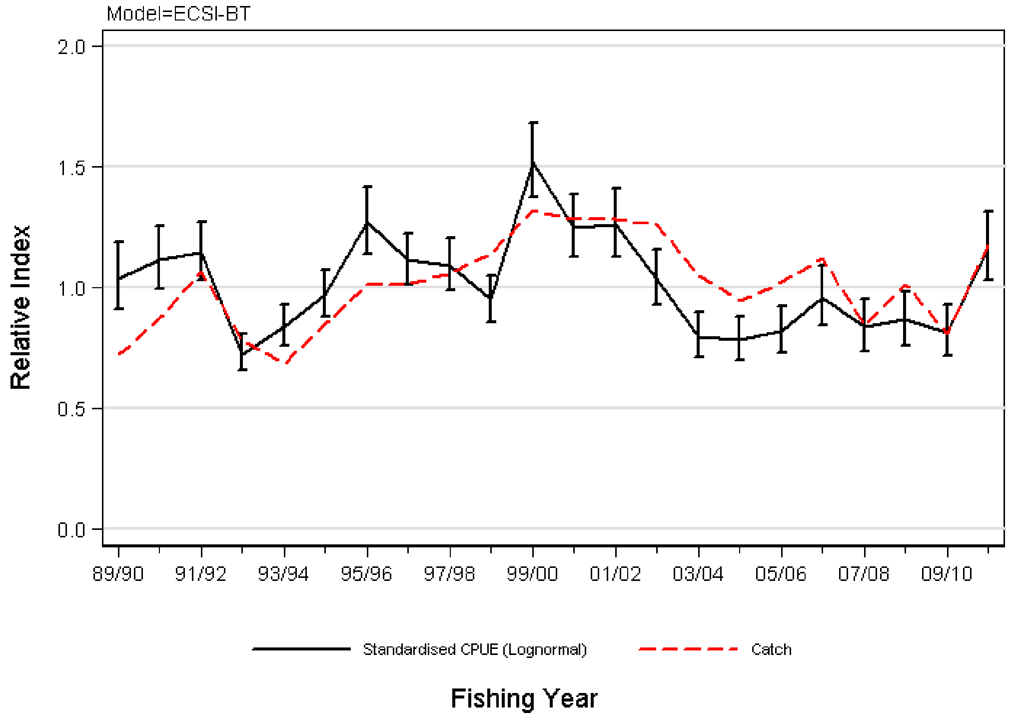


Figure 9: Standardised CPUE index for the east coast South Island bottom trawl (TAR 3; Table 8) plotted along with the annual sum of catches from the series statistical areas listed in Table 8. Both series have been normalised to a geometric mean =1.0. Error bars show ±97.5% confidence intervals.

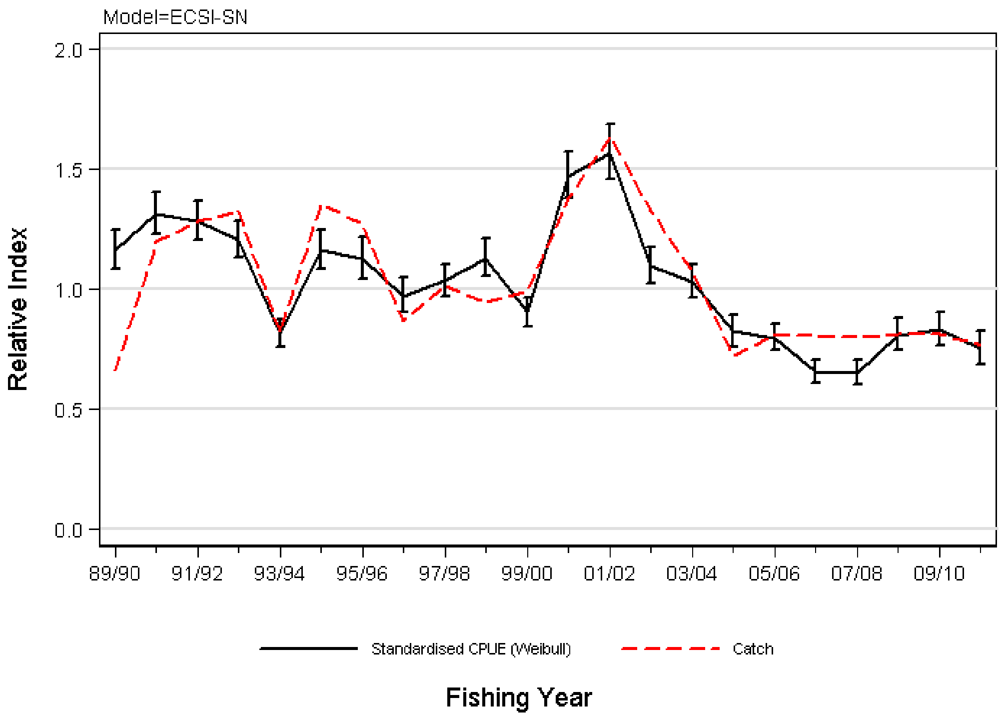


Figure 10: Standardised CPUE index for the east coast South Island setnet (TAR 3; Table 8) plotted along with the annual sum of catches from the series statistical areas listed in Table 8. Both series have been normalised to a geometric mean =1.0. Error bars show ±97.5% confidence intervals.

