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TAR 1, 2 and 3 Fishery Characterisation and CPUE

New Zealand Fisheries Assessment Report 2014/13

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EXECUTIVE SUMMARY

Starr, P.J.; Kendrick, T.H. (2014). TAR 1, 2. and 3 Fishery Characterisation and CPUE Report.

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The fisheries taking tarakihi (*Nemadactylus macropterus*) on the west, north and east coasts of the New Zealand North Island and on the east coast of the South Island are described from 1989–90 to 2010–11, based on compulsory reported commercial catch and effort data held by the Ministry for Primary Industries (MPI, formerly the Ministry of Fisheries). A number of bottom trawl fisheries take tarakihi on these coasts. These include mixed target species bottom trawl fisheries off both the east and west coasts of Northland, a mixed target species bottom trawl fishery in the Bay of Plenty and mixed target species bottom trawl fisheries off the east coasts of the North and South Islands. This report also identifies a developing bottom trawl fishery that captures tarakihi operating at the eastern entrance of Cook Strait. There has also been a long-standing target tarakihi setnet fishery operating in the vicinity of Kaikoura, off the northeast coast of the South Island. These fisheries span three MPI management units (TAR 1, TAR 2 and TAR 3) and some catches from TAR 7 are likely to be included in the eastern Cook Strait fisheries because of reporting ambiguities. Detailed characteristics of the landing data associated with these fisheries, as well as the spatial, temporal, target species and depth distributions relative to the catch of tarakihi in these fisheries are presented for TAR 1, TAR 2 and TAR 3. Annual performance of the TAR 1, TAR 2 and TAR 3 catches and some regulatory information are also presented.

Commercial Catch Per Unit Effort (CPUE) analyses for five bottom trawl fisheries and one setnet fishery, based on the compulsory reported commercial catch and effort data from the major bottom trawl fisheries, were used to estimate changes in abundance for this species in TAR 1, TAR 2 and TAR 3. Indices from three of these fisheries (the mixed target species bottom trawl fisheries off the east coasts of the North and South Islands and the target tarakihi setnet fishery off Kaikoura) were used as input into a trial stock assessment for a tarakihi stock that spanned most of the east coasts of the North and South Islands (Langley & Starr 2012).

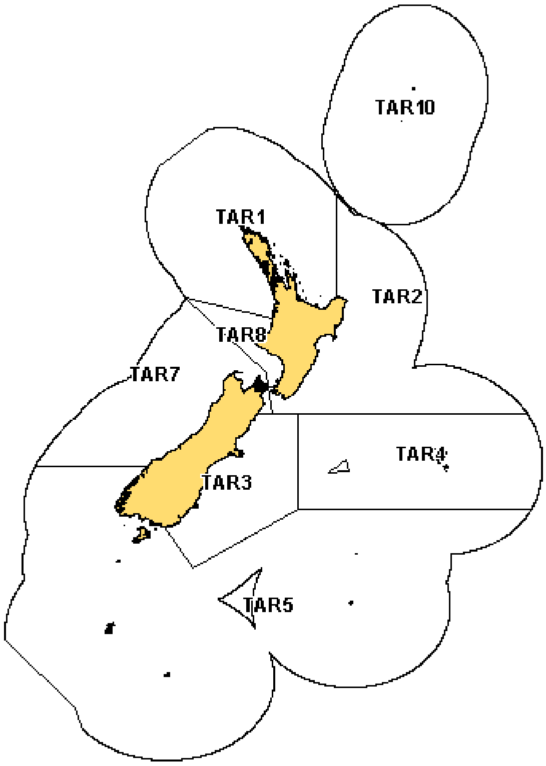

Figure 1. Map of TAR QMAs.

1. INTRODUCTION

This study is part of a larger project to refine the understanding and definitions of tarakihi stock boundaries along the east coasts of the North and South Islands of New Zealand, with the intention of assessing the resulting stocks with respect to their status relative to management targets (Langley & Starr 2012). The purpose of this document was to assemble and present all relevant data from the fisheries that take this species along these two east coasts, documenting their spatial extent along with other important characteristics. A further component of this study was to extract indices of annual CPUE using catch and effort data taken from the primary fisheries harvesting tarakihi on these two coasts. These indices would become input to models used to assess stock status for this species based on an agreed stock definition, under the assumption that such CPUE indices tracked tarakihi population abundance. Three additional bottom trawl CPUE series (west coast North Island, East Northland and Bay of Plenty) are documented in this report but were not used in the stock assessment analyses.

Tarakihi was brought into the QMS at its inception in 1986, with the main QMAs (TAR 1, TAR 2 and TAR 3 [Figure 1]) contributing between 70 to 80% of the total NZ-EEZ landings. The TACCs for TAR 2 and TAR 3 were increased in 2004–05 under the conditions of the Adaptive Management Programme (AMP) as specified by the Ministry of Fisheries in the "*Draft Frameworks for Exploratory, Developing, and Established Fisheries under the Adaptive Management Programme*", dated December 1999. A nominal increase of 48 t was granted to TAR 1 for the 2007–08 fishing year. The text table below summarises these changes to the TACCs for these Fishstocks:

Fishstock	Year TACC raised	TACC prior to change	AMP or new TACC	% increase
TAR 1	2007–08	1 399	1 447	3.4%
TAR 2	2004–05	1 633	1 796	10.0%
TAR 3	2004–05	1 169	1 403	20.0%
Total		4 201	4 646	10.6%

The TAR 2 and TAR 3 AMPs are no longer active, having been discontinued by the Ministry of Fisheries in 2009–10, but the TACCs have remained unchanged.

This report summarises fishery and landings characterisations for TAR 1, TAR 2 and TAR 3, as well as presenting CPUE standardisations derived from trawl data originating from that part of TAR 1 east of North Cape (East Northland and Bay of Plenty), the east coast of the North Island between East Cape and Cook Strait (TAR 2) and from the entire east coast of the South Island (TAR 3), including the eastern sections of Cook Strait. This report also presents a CPUE analysis based on a target tarakihi setnet fishery located in the northern part of the South Island east coast. Abbreviations and definitions of terms used in this report are presented in Appendix A.

2. INFORMATION ABOUT THE STOCK/FISHERY

2.1 Catches

The TACC for tarakihi in TAR 1 was set at 1201 t when this Fishstock was first brought into the QMS in 1986, but increased quickly, reaching 1387 t in 1989–90, probably through the process of quota appeals (Table 1). Catch levels have been generally at or above the TACC for most years since 1991–92 up to 2005–06 (Figure 2; Table 1). After that year, landings in TAR 1 have tended to be below the TACC, and have remained below 1400 t since 2005–06 (Table 1).

Table 1: Total landings (t) and TACCs (t) for tarakihi in TAR 1, TAR 2 and TAR 3 from 1983–84 to 2010–11. Landings and TACCs from 1985–86 to 2000–01 are from Quota Management Returns (QMR). Landings from 2001–02 to 2010–11 are from Monthly Harvest Returns (MHR); '–': not set

Fishing	TAR 1		TAR 2		TAR 3	
year	Landings	TACC	Landings	TACC	Landings	TACC
83/84	1 326	–	1 118	–	902	–
84/85	1 022	–	1 129	–	1 283	–
85/86	1 038	–	1 318	–	1 147	–
86/87	912	1 210	1 382	1 501	938	988
87/88	1 093	1 285	1 386	1 568	1 025	1 035
88/89	939	1 328	1 415	1 611	759	1 061
89/90	973	1 387	1 374	1 627	1 007	1 107
90/91	1 125	1 387	1 729	1 627	1 070	1 148
91/92	1 373	1 387	1 697	1 627	1 132	1 148
92/93	1 476	1 397	1 654	1 633	813	1 169
93/94	1 431	1 397	1 594	1 633	735	1 169
94/95	1 390	1 398	1 580	1 633	849	1 169
95/96	1 415	1 398	1 521	1 633	1 111	1 169
96/97	1 421	1 398	1 637	1 633	1 087	1 169
97/98	1 515	1 398	1 672	1 633	1 024	1 169
98/99	1 437	1 398	1 594	1 633	1 098	1 169
99/00	1 386	1 398	1 743	1 633	1 260	1 169
00/01	1 403	1 398	1 658	1 633	1 218	1 169
01/02	1 479	1 399	1 739	1 633	1 241	1 169
02/03	1 517	1 399	1 745	1 633	1 156	1 169
03/04	1 541	1 399	1 638	1 633	1 009	1 169
04/05	1 528	1 399	1 692	1 796	905	1 403
05/06	1 410	1 399	1 986	1 796	1 024	1 403
06/07	1 193	1 399	1 729	1 796	1 080	1 403
07/08	1 286	1 447	1 716	1 796	844	1 403
08/09	1 398	1 447	1 901	1 796	1 017	1 403
09/10	1 332	1 447	1 858	1 796	757	1 403
10/11	1 349	1 447	1 659	1 796	1 207	1 403

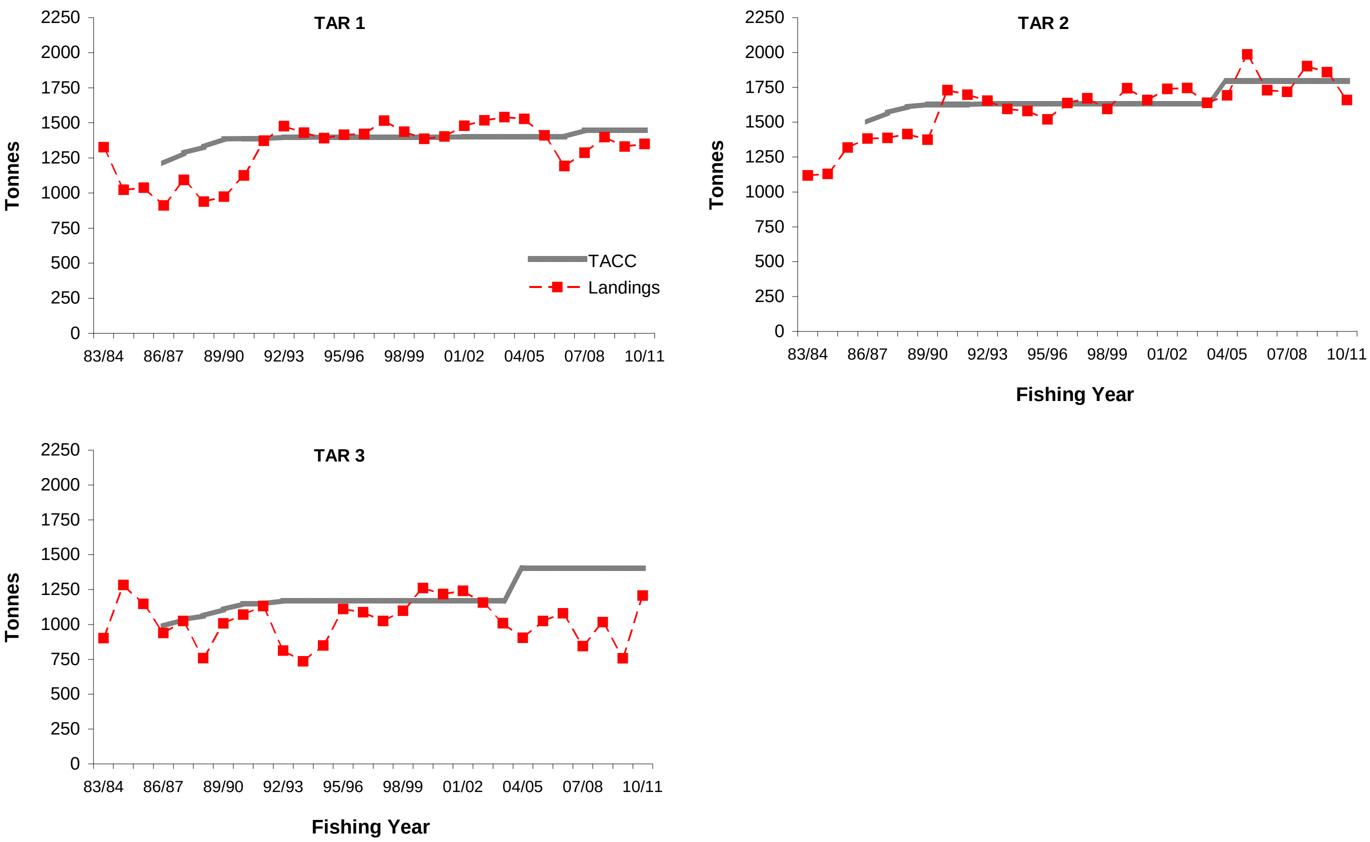

Figure 2: Plots of TAR 1, TAR 2, and TAR 3 landings and TACCs from 1983–84 to 2010–11 (see Table 1).