TAR 3: Two standardised CPUE series are available for monitoring the east coast of the South Island tarakihi populations (Table 8). One, based on bottom trawl data collected from Cook Strait to the Catlins, shows a trend that superficially resembles the trends observed for the Bay of Plenty and the east coast of the North Island, with the abundance peak shifted earlier by about two years and possibly being less broad (Figure 9). Stock hypotheses described in Section 3 (above) suggests that the east coast of the South Island may serve as a nursery area to the North Island fisheries, in which case the 50% increase in CPUE and catch in 2010–11 may bode well for the more northerly fisheries. A second TAR 3 series is provided from a setnet fishery located in Area 018 (Kaikoura) (Figure 10). This series also bears a resemblance to the BoP-BT, ECNI-BT and ECSI-BT series, but with the recent indices located below the long-term average.

4.2.2 West Coast South Island (TAR 7)

CPUE indices were developed for two bottom trawl fisheries that operate in different substock areas and account for most of the catch of TAR 7 (Kendrick et al 2011). The two fisheries are defined by target species and statistical area: 1) the mixed trawl fishery targeting TAR, BAR, WAR, RCO, STA off the west coast of the South Island (Statistical Areas 033, 034, 035, 036), and 2) the inshore trawl fishery targeting TAR, BAR and WAR through the eastern and western approaches to Cook Strait, including outer Tasman Bay (TBCS). Overall, the WCSI area accounted for approximately 60–75% of the annual of the TAR 7 catch from 2004–05 to 2011–12.

The CPUE data for analysis were from a core fleet of vessels with consistent participation in the fishery. Standardised CPUE analyses were based on lognormal models of positive (allocated) landed catches and attempted to account for differences in reporting associated with changes in statutory reporting forms (from CELR to TCER). In 2014, both sets of CPUE indices were updated to the end of the 2012/13 fishing year (Langley 2014).

The series demonstrate differences between substock areas, the West Coast and Tasman Bay/Cook Strait indices are both cyclical, but asynchronous with the West Coast series peaking 2–3 years after the series in Tasman Bay/Cook Strait. The TBCS CPUE series has remained relatively stable during

2001/02–2012/13, while the CPUE index from WCSI declined from 2003/04 to 2008/09 and remained relatively stable for the last five years (to 2012/13) (Figure 11). The longer term trends in CPUE from the WCSI fishery are more variable than the WCSI trawl survey recruited biomass indices for the WCSI area of the survey (Figure 2). An analysis of the recent location based catch and effort data from both the WCSI and TBCS fisheries indicated that since 2007/08 there had been an increase in the proportion of fishing effort directed at locations with generally higher tarakihi catch rates. This may indicate a positive bias in both sets of CPUE indices during the latter period.

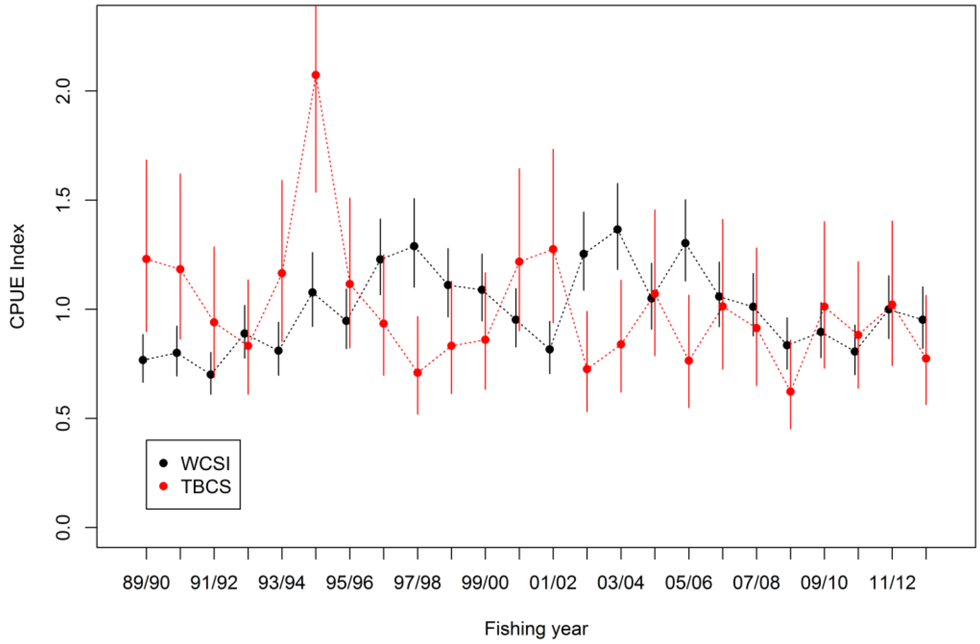


Figure 11: Comparison of the lognormal indices from two independent CPUE series for TAR 7; a) WCSI_BT_MIX: bottom trawl, target TAR, BAR, WAR, STA or RCO in Statistical Areas (033, 034, 035, and 036) ; b) TBCS_BT_MIX: bottom trawl, target, BAR, TAR, WAR in Statistical Areas (038, 039, 017, or 018).

4.2 Stock Assessment Models

TAR 1, 2, 3, and 4

Estimates of current absolute biomass for TAR 1, 2, 3, and 4 are not available.

In 2012, an assessment of the east coast mainland New Zealand tarakihi stocks was attempted (Langley & Starr 2013). Three alternative models were configured with spatial domain and structure representing the range of alternative hypotheses regarding stock structure:

i. A *TAR 2/BPLE* model (Statistical Areas 008–016);
ii. A *TAR 3* model (Statistical Areas 017, 018, 020, 022 and 024); and
iii. A *combined* model encompassing two separate regions equivalent to the *TAR 2/BPLE* and *TAR 3*. Northward age-specific movement between the two regions was estimated.

The three models were configured as age structured population models and implemented in Stock Synthesis (Methot 2009). The models incorporated the available catch, CPUE indices, trawl survey biomass estimates and length frequency distributions, historical age frequency data and recent commercial age frequency samples that corresponded to the spatial domain of the respective models.

A key source of uncertainty in the models related to the vulnerability of the older age classes to the fishery, at least in the recent period. Age frequency data from the commercial fishery are only available for the final two years of the model. The limited number of age classes sampled in the catch of the main fisheries could be interpreted as the result of high fishing mortality rates or to the lower vulnerability of the older age classes. Preliminary modelling results indicated that the first explanation was less likely given the relatively low natural mortality (0.1) of the species and the consistent historical levels of catch from the fishery (informing estimates of R_0 and, therefore, potential yields). Relaxing the constraints on the main fishery selectivities resulted in substantial improvements to the fits to the main input data sets. However, these models estimated that a large (80–85%) proportion of the current adult biomass was not vulnerable to the fishery and, therefore, not monitored by the principal abundance indices (primarily CPUE). Furthermore, the model options with a domed selectivity resulted in a much higher model uncertainty, particularly at the upper bound, suggesting that very large biomass levels were possible, which the Working Group found implausible.

Given the uncertainty associated with the key model assumptions, particularly related to fishery selectivity and stock structure, the Northern Inshore Working Group concluded that the range of models investigated was not adequate for the formulation of management advice for the tarakihi stocks along the east coast of New Zealand. It is considered unlikely that a more definitive stock assessment could be undertaken until a more extensive time-series of age frequency data became available from the main commercial fisheries. These data would improve the capacity of the model to estimate fishery selectivity and to distinguish between hypotheses.

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 9. 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 9). None of the three estimated 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 12).

Table 9: 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 (instantaneaous)	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 10: **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_{2007} / B_0) %, B_0 as a percentage of B_{2007}; Min, minimum; Max, maximum; *Q*i, 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_{2007} / B_0) %	B_0	B_{2007}	(B_{2007} / B_0) %
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	18 310	11 500	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			

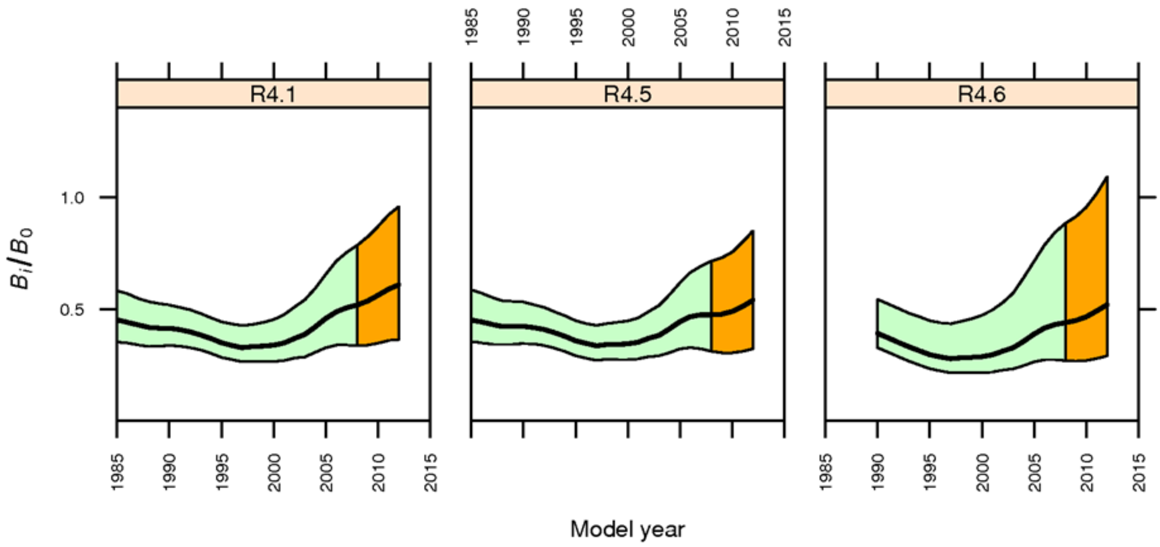


Figure 12: **Relative SSB trajectories (green) and projected status assuming a future constant catch equal to the current catch (orange) calculated from the MCMC runs for model runs 4.1, 4.5, and 4.6 in the quantitative stock assessment of TAR 7. The shaded region indicates the 95% credibility region about median SSB (dotted lines) calculated from each model's SSB posterior distribution.**