The TACC for tarakihi in TAR 2 was set at 1501 t when this Fishstock was first brought into the QMS in 1986. It gradually increased, reaching 1633 t in 1992–93, through the process of quota appeals (Table 1). Catch levels have stayed near to or above the TACC for most years since 1991–92 (Figure 2; Table 1). Landings have generally gone up since the TAR 2 TACC was raised to 1796 t in 2004–05, exceeding the higher TACC in three of the seven years since the increase (Table 1).

The TACC for tarakihi in TAR 3 was set at 988 t when this Fishstock was first brought into the QMS in 1986. It was raised in the following year to 1035 t, most likely through the process of quota appeals which gradually lifted the TACC to 1169 t by 1993–94 (Table 1). Catch levels declined to below 750 t in 1993–94 (the lowest since TAR 3 entered the QMS), but showed a steady increase to over 1200 t per year from 1999–2000 to 2001–02, catch levels which were above the TACC of 1169 t (Figure 2; Table 1). Landings since the TAR 3 TACC was raised to 1403 t in 2004–05 did not reach the previous TACC until 2010–11, when there was a 60% increase in landings from 757 t in 2009–10 to 1207 t (Table 1).

2.1.1 Recreational catches

Recreational catches in New Zealand are poorly known, a conclusion which applies to TAR 1, TAR 2 and TAR 3. A series of regional and national surveys, which combined phone interviews with randomly selected diarists, have been conducted since the early 1990s (Tierney et al. 1997, Bradford 1998, Boyd & Reilly 2005), but the results from these surveys are not considered to be reliable by most of the Fishery Assessment Working Groups. In particular, the Recreational Technical Working Group (RTWG) concluded that the framework used for the telephone interviews for the 1996 and previous surveys contained a methodological error, resulting in biased eligibility figures. Consequently the harvest estimates derived from these surveys are unreliable. This group also indicated concerns with some of the harvest estimates from the 2000–01 survey. The following summarises that group’s views on the telephone /diary estimates:

> “*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 harvest estimates are implausibly high for many important fisheries*.” (quoted from the chapter on kahawai, Ministry of Fisheries 2011)

The quality of recreational harvest estimates appears to be improving in recent years. Statistical methods involving counting actively fishing recreational vessels from aircraft and combining these effort estimates with catch information have led to more reliable estimates of total recreational harvest for a number of species, mostly in northern New Zealand. For instance, a harvest of 89.5 t (CV 18.5%) of tarakihi was estimated for all of QMA 1 in 2004–05 (B. Hartill [NIWA Auckland] pers.comm.). A large scale diary/interview survey is presently being conducted over the period July 2011–June 2012, with results expected to be available in 2013.

2.2 Regulations Affecting the Fishery

There have been no significant changes to the management regulations affecting tarakihi in recent years. While there have been significant curtailments of setnet fishing in Pegasus Bay and Canterbury Bight, designed to protect Hector’s dolphins, these changes have had relatively little impact on setnet fishing for tarakihi because the latter fishery occurs mostly offshore from Kaikoura where these dolphins are relatively rare. As well, there have been no important changes to the trawl fishery for this species. Most tarakihi are landed unprocessed (green), so there are no problems with changing conversion factors when interpreting the landing information (see Section 2.3.2).

2.3 Analysis of TAR 1, TAR 2 and TAR 3 catch and effort data

2.3.1 Methods used for 2012 analysis of MPI catch and effort data

Data extracts were obtained from the Ministry of Fisheries (now Ministry for Primary Industries) Warehou database (Ministry of Fisheries 2010). One extract consisted of the complete data set (all fishing event information along with all tarakihi landing information) from every trip which recorded landing tarakihi from TAR 1, TAR 2 or TAR 3, starting from 1 October 1989 and extending to 30 September 2011. Two further extracts were obtained: one consisting of all trips using the methods BT, BPT (bottom pair trawl), MW or MWPT (midwater pair trawl), did not target ORH (orange roughy), OEO (oreo) or CDL (cardinalfish), fished at least one event in either TAR 1, TAR 2 or TAR 3. The final extract requested trips which used the setnet method in TAR 3 and which targeted or captured one of the following 9 species: SPO, SCH, ELE, SPD, OSD, NSD, KAH, TAR, and STA (see Appendix A for definitions of abbreviations). Once these trips were identified, all fishing event data and tarakihi landing data from the entire trip, regardless of method of capture, were obtained. These data extracts (MPI replog 8360) were received 19 December 2011. The first data extract was used to characterise and understand the fisheries taking tarakihi. These characterisations are reported in Sections 2.3.2 and 2.3.3, plus detailed summary tables in Appendix E, Appendix F and Appendix G. The remaining two extracts were used to calculate CPUE standardisations (Section 3, Appendix H, Appendix J and Appendix L).

Data were prepared by linking the effort (“fishing event”) section of each trip to the landing section, based on trip identification numbers supplied in the database. Effort and landing data were groomed to remove “out-of-range” outliers (the method used to groom the landings data are documented in Appendix C; the remaining procedures used to prepare these data are documented in Starr (2007).

The original level of time stratification for a trip is either by tow, or day of fishing, depending on the type of form used to report the trip information. These data were amalgamated into a common level of stratification known as a “trip stratum” (see table of definitions: Appendix A). Depending on how frequently an operator changed areas, method of capture or target species, a trip could consist of one to several “trip strata”. This amalgamation was required so that these data could be analysed at a common level of stratification across all reporting form types. Landed catches of tarakihi by trip were allocated to the “trip strata” in proportion to the estimated tarakihi catches in each “trip stratum”. In situations when trips recorded landings of tarakihi without any associated estimates of catch in any of the “trip strata” (operators were only required to record the top five species in any fishing event), the tarakihi landings were allocated proportionally to effort (tows for trawl data and length of net set for setnet data) in each “trip stratum”.

Table 2: Comparison of the total QMR/MHR catch (t), reported by fishing year, with the sum of the corrected landed catch totals (bottom part of the MPI CELR form), the total catch after matching effort with landing data (‘Analysis’ data set) and the sum of the estimated catches from the Analysis data set, all representing the combined TAR 1, TAR 2 and TAR 3 QMAs. Data source: MPI replog 8360: 1989–90 to 2010–11.

Fishing Year	QMR/MHR (t)	Total landed catch (t)[1]	% landed/ QMR/MHR	Total Analysis catch (t)[2]	% Analysis /Landed	Total Estimated Catch (t)	% Estimated /Analysis
89/90	3 355	2 775	83	2 727	98	2 488	91
90/91	3 925	3 762	96	3 745	100	3 470	93
91/92	4 202	4 148	99	4 174	101	3 806	91
92/93	3 943	3 883	98	3 932	101	3 439	87
93/94	3 760	3 774	100	3 756	100	3 328	89
94/95	3 819	3 824	100	3 835	100	3 380	88
95/96	4 047	4 041	100	3 987	99	3 624	91
96/97	4 145	4 023	97	4 042	100	3 658	90
97/98	4 211	4 158	99	4 246	102	3 896	92
98/99	4 129	4 121	100	4 249	103	3 857	91
99/00	4 388	4 379	100	4 541	104	4 065	90
00/01	4 279	4 244	99	4 466	105	4 082	91
01/02	4 459	4 394	99	4 641	106	4 256	92
02/03	4 418	4 401	100	4 646	106	4 118	89
03/04	4 188	4 166	99	4 353	104	3 970	91
04/05	4 124	4 136	100	4 288	104	3 903	91
05/06	4 420	4 366	99	4 506	103	4 152	92
06/07	4 002	3 993	100	4 116	103	3 824	93
07/08	3 847	3 836	100	3 908	102	3 600	92
08/09	4 316	4 285	99	4 378	102	4 037	92
09/10	3 947	3 965	100	4 069	103	3 765	93
10/11	4 215	4 170	99	4 239	102	3 955	93
Total	90 141	88 844	99	90 845	102	82 672	91

1 includes all TAR 1, TAR 2 and TAR 3 landings in replog 8360 except for 12 trips excluded for being “out of range” (Appendix C)

2 based on statistical areas valid for TAR 1 or TAR 2 or TAR 3 (Appendix D), but will contain some landings from other TAR QMAs

The catch totals (Table 2, Figure 3) resulting from this procedure may not be the same as those reported to the QMS (Table 1) because the QMS is a separate reporting system from the MPI catch/effort reporting system. The procedure described by Starr (2007) drops trips which fished in ambiguous “straddling” statistical areas (the statistical area boundaries do not coincide with the QMA boundaries–see Appendix B) and which reported multiple tarakihi QMAs in the landing data. This procedure resulted in dropping an unacceptable proportion of trips and associated landings in Area 017 and Area 041, important areas for tarakihi fisheries. Consequently, the method of Starr (2007) was modified to scale estimated catches to the level of landings by statistical area, without regard to the reported QMA. This modification resulted in much better retention of the landings, especially in Area 017 and Area 041 but at the cost of losing the capacity to link captures and effort to a specific

QMA. Appendix D lists the total landings obtained for each statistical areas in the data set using each method, showing the improvement in the retention of landings when the QMA information is ignored.

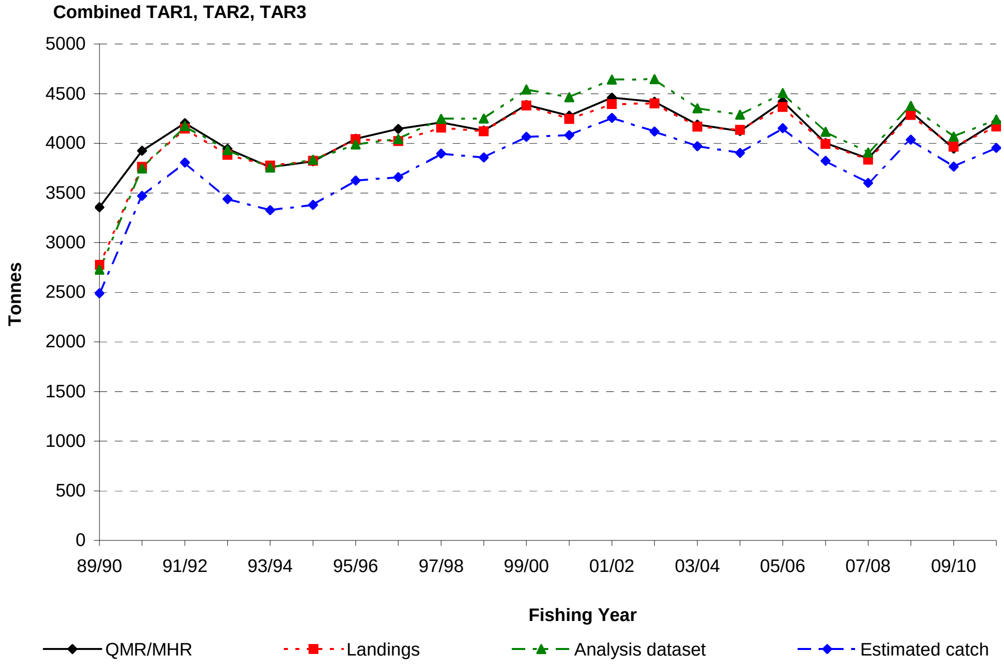

Figure 3: **Plot of the combined TAR 1, TAR 2 and TAR 3 catch dataset using the "statarea expansion" method with totals presented in Table 2.**

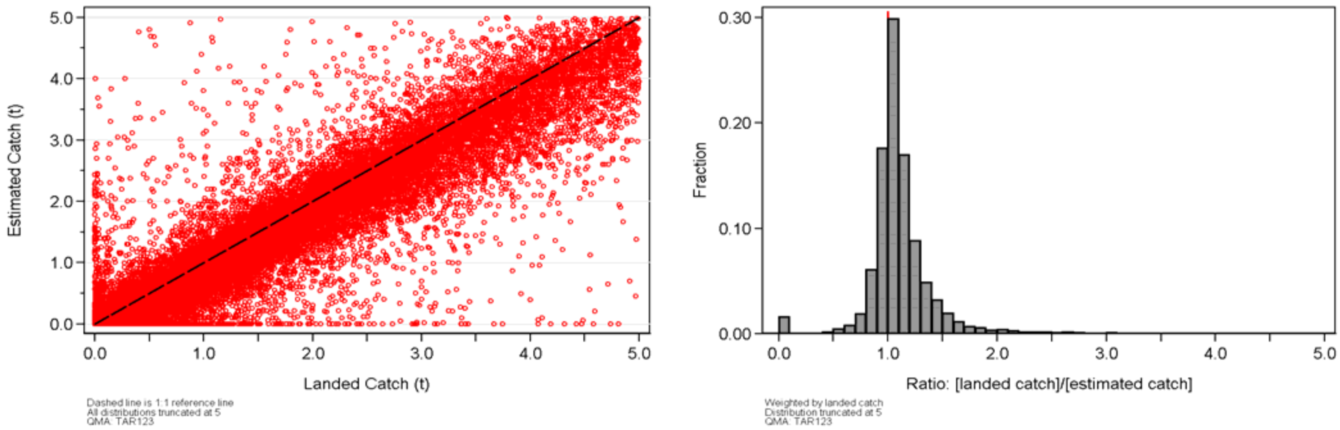

Figure 4: **[left panel]: Scatter plot of the sums of landed and estimated tarakihi catch for each trip in the combined TAR 1&2&3 analysis dataset. [right panel]: Distribution (weighted by the landed catch) of the ratio of landed to estimated catch per trip. Trips where the estimated catch=0 have been assigned a ratio=0.**

The annual totals at different stages of the data preparation procedure are presented in Table 2 and Figure 3. Total landings in the data set are similar to the landings in the QMR/MHR system, except for a 17% shortfall in landings in the first year of data (1989–90), which was affected by the changeover to a new system of data reporting. Landings by year in the subsequent fishing years vary from –4% to +0% relative to the QMR/MHR annual totals (Table 2). The shortfall between landed and estimated catch by trip varies from –13% to –7% by fishing year and may be diminishing in recent years (Table 2). Note that the "analysis" dataset exceeds the combined TAR 1, TAR 2 and TAR 3 landings because it is based on statistical areas (see Appendix D) and will contain landings from TAR 7, TAR 8, and possibly TAR 4 or TAR 5. A scatter plot of the estimated and landed catch by trip shows that relatively few trips overestimate the landing total for the trip (Figure 4 [left panel]). The distribution of the ratios of the landed relative to estimated catch shows a skewed distribution with many ratios greater than 1.0 and with a mode slightly above 1.0 (Figure 4 [right panel]).

The 5% to 95% quantiles (excluding trips where there was no estimated catch) for the ratio of landed to estimated catch range from 0.58 to 2.12 for the dataset, with the median and mean ratios showing the landed catch 4% and 29% higher respectively than the estimated catch (Table 3). On average, 23% of trips estimated no catch of tarakihi but then reported TAR in the landings (Table 3). These landings represented only 2% of the total TAR landings over the period, for a total of 1421 tonnes over all years (Table 3). The introduction of the new inshore forms (NCELR and TCER), which record fishing activity at the event level as well as the top eight species (instead of top five species), has nearly halved the proportion of trips which estimate nil tarakihi while landing this species, with the TAR landings in this category accounting for less than 1% of the total TAR 1, TAR 2 and TAR 3 landings in the most recent three years (Table 3).

Table 3: Summary statistics pertaining to the reporting of estimated catch from the combined TAR 1&2&3 analysis dataset. A_y, $L_{i,y}$, AL_y, and AC_y are defined in Table 2; $L'_{i,y}$ is defined in Eq.1; Z_y: number of trips in year y with no estimated catch; 5%: fifth percentile; 50%: median; 95%: ninety-fifth percentile.

	Trips with landed catch but which report no estimated catch			Statistics (excluding 0s) for the ratio of landed/estimated catch by trip			
Fishing year	Trips: % relative to total trips	Landings: % relative to total landings	Landings (t)	5% quantile	Median	Mean	95% quantile
89/90	23	3	85	0.60	1.00	1.27	1.89
90/91	22	2	66	0.60	1.01	1.33	1.89
91/92	24	2	78	0.60	1.01	1.16	1.94
92/93	26	3	130	0.60	1.02	1.24	2.00
93/94	25	2	81	0.53	1.00	1.22	2.00
94/95	25	2	80	0.55	1.02	1.22	2.05
95/96	25	3	117	0.50	1.03	1.36	2.10
96/97	26	2	87	0.50	1.03	1.26	2.16
97/98	26	2	75	0.57	1.03	1.39	2.08
98/99	26	2	93	0.57	1.04	1.26	2.00
99/00	23	2	104	0.54	1.04	1.20	2.00
00/01	24	1	56	0.56	1.04	1.20	2.00
01/02	24	1	44	0.60	1.05	1.23	2.04
02/03	23	1	57	0.60	1.06	1.24	2.10
03/04	23	1	46	0.65	1.05	1.27	2.20
04/05	26	1	52	0.64	1.06	1.33	2.32
05/06	26	1	42	0.67	1.07	1.31	2.33
06/07	23	1	36	0.60	1.08	1.29	2.23
07/08	15	0	18	0.56	1.06	1.26	2.33
08/09	12	0	11	0.56	1.05	1.32	2.50
09/10	13	0	16	0.50	1.06	1.48	2.70
10/11	14	1	49	0.55	1.04	1.72	2.74
Total	23	2	1 421	0.58	1.04	1.29	2.12

2.3.2 Description of TAR 1, TAR 2 and TAR 3 landing information

Landing data for tarakihi were provided for every trip which landed TAR 1, TAR 2 or TAR 3 at least once, with one record for every reported TAR landing (including landings from all TAR Fishstocks landed by a trip that also landed TAR 1, TAR 2 or TAR 3) from the trip. Each of these records contained a reported green weight (in kilograms), a code indicating the processed state of the landing, along with other auxiliary information such as the conversion factor used, the number of containers involved and the average weight of the containers. Every landing record also contained a “destination code” (Table 4), which indicated the category under which the landing occurred. The majority of the landings were made using destination code "L" (landed to a Licensed Fish Receiver; Table 4). However, other codes (e.g., A, O and C; Table 4) also potentially described valid landings and were included in this analysis. A number of other codes (notably R, Q and T; Table 4) were not included because it was felt that these landings were likely to have been reported at a later date under the "L" destination category. Two other codes (D and NULL) represented errors which could not be reconciled without making unwarranted assumptions and these were not included in the landing data set.

Almost all of the valid landing data for TAR 1, TAR 2 or TAR 3 were reported using state code GRE with the majority of the remaining landings using the state code DRE (Table 5). The few remaining landings were spread among HGU, GUT and MEA codes. There have only been minor changes in the conversion factors used for some of the state codes used for processing TAR (Table 6): these occurred early in the time series and only pertain to state codes that appear infrequently in the data set.

Table 4: Destination codes in the unedited landing data received for the TAR 1&2&3 analysis. The "how used" column indicates which destination codes were included in the characterisation analysis. These data summaries have been restricted to TAR 1, TAR 2 and TAR 3 over the period 1989–90 to 2010–11.

Destination code	Number events	Green weight (t)	Description	How used
L	196 425	89 707.2	Landed in NZ (to LFR)	Keep
C	365	97.1	Disposed to Crown	Keep
F	3 608	24.4	Section 111 Recreational Catch	Keep
A	219	19.6	Accidental loss	Keep
E	636	9.0	Eaten	Keep
W	750	7.1	Sold at wharf	Keep
S	67	5.3	Seized by Crown	Keep
U	266	4.1	Bait used on board	Keep
O	6	4.1	Conveyed outside NZ	Keep
H	7	0.1	Loss from holding pot	Keep
X	1	0.0	QMS returned to sea, except 6A	Keep
T	256	329.7	Transferred to another vessel	Drop
R	855	217.0	Retained on board	Drop
Q	1 504	202.4	Holding receptacle on land	Drop
NULL	97	29.1	Nothing	Drop
D	30	4.9	Discarded (non-ITQ)	Drop
B	159	1.6	Bait stored for later use	Drop
P	1	0.0	Holding receptacle in water	Drop

Table 5: Total greenweight reported and number of events by state code in the landing file used to process the TAR 1&2&3 characterisation and CPUE data, arranged in order descending landed weight (only for destination codes indicated as "Keep" in Table 4). These data summaries have been restricted to TAR 1, TAR 2 and TAR 3 from 1989–90 to 2010–11.

State code	Number Events	Total reported green weight (t)	Description
GRE	199 455	88 498.4	Green (or whole)
DRE	1 150	1 141.0	Dressed
HGU	533	135.4	Headed and gutted
GUT	516	51.6	Gutted
MEA	161	30.4	Fish meal
FIL	125	6.3	Fillets: skin-on
Other	410	15.1	Other[1]

[1] includes (in descending order): unknown, fins, gilled and gutted tail-on, heads, dressed-v cut (stargazer), fillets: skin-off, fillets: skin-off trimmed, squid wings, gilled and gutted tail-off, headed, gutted, and tailed, shark fins, headed, gutted, and finned, fillets: skin-on untrimmed

Total landings available in the data set are primarily for TAR 2, TAR 1 or TAR 3 (in descending order of importance) (Table 7). Small amounts of TAR 4, TAR 5, and TAR 8 were also taken in this set of trips. There is a greater amount of TAR 7 present in the data set which is the result of the complex relationships between TAR 2, TAR 3 and TAR 7 in Cook Strait. These landings have been included in this analysis by adopting the "statistical area" expansion procedure (see Appendix D).