Table 11: **Yield estimates (t) of tarakihi (TAR 7)**

	Run		
Parameter	4.1	4.5	4.6
MCY	549	522	755
B_{MCY}	18 237	16 233	18 620
CAY	1 588	1 361	1 682
F_{CAY}	0.1685	0.1661	0.1508
MAY	1 086	976	1 203
B_{MAY}	6 350	5 790	7 865

4.3 Yield estimates and projections

The Working Group concluded that *MCY* estimates are not appropriate.

Estimates of current biomass are not available and *CAY* cannot be determined.

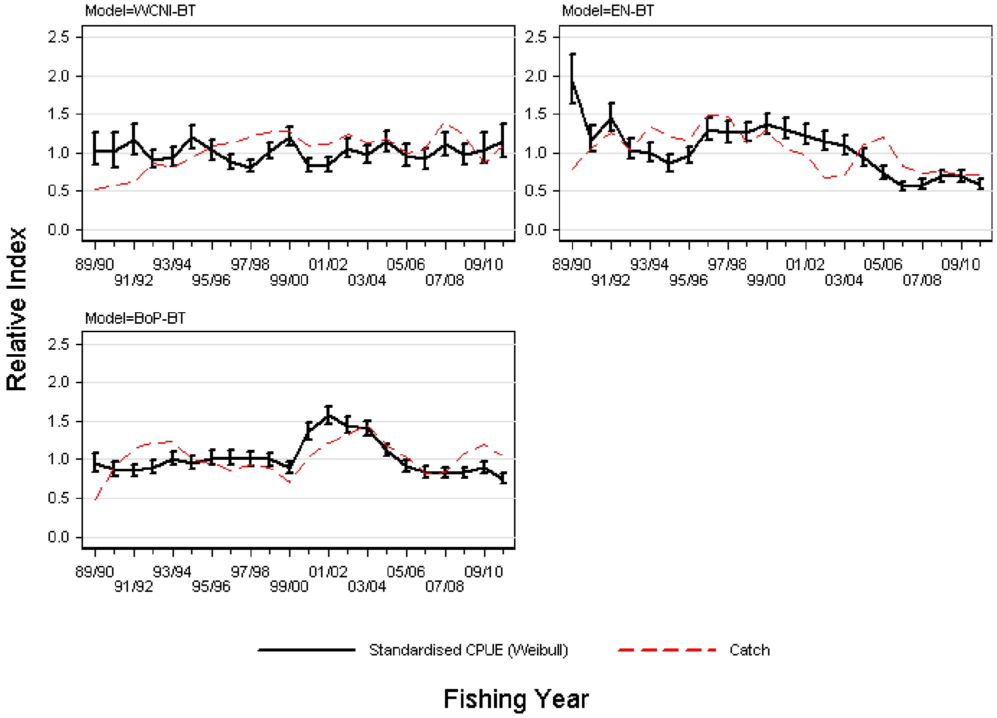
5. STATUS OF THE STOCKS

• TAR 1

Three substocks are recognised within TAR 1: Bay of Plenty (BoP), East Northland and west coast North Island. The Bay of Plenty fishery accounts for approximately 50% of the TAR 1 catch but is considered to be an extension of the TAR 2 stock with a primary spawning area around East Cape.

Stock Status	
Year of Most Recent Assessment	2012
Assessment Runs Presented	The following three standardised CPUE series were developed using positive catches: WCNI - West Coast North Island bottom trawl mixed target species EN - East Northland bottom trawl mixed target species BoP - Bay of Plenty bottom trawl mixed target species
Reference Points	Target: B_{MSY} (value to be determined) Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: -
Status in relation to Target	Unknown
Status in relation to Limits	Soft Limit: Unknown Hard Limit: Unknown
Status in relation to Overfishing	-

Historical Stock Status Trajectory and Current Status



Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Overall trends in CPUE vary between substocks: WCNI - the series shows almost no trend, fluctuating around the long-term mean with fairly wide error bars, indicating that the model is not well determined. EN - the series showed a long gradual declining trend beginning towards the end of the 1990s. This decline appears to have stabilised at about 60% of the long-term mean since 2006–07. BoP - the series shows no long-term trend, with current levels near to the levels observed at the beginning of the series, interrupted by about 5 years of increased CPUE in the early 2000s.
Recent Trend in Fishing Intensity or Proxy	Unknown
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-
Projections and Prognosis	
Stock Projections or Prognosis	Unknown
Probability of Current Catch or TACC causing decline biomass to remain below or to decline below Limits	Soft Limit: Unknown Hard Limit: Unknown
Probability of Current Catch or TACC causing overfishing to continue or to increase	-

Assessment Methodology and Evaluation		
Assessment Type	Level 2 - Fishery characterisation and CPUE analysis	
Assessment Method	CPUE analysis of trawl catch and effort data	
Assessment Dates	Latest assessment: 2012	Next assessment: 2017
Overall assessment of quality rank	1- High Quality	
Main data inputs (rank)	- Bottom trawl catch and effort data	1 – High Quality
Data not used (rank)	-	
Changes to Model Structure and Assumptions	- Change to a trip stratum roll-up - Use of target species definition instead of depth as an explanatory variable	
Major Sources of Uncertainty	- Uncertainty in the stock structure - The relationship between CPUE and biomass	

Qualifying Comments
-

Fishery Interactions
The main fishing method is trawling. Target tarakihi sets land snapper, john dory, gemfish and trevally in East northland; snapper, trevally and gemfish in the Bay of Plenty; and snapper and trevally as bycatch. Incidental captures of seabirds occur in the bottom longline and setnet fisheries, including black petrel, are ranked as at very high risk in the Seabird Risk Assessment.[1] There is a risk of incidental captures of dolphins and New Zealand fur seal.

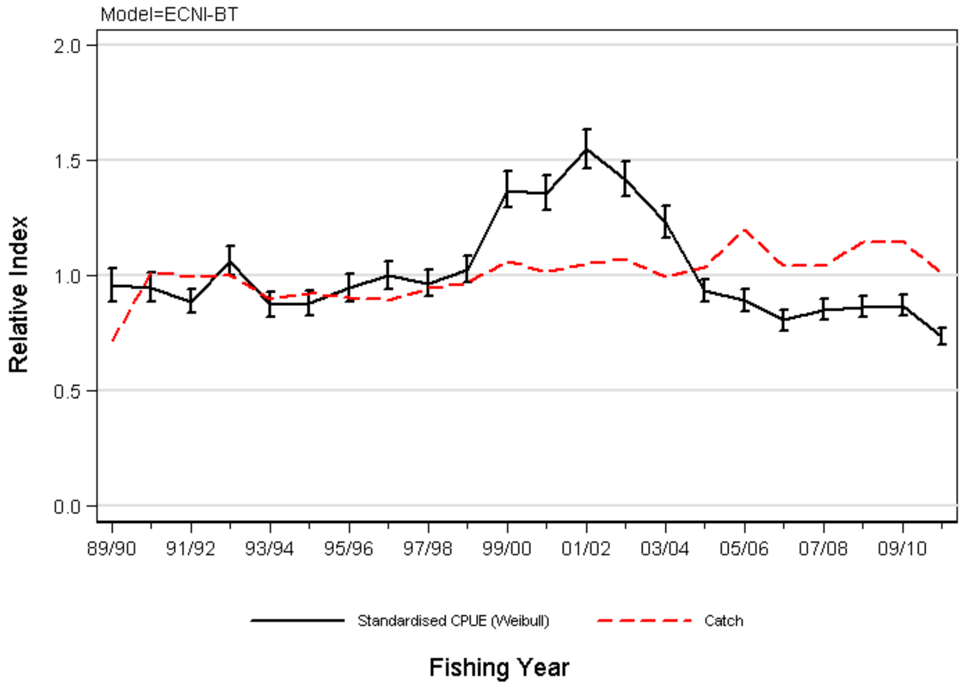
[1] The risk was defined as the ratio of the estimated annual number of fatalities of birds due to bycatch in fisheries to the Potential Biological Removal (PBR), which is an estimate of the number of seabirds that may be killed without causing the population to decline below half the carrying capacity. Richard & Abraham (2013).

- **TAR 2**

The stock relationships between TAR 2 (including TAR 1 BoP) and TAR 3 are unclear. Data from the main fisheries reveal similarities in abundance trends and age composition and it is possible that the two areas represent a single tarakihi stock or, at a minimum, that there is substantial connectivity between the two areas. However, definitive conclusions regarding the stock structure are not possible and, hence, the status of the two stocks is reviewed separately.

Stock Status	
Year of Most Recent Assessment	2012
Assessment Runs Presented	The standardised CPUE series was developed using positive catches of mixed target species in bottom trawl from TAR 2.
Reference Points	Target: Not established but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: -
Status in relation to Target	Unknown
Status in relation to Limits	Soft Limit: Unknown, Hard Limit: Unlikely (< 40%) to be below

Historical Stock Status Trajectory and Current Status



Standardised CPUE index for the east coast North Island bottom trawl plotted along with the annual sum of catches from the series statistical areas. Both series have been normalised to a geometric mean =1.0. Error bars show ±2.5% confidence intervals.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	There is no strong long-term trend since the early 1990s, with current levels slightly below the levels observed at the beginning of the series, interrupted by 5 years of increased CPUE in the early 2000s.
Recent Trend in Fishing Mortality	Unknown

or Proxy	
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis	
Stock Projections or Prognosis	Unknown
Probability of Current Catch or TACC causing Biomass to remain below or decline below Limits	Soft Limit: Unknown Hard Limit: Unlikely (< 40%)
Probability of Current Catch or TACC causing Overfishing to continue or to commence	-