Table 6.: Median conversion factor for the five most important state codes reported in Table 5 (in terms of total landed greenweight) and the total reported greenweight by fishing year in the edited file used to process TAR 3 landing data. These data summaries have been restricted to TAR 1, TAR 2 and TAR 3 over the period 1989–90 to 2010–11. '–': no observations

Fishing	Landed State Code					
Year	GRE	DRE	HGU	GUT	MEA	Other
	Median Conversion Factor					
89/90	1	–	1.5	1.1	–	2.3
90/91	1	1.6	1.5	1.1	–	–
91/92	1	1.6	1.55	1.05	–	2.4
92/93	1	1.6	1.55	1.05	5.6	2.8
93/94	1	1.6	1.55	1.05	5.6	2.8
94/95	1	1.6	1.55	1.05	–	2.4
95/96	1	1.6	1.55	1.05	5.6	2.8
96/97	1	1.6	1.55	1.05	5.6	2.8
97/98	1	1.6	1.55	1.05	5.6	1.7
98/99	1	1.6	1.55	1.05	5.6	2.6
99/00	1	1.6	1.55	1.05	5.6	2.4
00/01	1	1.6	1.55	1.05	5.6	2.8
01/02	1	1.6	1.55	1.05	5.6	2.6
02/03	1	1.6	1.55	1.05	5.6	2.4
03/04	1	1.6	1.55	1.05	5.6	2.4
04/05	1	1.6	1.55	1.05	5.6	2.8
05/06	1	1.6	1.55	1.05	5.6	2.8
06/07	1	1.6	1.55	1.05	5.6	2.8
07/08	1	1.6	1.55	1.05	5.6	2.8
08/09	1	1.6	1.55	1.05	5.6	2.8
09/10	1	1.6	1.55	1.05	5.6	2.8
10/11	1	1.6	1.55	1.05	5.6	2.8
	Total Landings (t)					
89/90	2 752.6	–	15.6	6.5	–	0.3
90/91	3 700.5	43.8	16.8	0.3	–	0.2
91/92	4 082.1	41.9	9.7	11.4	–	2.8
92/93	3 827.4	12.1	16.2	4.4	22.6	0.0
93/94	3 737.3	23.0	7.5	4.4	0.0	1.9
94/95	3 802.8	8.4	11.3	1.1	–	0.8
95/96	3 990.2	39.8	6.2	3.9	0.1	0.2
96/97	3 941.3	72.5	4.6	1.0	0.1	3.3
97/98	4 048.5	95.7	8.4	0.4	1.4	3.7
98/99	4 074.1	39.9	3.4	0.9	0.0	2.2
99/00	4 319.6	55.2	3.0	0.7	0.0	0.4
00/01	4 208.6	33.9	0.4	0.6	0.1	0.3
01/02	4 284.8	98.6	7.7	1.4	0.1	0.9
02/03	4 332.8	57.6	8.4	0.5	0.1	1.4
03/04	4 140.7	11.1	6.5	7.0	0.6	0.4
04/05	4 120.9	13.9	0.2	0.4	0.2	0.4
05/06	4 342.4	21.8	0.4	0.8	0.3	0.1
06/07	3 948.8	42.8	0.2	0.7	0.1	0.2
07/08	3 785.2	44.5	4.7	0.5	0.5	0.2
08/09	4 258.3	22.2	1.6	1.2	0.1	1.1
09/10	3 938.8	21.6	1.0	2.5	1.4	0.2
10/11	4 132.8	30.5	2.4	0.8	2.7	0.4
Total	87 771.0	830.9	136.3	51.3	30.4	21.5

Table 7.: **Distribution of total landings (t) by tarakihi Fishstock and by fishing year for the set of trips that recorded TAR 1 or TAR 2 or TAR 3 landings. Landing records with improbable greenweights have been dropped (see Appendix C).**

Fishing year	TAR 1	TAR 2	TAR 3	TAR 4	TAR 5	TAR 7	TAR 8	Total
89/90	772	1 154	849	83	10	262	19	3 149
90/91	1 156	1 654	951	42	3	219	50	4 076
91/92	1 418	1 626	1 104	47	2	250	51	4 498
92/93	1 452	1 641	790	7	4	290	58	4 242
93/94	1 453	1 578	743	2	4	272	57	4 109
94/95	1 376	1 573	875	31	7	493	68	4 424
95/96	1 428	1 541	1 072	33	5	424	40	4 543
96/97	1 405	1 553	1 065	25	7	494	89	4 637
97/98	1 523	1 612	1 023	42	3	334	128	4 665
98/99	1 442	1 579	1 100	15	4	376	142	4 658
99/00	1 420	1 691	1 267	37	5	363	151	4 934
00/01	1 407	1 640	1 197	81	9	590	159	5 083
01/02	1 499	1 697	1 197	141	31	542	193	5 300
02/03	1 505	1 730	1 165	32	26	393	197	5 050
03/04	1 535	1 627	1 004	15	8	424	173	4 787
04/05	1 540	1 720	876	27	7	366	173	4 708
05/06	1 400	1 960	1 006	122	7	347	267	5 109
06/07	1 194	1 714	1 085	63	20	314	218	4 608
07/08	1 273	1 714	848	70	4	194	154	4 258
08/09	1 396	1 873	1 015	64	7	291	115	4 762
09/10	1 331	1 872	763	29	4	443	196	4 637
10/11	1 365	1 643	1 162	64	7	310	129	4 679
Total	30 290	36 393	22 158	1 073	182	7 989	2 829	100 915

Table 8: **Distribution by form type for landed catch by weight for each fishing year in TAR 1&2&3. Also provided are the number of days fishing and the associated distribution of days fishing by form type for the effort data using statistical areas consistent with TAR 1&2&3. See Appendix A for definitions of abbreviations used in this table.**

	Landings (%)[1]			Days Fishing (%)[2]			Days Fishing					
Year	CELR	CLR	NCELR	CELR	TCEPR	TCER	CELR	TCEPR	TCER	NCELR	Other[3]	Total
89/90	93	7	0	88	12	–	13 150	1 743	–	–	–	14 893
90/91	92	8	0	91	9	–	17 162	1 774	–	–	–	18 936
91/92	92	8	0	90	10	–	19 312	2 100	–	–	–	21 412
92/93	94	6	0	88	12	–	19 169	2 626	–	–	3	21 798
93/94	87	13	0	87	13	–	18 968	2 825	–	–	–	21 793
94/95	83	17	0	82	18	–	16 700	3 731	–	–	–	20 431
95/96	59	41	0	69	31	–	14 448	6 523	–	–	1	20 972
96/97	62	38	0	69	31	–	14 635	6 477	–	–	2	21 114
97/98	64	36	0	68	32	–	13 919	6 576	–	–	–	20 495
98/99	67	33	0	69	31	–	13 357	5 997	–	–	–	19 354
99/00	70	30	0	70	30	–	14 188	6 061	–	–	–	20 249
00/01	65	35	0	67	33	–	13 422	6 588	–	–	13	20 023
01/02	57	43	0	67	33	–	11 464	5 757	–	–	17	17 238
02/03	59	41	0	65	35	–	11 424	6 257	–	–	7	17 688
03/04	56	44	0	65	35	–	10 615	5 661	–	–	13	16 289
04/05	53	47	0	68	32	–	11 449	5 430	–	–	29	16 908
05/06	59	41	0	73	26	–	12 428	4 422	–	–	113	16 963
06/07	56	40	4.0	66	25	–	11 068	4 207	–	1 287	172	16 734
07/08	5.3	91	3.9	12	20	39	1 914	3 109	6 241	1 177	3 385	15 826
08/09	8.8	89	2.5	12	19	39	1 872	2 994	6 256	1 216	3 649	15 987
09/10	5.8	92	2.5	11	19	40	1 866	3 299	6 882	1 217	4 068	17 332
10/11	5.4	93	1.9	12	19	39	1 972	3 229	6 685	1 090	4 118	17 094
Total	58	41	0.7	65	24	6	264 502	97 386	26 064	5 987	15 590	409 529

[1] Percentages of landed greenweight
[2] Percentages of number of days fishing
[3] includes 184 days for TUN (tuna lining), 1258 days for LCER (lining), and 14 148 days for LTCER (lining trip)

Just under sixty percent of the combined TAR 1, TAR 2 and TAR 3 landings have been reported on CELR forms over the 22 years of record, with just over 40% of the remaining landings reported using CLR forms and less than 1% on NCELR forms (Table 8). The NCELR form is used exclusively to report setnet effort and landings. The CLR form is used by vessels using the new TCER form developed specifically for small inshore trawl vessels as well as vessels using the older TCEPR forms. The use of these new forms, beginning in 2006–07, has resulted in a substantial drop in the use of the CELR form in the inshore fisheries, which have only accounted for between 5 and 9 percent of the combined TAR 1, TAR 2 and TAR 3 landings since the new forms were introduced from 2006–07 (Table 8). The introduction of these new forms can also be seen in the effort data associated with these trips, with a strong decline in the usage of the CELR form from 2007–08 (calculated as days fishing, Table 8).

2.3.3 Description of the TAR 1, TAR 2 and TAR 3 fisheries

2.3.3.1 Introduction

As discussed in Section 2.3.1, matching landings with effort by trip while maintaining the integrity of the QMA-specific information was not possible because of the large amount of fishing taking place in Area 017 (eastern Cook Strait) and Area 041 (North Taranaki Bight). Consequently, trips which fished in ambiguous statistical areas and landed to multiple QMAs were retained and corrections to estimated catches based on total trip landings were made without regard to the QMA information. For this reason, the summaries presented in this section of the report are presented by grouped statistical areas, rather than by QMA, using the statistical area grouping definitions in Table 9 (see Appendix B for statistical area locations):

Table 9: Definitions of Major Area groupings used in Appendix E and in the characterisation descriptions in this document.

Major Area grouping	Code	Statistical Area definition
East Northland	EN	001–007,105, 106
Bay of Plenty	BoP	008–010, 107
East coast, North Island	ECNI	011-016, 201–206
East coast, South Island	ECSI	017–026, 301–303
West coast, North Island	WCNI	041–048, 101–104

Table E.1 provides the total landings by “Major Area grouping” for all statistical areas included in the above definitions, listed in descending rank order of importance in terms of total landings accumulated over the 22 years of available data. Similarly, Table E.2 provides a list by “Major Area groupings” for method of capture. Finally, target species ranked in descending order of landing importance for each “Major Area grouping” are provided for bottom trawl (Table E.3) and second and third tier tarakihi fisheries (defined independently for each Major Area grouping: Table E.4).