Assessment Methodology and Evaluation		
Assessment Type	Level 2 - Fishery characterisation and CPUE analysis	
Assessment Method	CPUE analysis of trawl catch and effort data	
Assessment Dates	Latest assessment: 2012 CPUE analysis	Next assessment: 2017
Overall assessment of quality rank	1- High Quality	
Main data inputs (rank)	Bottom trawl catch and effort data	1 – High Quality
Data not used (rank)	-	

Changes to Model Structure and Assumptions	- Changed from a target TAR fishery to a bottom trawl mixed fishery
Major Sources of Uncertainty	- Uncertainty in the stock structure - The relationship between CPUE and biomass

Qualifying Comments
-

Fishery Interactions
This is mostly (83%) a TAR target fishery. The main fishing method is trawling. The following species are caught as bycatch in this fishery: GUR, SKI and WAR. Incidental captures of seabirds occur. There is a risk of incidental captures of dolphins and New Zealand fur seal.

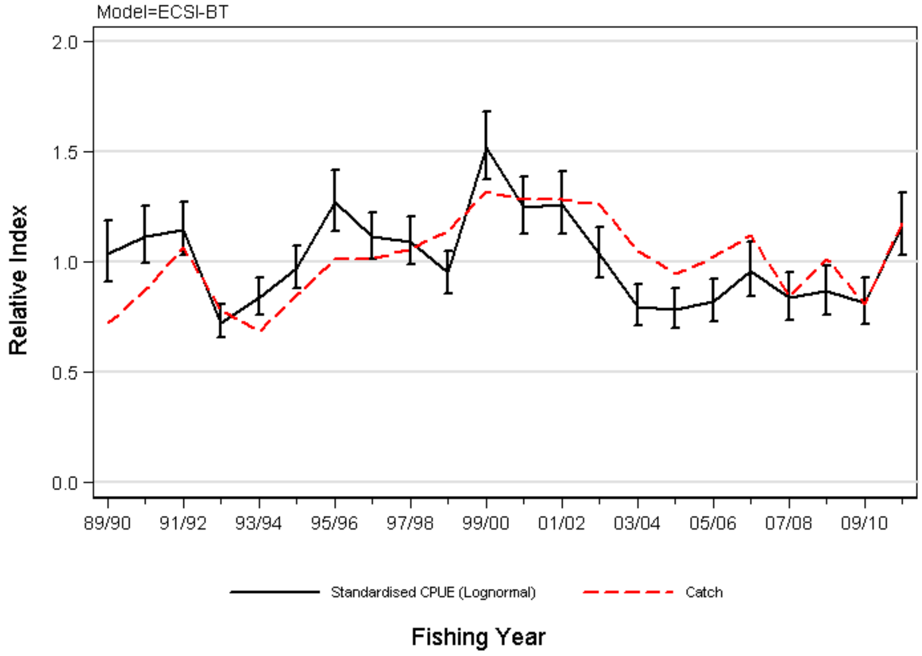
- **TAR 3**

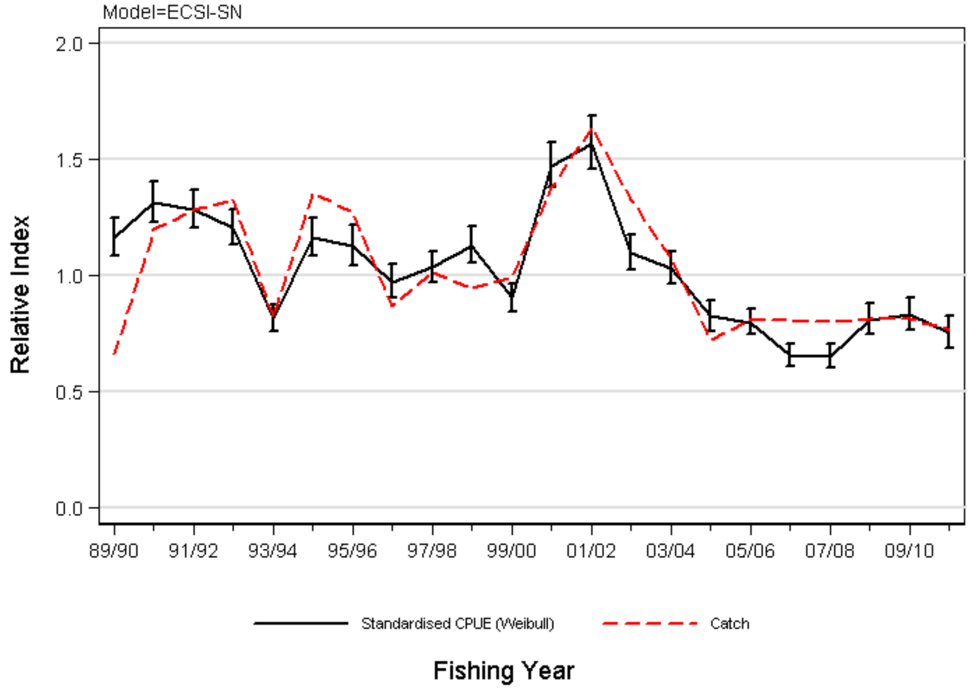
The stock relationships between TAR 2 (including TAR 1 BoP) and TAR 3 are unclear. Data from the main fisheries reveal similarities in abundance trends and age composition and it is possible that the two areas represent a single tarakihi stock or, at a minimum, that there is substantial connectivity between the two areas. However, definitive conclusions regarding the stock structure are not possible and, hence, the status of the two stocks is reviewed separately.

Stock Status	
Year of Most Recent Assessment	2012
Assessment Runs Presented	Two standardised CPUE series were developed using positive catches: bottom trawl mixed target species and setnet TAR target.
Reference Points	Target: Not established but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishng threshold: -

Status in relation to Target	Unknown
Status in relation to Limits	Soft Limit: Unknown Hard Limit: Unlikely (< 40%) to be below

Historical Stock Status Trajectory and Current Status





Standardised CPUE index for the east coast South Island bottom trawl (ECSI-BT) and setnet (ECSI-SN) plotted along with the annual sum of catches from the series statistical areas. Both series have been normalised to a geometric mean =1.0. Error bars show ±97.5% confidence intervals.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	The BT-MIX series shows no long-term trend, with current levels near to the levels observed at the beginning of the series, interrupted by about 3 years of increased CPUE from the late 1990s. The increase in 2010–11 may indicate strong recent recruitment to the fishery.

	The setnet index is similar but the peak is offset by a few years, and the last few years are lower than the long-term mean.
Recent Trend in Fishing Mortality or Proxy	Unknown
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis	
Stock Projections or Prognosis	Unknown
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Soft Limit: Unknown Hard Limit: Unlikely (< 40%)
Probability of Current Catch or TACC causing Overfishing to continue or to commence.	-

Assessment Methodology and Evaluation		
Assessment Type	Level 2 - Fishery characterisation and CPUE analysis	
Assessment Method	CPUE analysis of positive trawl and setnet catch and effort data	
Assessment Dates	Latest assessment: 2012	Next assessment: 2017
Overall assessment of quality rank	1 – High Quality	
Main data inputs (rank)	Bottom trawl and setnet catch and effort data	1 – High Quality
Data not used (rank)	-	
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	- Uncertainty in the stock structure - The relationship between CPUE and biomass	

Qualifying Comments
-

Fishery Interactions
The main fishing method is trawling. The following species are caught as bycatch in this fishery: RCO, BAR and FLA. The tarakihi target setnet fishery bycatch includes very small amounts of LIN and SPD. There is a risk of incidental capture of seabirds, white pointer sharks, Hector's dolphins, other dolphins and New Zealand fur seals. There is a risk of incidental capture of sea lions from Otago Peninsula south.

- **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.

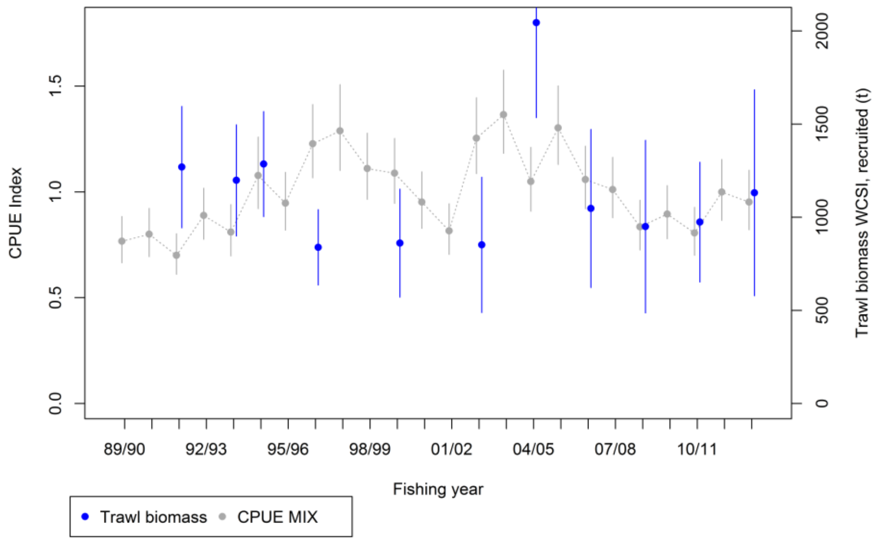
- **TAR 7**

Stock Structure Assumptions
For the purpose of this assessment TAR 7 is assumed to be a discrete stock.