2.3.3.2 Distribution of landings and effort by method of capture and statistical area

Tarakihi in all five major regions are primarily taken by the bottom trawl method, but the second method in terms of importance varies with the Major Area grouping (Table 10; Figure 5). In terms of relative importance, only bottom longline in EN and setnet in ECSI exceed 20% of the total landings in their respective areas, with bottom trawl accounting for over 85% of the total landings in BoP, and WCNI and for 99% of landings in ECNI (Table 10). The two major areas on the east coast, ECNI and ECSI, predominate in terms of total landings of tarakihi, accounting for 39% and 27% of the average landings among these five areas (Table 11). The BoP is third in order of importance, followed by WCNI and EN. This order of importance has been unchanged over the 22-years of available data (Table 11).

Only two or three statistical areas predominate in the bottom trawl catch in most of the five major areas, except for ECNI, where four statistical areas (011 to 014), have significant levels of catch (Figure 6). The distribution of bottom trawl effort by statistical area resembles the distribution of tarakihi landings, except for EN, where Areas 003 and 005 have a disproportionately high number of tows, which is likely to be reflecting the non-target nature of the tarakihi fishery in these statistical areas, and for Area 045 (WCNI) which also has a higher level of effort for the amount of tarakihi taken (Figure 6). The secondary tarakihi fisheries in these five areas tend to be localised by statistical area in terms of both landings and effort: the BLL fishery in EN takes place in Areas 002 and 003 (off the upper east coast), while the setnet fishery in ECSI is concentrated in Area 018 (Kaikoura) (Figure 7). Two tertiary tarakihi fisheries have relatively short histories: the setnet fishery in BoP disappeared by the end of the 1990s, while the developing Danish seine fishery in ECSI only started in the mid-2000s and is located in Area 020 (Pegasus Bay) and Area 022 (Canterbury Bight) (Figure 8).

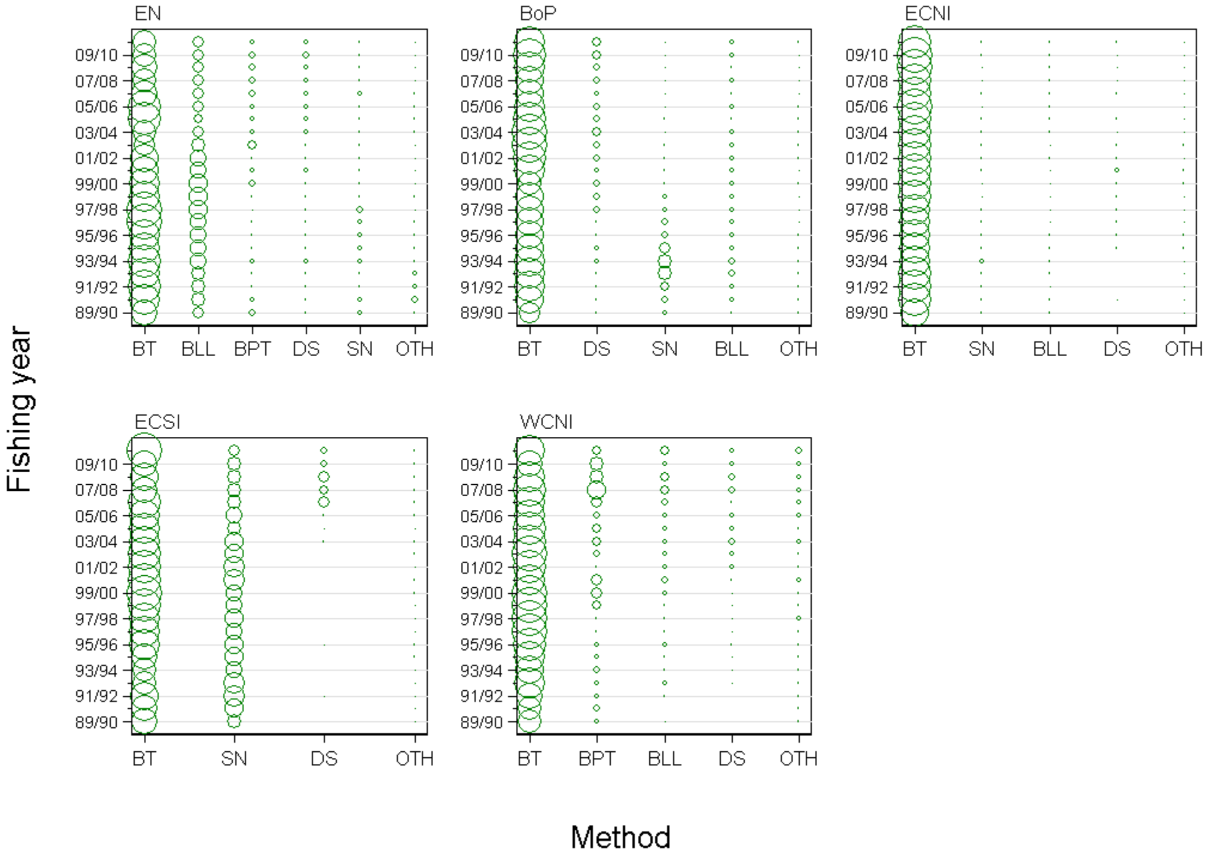

Figure 5: Distribution of catches for the major fishing methods by fishing year from trips which landed tarakihi to the statistical areas defined in Table A.1C from 1989–90 to 2010–11. Circles are proportional to the catch totals by method and fishing year within each sub-graph: [EN]: largest circle= 409 t in 96/97 for BT; [BoP]: largest circle= 852 t in 03/04 for BT; [ECNI]: largest circle=1937 t in 05/06 for BT; [ECSI]: largest circle=1165 t in 99/00 for BT; [WCNI]: largest circle= 439 t in 97/98 for BT

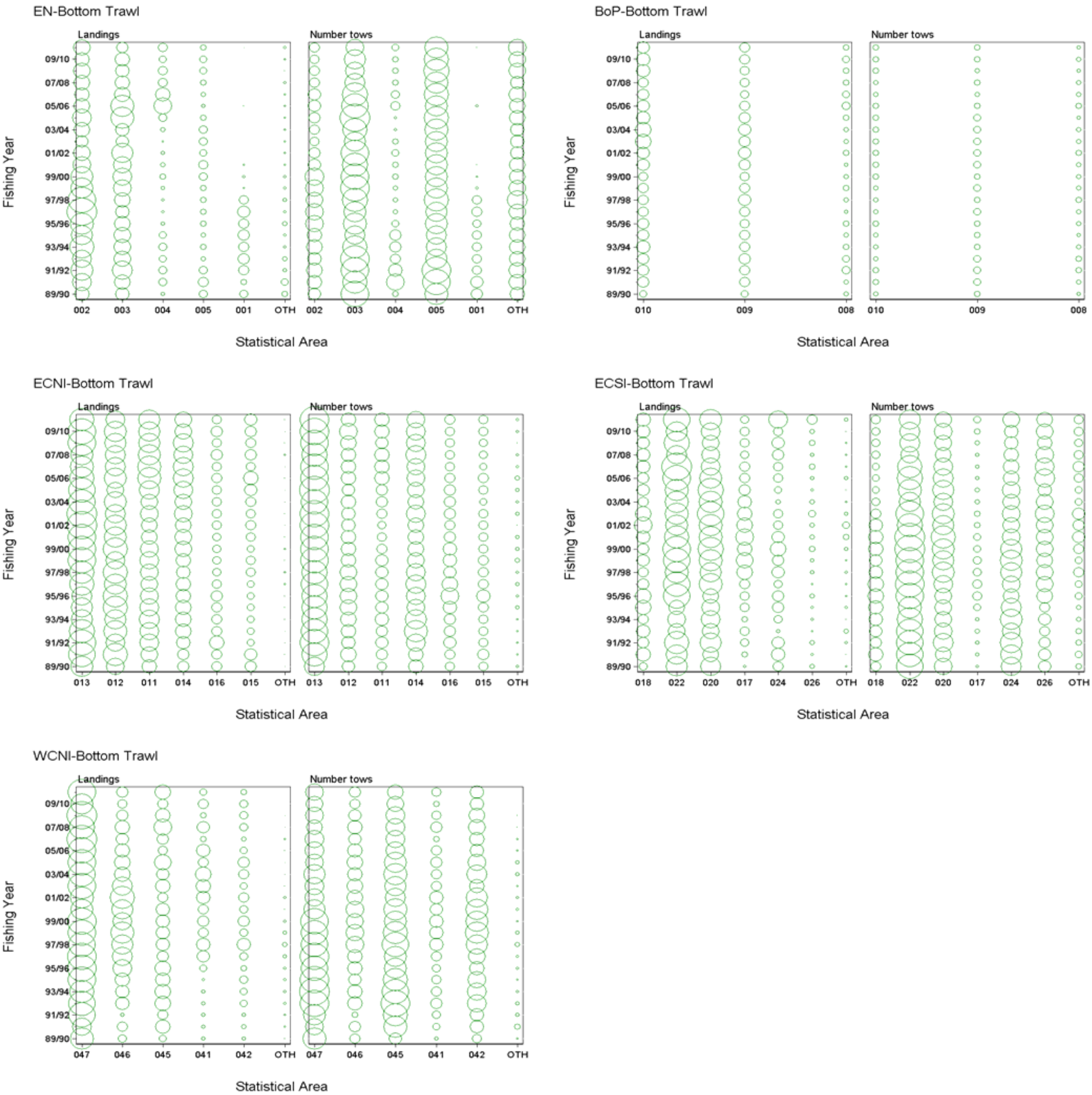

Figure 6: Distribution of landings and number tows for the bottom trawl method for each Major Area (Table 9) by statistical area and fishing year from trips which landed tarakihi. Circles are proportional within each panel: [EN-Landings]: largest circle= 282 t in 96/97 for 002; [EN-Number tows]: largest circle= 2517 tows in 04/05 for 003; [BoP-Landings]: largest circle= 514 t in 03/04 for 010; [BoP-Number tows]: largest circle= 2740 tows in 03/04 for 009; [ECNI-Landings]: largest circle= 728 t in 02/03 for 013; [ECNI-Number tows]: largest circle= 4694 tows in 04/05 for 013; [ECSI-Landings]: largest circle= 490 t in 06/07 for 022; [ECSI-Number tows]: largest circle= 5761 tows in 99/00 for 022; [WCNI-Landings]: largest circle= 223 t in 06/07 for 047; [WCNI-Number tows]: largest circle= 1809 tows in 93/94 for 047.

Table 10: Total landings (t) and distribution of landings (%) for tarakihi for important fishing methods over the five major areas described in Section 2.3.3.1 from trips which landed tarakihi, summed from 1989–90 to 2010–11. Major Areas are defined in Table 9.

	Method						
Major Area	BT	SN	BLL	DS	BPT	OTH	Total
	Total landings (t)						
EN	5 929	94	1 507	104	194	42	7 870
BoP	12 983	553	300	580	26	11	14 452
ECNI	35 421	123	92	88	1	39	35 763
ECSI	17 979	5 926	8	455	0	28	24 395
WCNI	7 330	39	192	98	630	75	8 364
Total	79 642	6 734	2 098	1 325	852	194	90 845
	Distribution of landings (%)						
EN	75.3	1.2	19.1	1.3	2.5	0.5	8.7
BoP	89.8	3.8	2.1	4.0	0.2	0.1	15.9
ECNI	99.0	0.3	0.3	0.2	0.0	0.1	39.4
ECSI	73.7	24.3	0.0	1.9	0.0	0.1	26.9
WCNI	87.6	0.5	2.3	1.2	7.5	0.9	9.2
Total	87.7	7.4	2.3	1.5	0.9	0.2	100.0

Table 11: Total landings (t) and distribution of landings (%) for tarakihi by fishing year over the five major areas described in Section 2.3.3.1 from trips which landed tarakihi, summed from 1989–90 to 2010–11. Major Areas are defined in Table 9.