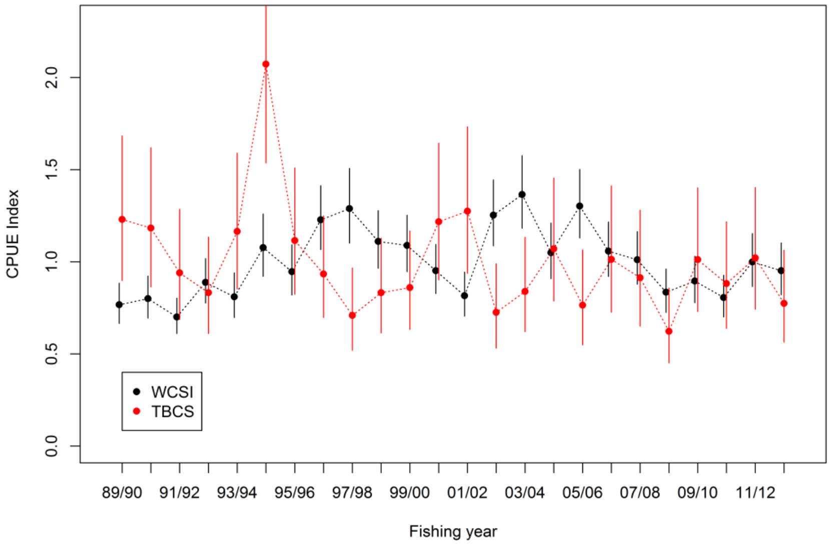
Stock Status

Year of Most Recent Assessment	2014
Assessment Runs Presented	Time series of WCSI trawl survey biomass, most recent survey 2013; updated standardised CPUE indices from two sub-stock areas within TAR 7 (West Coast South Island and Tasman Bay/Cook Strait)
Reference Points	Target: Not established but B_{MSY} assumed Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: F_{MSY}
Status in relation to Target	In 2007 the range of model results for TAR 7 estimated that the stock was Likely (> 60%) to be at or above B_{MSY} (40% B_0). Trawl survey recruited biomass index for WCSI in 2013 is 17% higher than in 2007, suggesting the stock is at a similar level and that the evaluation of stock status relative to B_{MSY} remains similar to that in 2007. WCSI CPUE index is marginally lower in 2013 than in 2007.
Status in relation to Limits	Soft Limit: Unlikely (< 40%) to be below Hard Limit: Very Unlikely (< 10%) to be below
Status in relation to Overfishing	Unknown

Historical Stock Status Trajectory and Current Status



Comparison of WCSI CPUE indices and trawl survey biomass estimates of recruited biomass from the west coast area of the WCSI trawl survey.



Comparison of the lognormal indices from two independent CPUE series for TAR 7; a) WCSI_BT_MIX: bottom trawl, target TAR, BAR, WAR, STA or RCO in Statistical Areas (033, 034, 035, and 036) ; b) TBCS_BT_MIX: bottom trawl, target, BAR, TAR, WAR in Statistical Areas (038, 039, 017, or 018)

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	WCSI trawl survey biomass has remained stable since 2006/07. CPUE has remained relatively stable since that time for both WCSI and TBCS fisheries.
Recent Trend in Fishing Mortality or Proxy	*Unknown*
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis	
Stock Projections or Prognosis	Biomass (WCSI) is expected to stay steady over the next 3–5 years assuming current (2012/13) catch levels
Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits	Soft Limit: Unlikely (< 40%) for current catch and TACC Hard Limit: Very Unlikely (< 10%) for current catch and TACC
Probability of Current Catch or TACC causing Overfishing to continue or to commence	Unknown

Assessment Methodology and Evaluation		
Assessment Type	Level 2: Partial Quantitative Stock Assessment	
Assessment Method	-West Coast South Island Trawl survey biomass - Standardised CPUE indices	
Assessment Dates	Latest assessment: 2014	Next assessment: 2018
Overall assessment quality rank	1 – High Quality	
Main data inputs (rank)	- Survey biomass and length frequency - CPUE indices	1 – High Quality 1 – High Quality
Changes to Model Structure and Assumptions	- a Level 1 Bayesian stock assessment was performed for this stock in 2007	
Major Sources of Uncertainty	- Stock structure is currently uncertain, especially regarding the	

	tarakihi fishery in eastern Cook Strait.

Qualifying Comments
The trawl survey indices are considered to represent the most reliable index of the WCSI component of the stock. There is no corresponding trawl survey index for the TBCS component of the stock. The relationship between the two sub stock areas is unknown.

Fishery Interactions
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. TAR 7 is reported as bycatch in target barracouta and red cod bottom trawl fisheries. Smooth skates are caught as a bycatch in this fishery, and the biomass index for smooth skates in the west coast trawl survey has declined substantially since 1997. There may be similar concerns for rough skates but the evidence is less conclusive. Incidental captures of seabirds occur. There is a risk of incidental capture of dolphins and New Zealand fur seals.

- **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 2012–13 fishing year are summarised in Table 12.

Table 12: **Summary TACCs (t) and reported landings (t) of tarakihi for the most recent fishing year.**

Fishstock	QMA	FMAs	2013–14 Actual TACC	2013–14 Reported landings
TAR 1	Auckland (East) (West)	1 & 9	1 447	1 463
TAR 2	Central (East)	2	1 796	1 947
TAR 3	South-East (Coast)	3	1 403	1 112
TAR 4	South-East (Chatham)	4	316	154
TAR 5	Southland and Sub-Antarctic	5 & 6	153	135
TAR 7	Challenger	7	1 088	1 002
TAR 8	Central (West)	8	225	224
TAR 10	Kermadec	10	10	0
Total			6 439	6 038

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