Fishing	Major Area/Region						Major Area/Region				
Year	EN	BoP	ECNI	ECSI	WCNI	Total	EN	BoP	ECNI	ECSI	WCNI
	Landings (t)						Distribution (%)				
89/90	273	311	1 163	787	192	2 727	10.0	11.4	42.7	28.9	7.1
90/91	368	573	1 642	952	210	3 745	9.8	15.3	43.9	25.4	5.6
91/92	439	733	1 611	1 164	227	4 174	10.5	17.6	38.6	27.9	5.4
92/93	361	781	1 622	849	319	3 932	9.2	19.9	41.2	21.6	8.1
93/94	465	789	1 456	749	296	3 756	12.4	21.0	38.8	19.9	7.9
94/95	421	645	1 496	927	346	3 835	11.0	16.8	39.0	24.2	9.0
95/96	404	612	1 462	1 109	400	3 987	10.1	15.3	36.7	27.8	10.0
96/97	516	553	1 447	1 108	419	4 042	12.8	13.7	35.8	27.4	10.4
97/98	510	600	1 532	1 157	447	4 246	12.0	14.1	36.1	27.3	10.5
98/99	392	574	1 568	1 247	468	4 249	9.2	13.5	36.9	29.4	11.0
99/00	452	452	1 723	1 439	475	4 541	10.0	10.0	37.9	31.7	10.5
00/01	361	655	1 642	1 404	403	4 466	8.1	14.7	36.8	31.4	9.0
01/02	338	784	1 706	1 401	412	4 641	7.3	16.9	36.8	30.2	8.9
02/03	232	848	1 734	1 378	455	4 646	5.0	18.3	37.3	29.6	9.8
03/04	244	936	1 610	1 149	414	4 353	5.6	21.5	37.0	26.4	9.5
04/05	382	759	1 679	1 032	436	4 288	8.9	17.7	39.2	24.1	10.2
05/06	417	660	1 946	1 116	367	4 506	9.2	14.7	43.2	24.8	8.2
06/07	288	530	1 686	1 226	385	4 116	7.0	12.9	41.0	29.8	9.4
07/08	252	533	1 687	920	517	3 908	6.4	13.6	43.2	23.5	13.2
08/09	264	690	1 859	1 109	456	4 378	6.0	15.8	42.5	25.3	10.4
09/10	246	766	1 859	883	316	4 069	6.0	18.8	45.7	21.7	7.8
10/11	246	669	1 634	1 289	402	4 239	5.8	15.8	38.5	30.4	9.5
Total	7 870	14 452	35 763	24 395	8 364	90 845	8.7	15.9	39.4	26.9	9.2

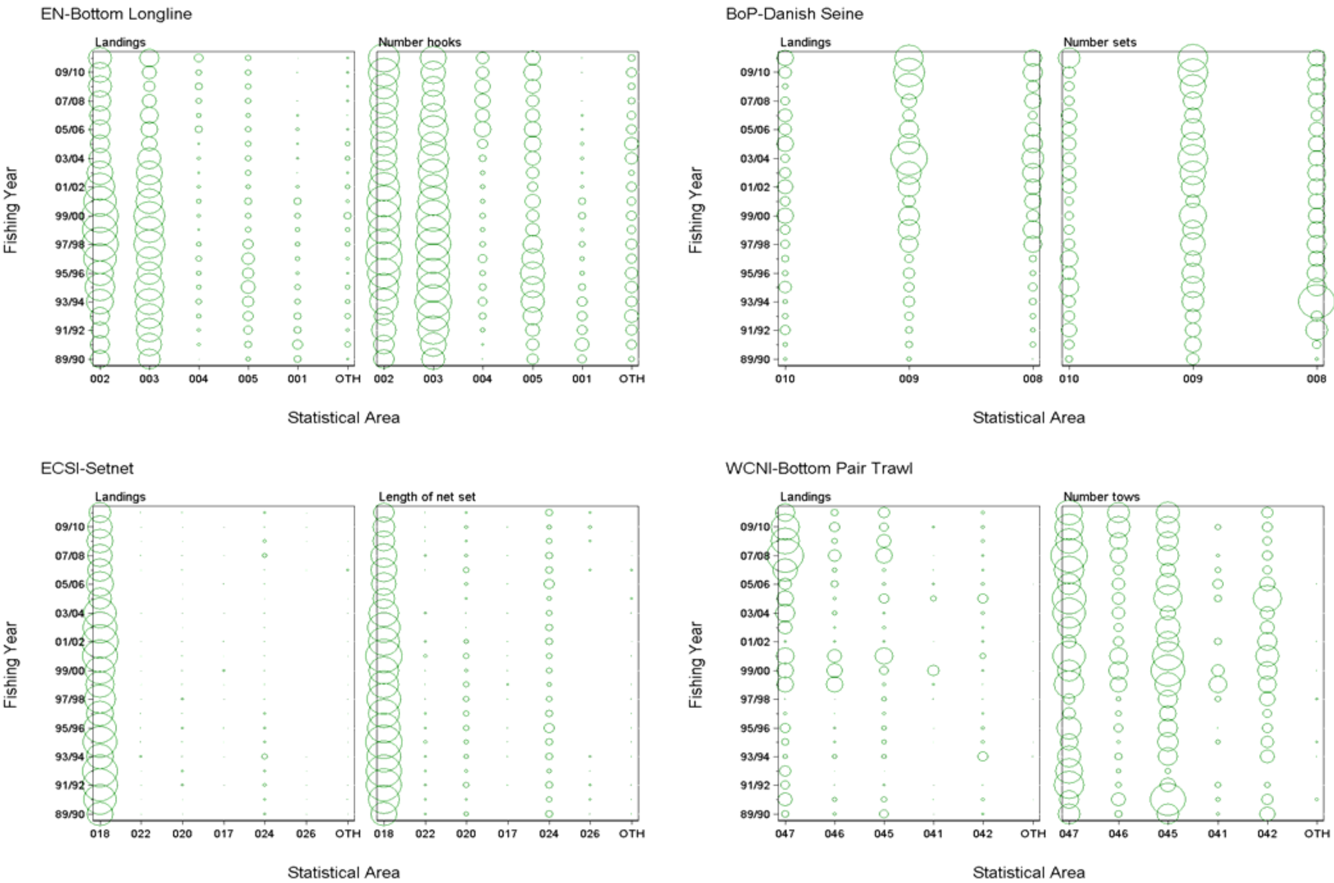

Figure 7: **Distribution of landings and effort for the 'second tier' methods for each Major Area (Table 9) by statistical area and fishing year from trips which landed tarakihi. Circles are proportional within each panel: [EN-Landings]: largest circle= 65 t in 97/98 for 002; [EN-Number hooks]: largest circle= 2951 × 1000 hooks in 93/94 for 003; [BoP-Landings]: largest circle= 49 t in 03/04 for 009; [BoP-Number sets]: largest circle= 1216 sets in 93/94 for 008; [ECSI-Landings]: largest circle= 400 t in 01/02 for 018; ECSI-Length of net set]: largest circle= 2594 km in 00/01 for 018; [WCNI-Landings]: largest circle= 83 t in 07/08 for 047; [WCNI-Number tows]: largest circle= 493 tows in 07/08 for 047.**

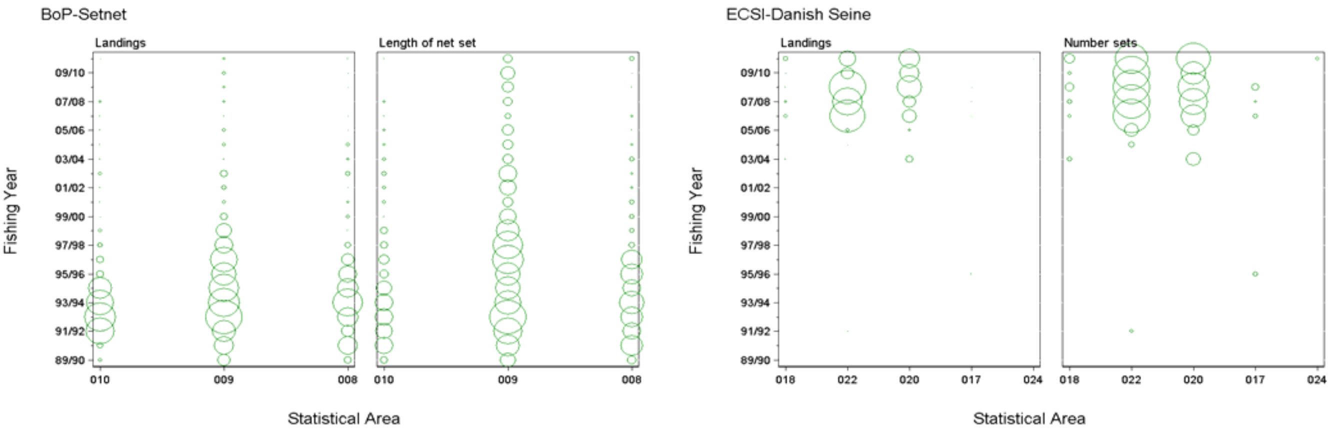

Figure 8: **Distribution of landings and effort for the 'third tier' methods for each Major Area (Table 9) by statistical area and fishing year from trips which landed tarakihi. Circles are proportional within each panel: [BoP-Landings]: largest circle= 58 t in 92/93 for 009; [BoP-Length of net set]: largest circle= 1380 km in 92/93 for 009; [ECSI-Landings]: largest circle= 104 t in 08/09 for 022; [ECSI-Number sets]: largest circle= 255 sets in 06/07 for 022.**

2.3.3.3 Fine scale distribution of landings and CPUE for bottom trawl and setnet

Fine scale landings and effort data are available for the entire bottom trawl fleet taking tarakihi from 1 Oct 2007 onwards. A plot (Figure 9) showing landings gridded into 0.1×0.1° cells, summed over all four years, shows a broad range of latitudes where tarakihi have been successfully taken, with concentrations of catch extending northwards from north of the Otago Peninsula up to south of Kaikoura. High concentration landing grids appear in Cook Strait, and then extend northwards up the east coast of the North island and into the Bay of Plenty. High landing grids also are observed along both the east and west sides of North Cape, but do not extend very far down the west coast of the North Island, stopping near Manukau Harbour (Figure 9).

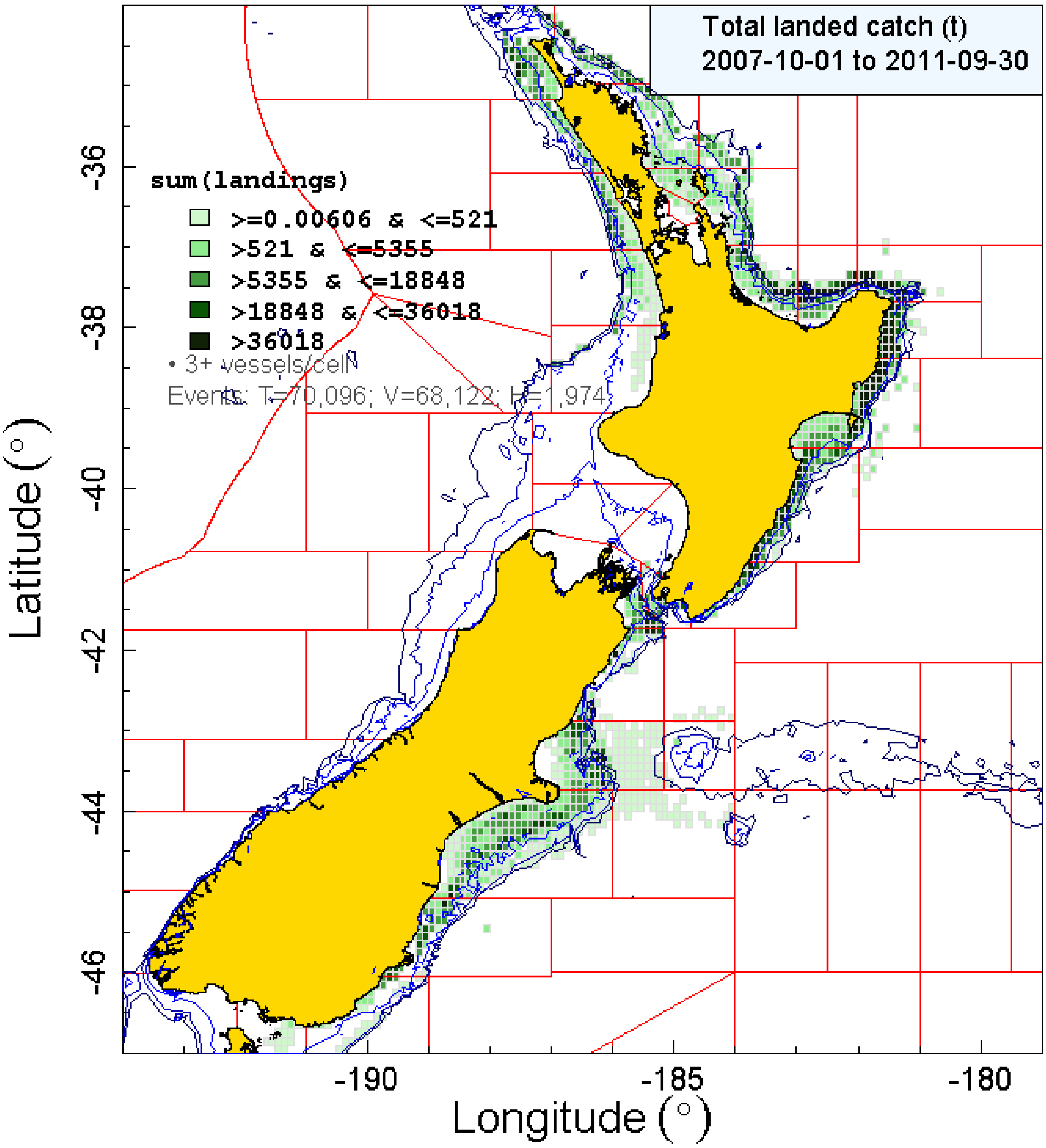

Figure 9: Total bottom trawl landings for tarakihi, arranged in 0.1° × 0.1° grids, summed from 2007–08 to 2010–11. Legend colours divide the distribution of total landings into approximate 25%, 50%, 75%, 90% and 95% quantiles. Only grids consistent with the statistical areas present in TAR 1, TAR 2 or TAR 3, and which have at least three reporting vessels, are plotted. Boundaries are shown for the general statistical areas plotted in Appendix B and the bathymetry indicates the 100 m, 200 m and 400 m depth contours.

Bottom trawl tarakihi CPUE is more patchy, with areas of the highest catch rates concentrated in the Canterbury Bight, eastern Cook Strait, around East Cape into the Bay of Plenty and on both sides of North Cape, but do not go down very far on either side of the North Island (Figure 10).

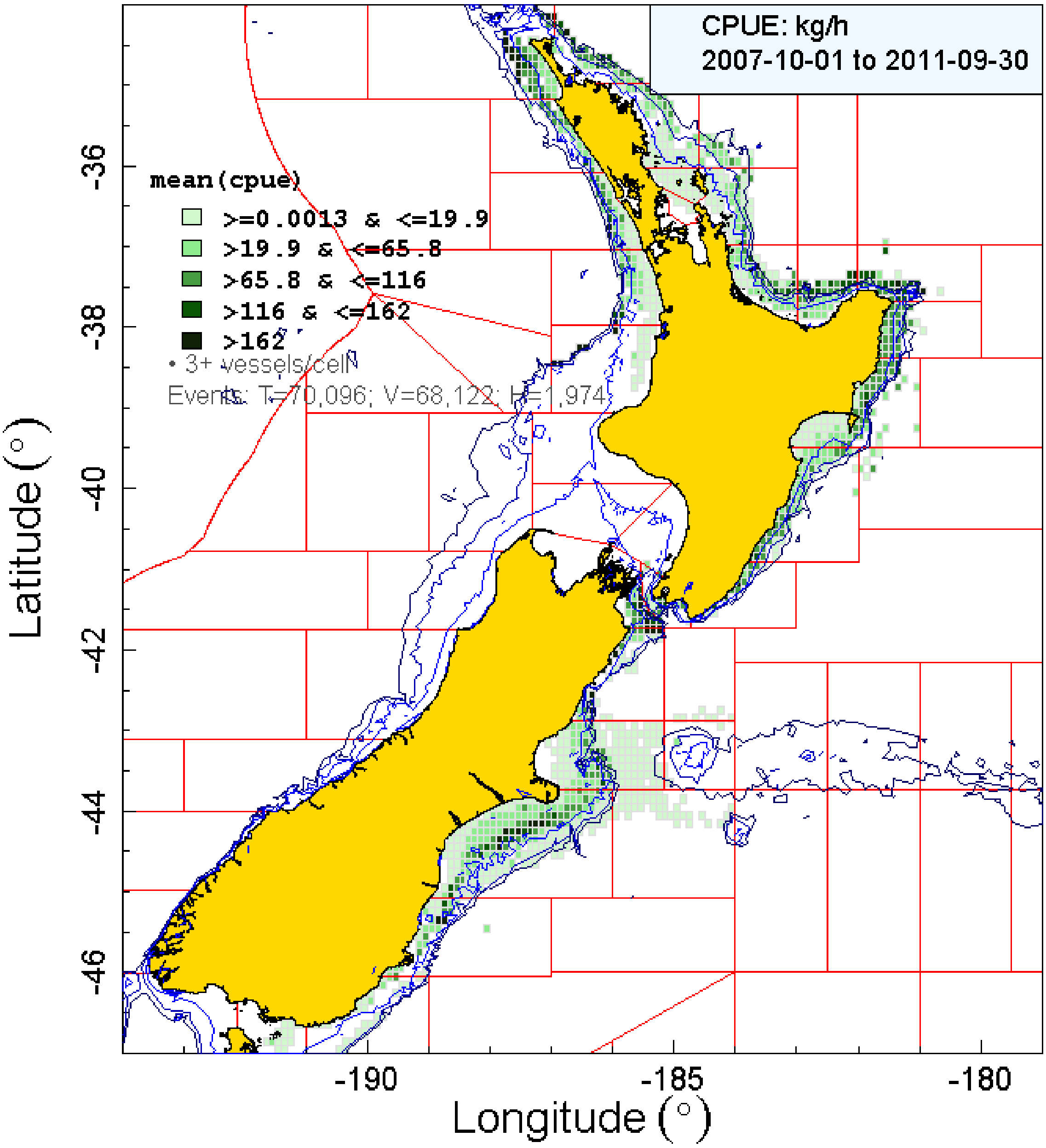

Figure 10: Mean bottom trawl CPUE (in kg/h) for tarakihi, arranged in 0.1° × 0.1° grids, summed from 2007–08 to 2010–11. Legend colours divide the distribution of BT CPUE into approximate 25%, 50%, 75%, 90% and 95% quantiles. Only grids consistent with the statistical areas present in TAR 1, TAR 2 or TAR 3, and which have at least three reporting vessels, are plotted. Boundaries are shown for the general statistical areas plotted in Appendix B and the bathymetry indicates the 100 m, 200 m and 400 m depth contours.

Tarakihi landings and CPUE stemming from the setnet method are much more localised than observed for the bottom trawl method taking tarakihi. Fine scale data are available for an additional earlier fishing year (2006–07). Tarakihi landings using the setnet method are located near Timaru at the southern end of the Canterbury Bight, in a small area just south of Kaikoura, in the eastern Bay of Plenty near Tauranga and on the east side of North Cape (Figure 11). There are only two areas which have relatively high setnet catch rates for tarakihi: Kaikoura and Timaru (Figure 12).

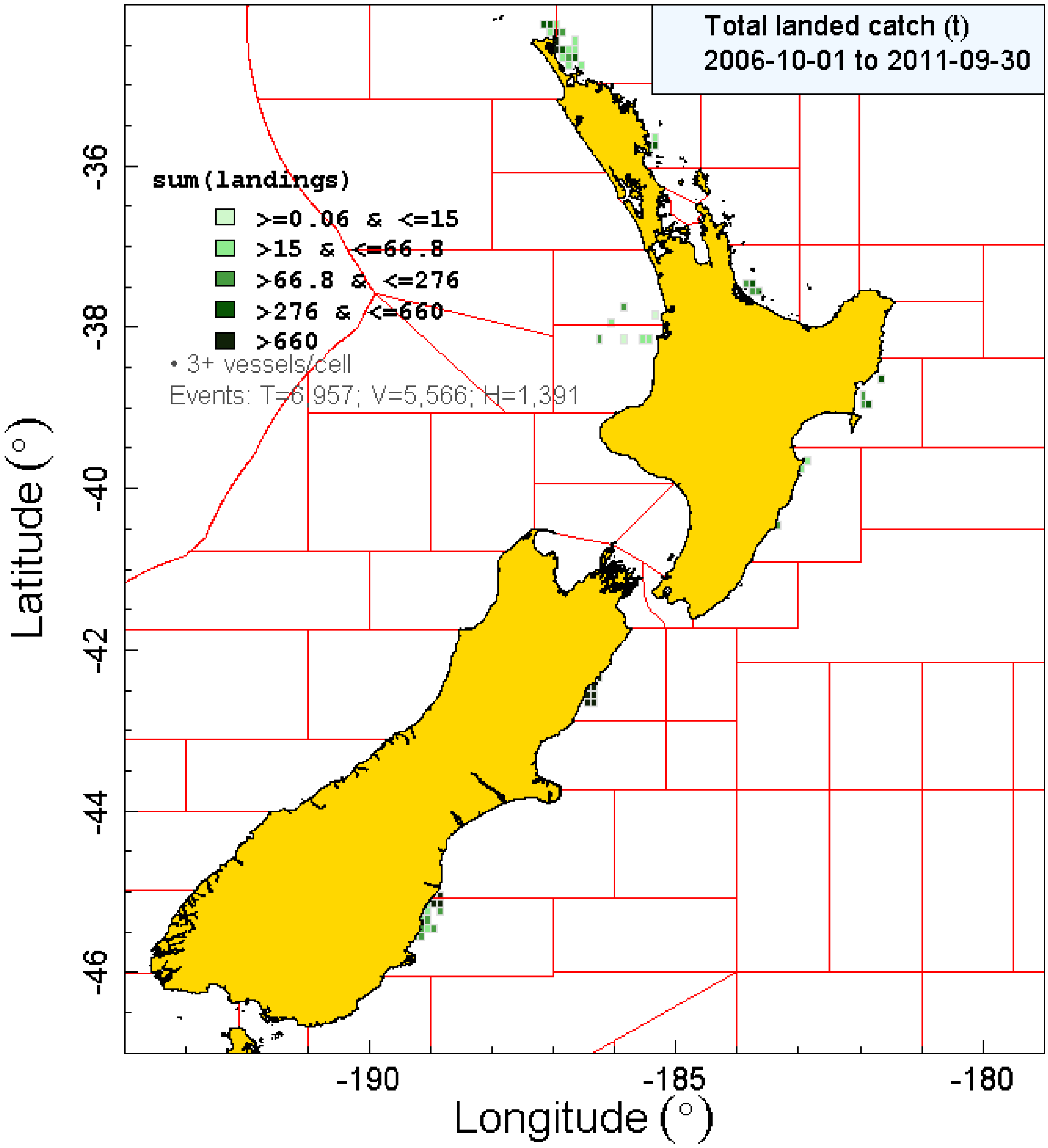

Figure 11: **Total setnet landings for tarakihi, arranged in 0.1° × 0.1° grids, summed from 2006–07 to 2010–11. Legend colours divide the distribution of total landings into approximate 25%, 50%, 75%, 90% and 95% quantiles. Only grids consistent with the statistical areas present in TAR 1, TAR 2 or TAR 3, and which have at least three reporting vessels, are plotted. Boundaries are shown for the general statistical areas plotted in Appendix B and the bathymetry indicates the 100 m, 200 m and 400 m depth contours.**

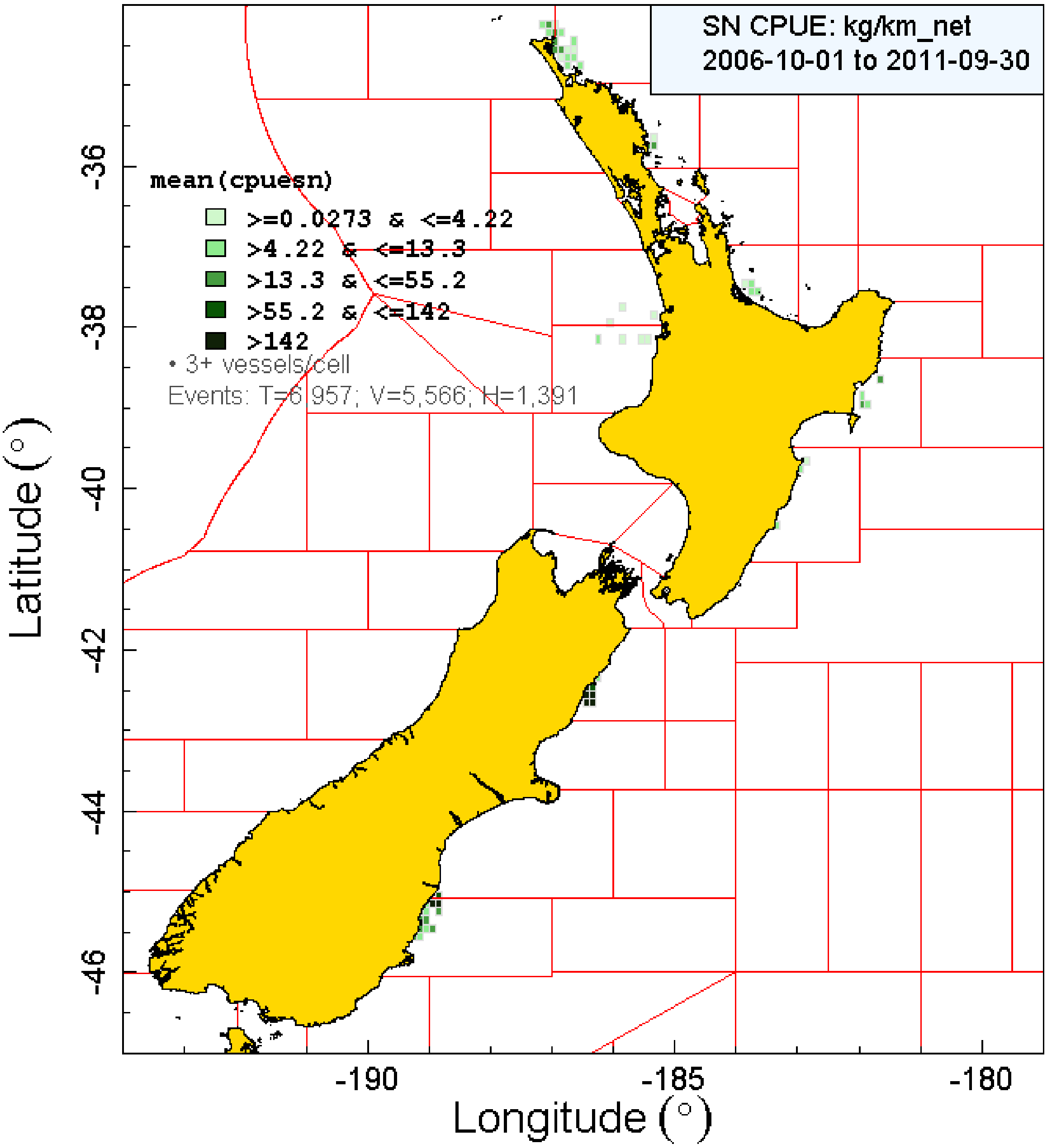

Figure 12: Mean setnet CPUE (in kg/km of net) for tarakihi, arranged in 0.1° × 0.1° grids, summed from 2006–07 to 2010–11. Legend colours divide the distribution of mean CPUE into approximate 25%, 50%, 75%, 90% and 95% quantiles. Only grids consistent with the statistical areas present in TAR 1, TAR 2 or TAR 3, and which have at least three reporting vessels, are plotted. Boundaries are shown for the general statistical areas plotted in Appendix B and the bathymetry indicates the 100 m, 200 m and 400 m depth contours.

2.3.3.4 Seasonal distribution of landings

The seasonal distribution of bottom trawl landings has been relatively uniform over all months in ECNI, while the remaining four areas show a proportional increase in landings for three or five months during the period from January to June, depending on the area (Figure 13; Table F.1). The "bulge" is earliest in ECSI, spanning the 5-month period from January to May. Moving north, but skipping over ECNI where the "bulge" isn't apparent, the peak landing months in BoP are from March to May and in EN from April to June (Table F.1). This shift in peak catch months when going north may be weak evidence of a northward migration for this species along the NZ east coast. The west coast of the North Island has a slightly broader landing "bulge", covering a 4-month period between February and May (Table F.1).

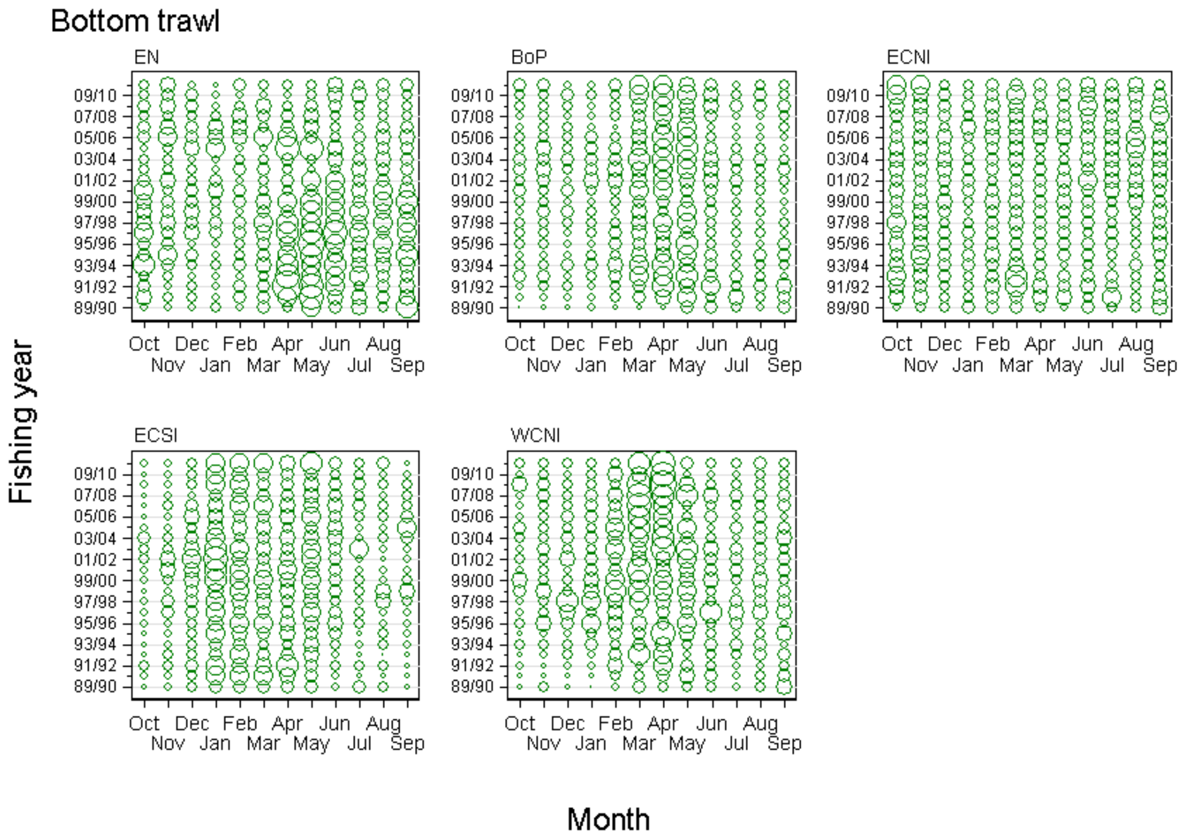

Figure 13: Distribution of landings by month and fishing year for bottom trawl in the five defined Major Areas (Table 9) based on trips which landed tarakihi. Circle sizes are proportional within each panel: [EN]: largest circle= 113 t in 91/92 for Apr; [BoP]: largest circle= 150 t in 92/93 for May; [ECNI]: largest circle= 321 t in 92/93 for Mar; [ECSI]: largest circle= 274 t in 01/02 for Jan; [WCNI]: largest circle= 111 t in 08/09 for Apr. Values for the plotted data are provided in Appendix F.

The ECSI setnet fishery is highly seasonal, being timed to the spawning migration of this species (Annala 1988). It has an initial broad peak between December and February, wanes in the months of March and April and then peaks again in May, apparently timed with the return of the spawning population (Figure 14; Table F.2). The timing of peak landing months in both the BoP Danish seine fishery and the EN bottom longline fishery has been in the late winter months, which are also the end of the fishing year (Figure 14; Table F.2). The BoP setnet fishery, when it existed, had its peak landings between February and May, similar to the peak months for the bottom trawl fishery in the same area (Figure 15; Table F.3). The ECSI Danish seine fishery has a late-season winter timing similar to that seen in the Bay of Plenty Danish seine fishery (Figure 15; Table F.3).

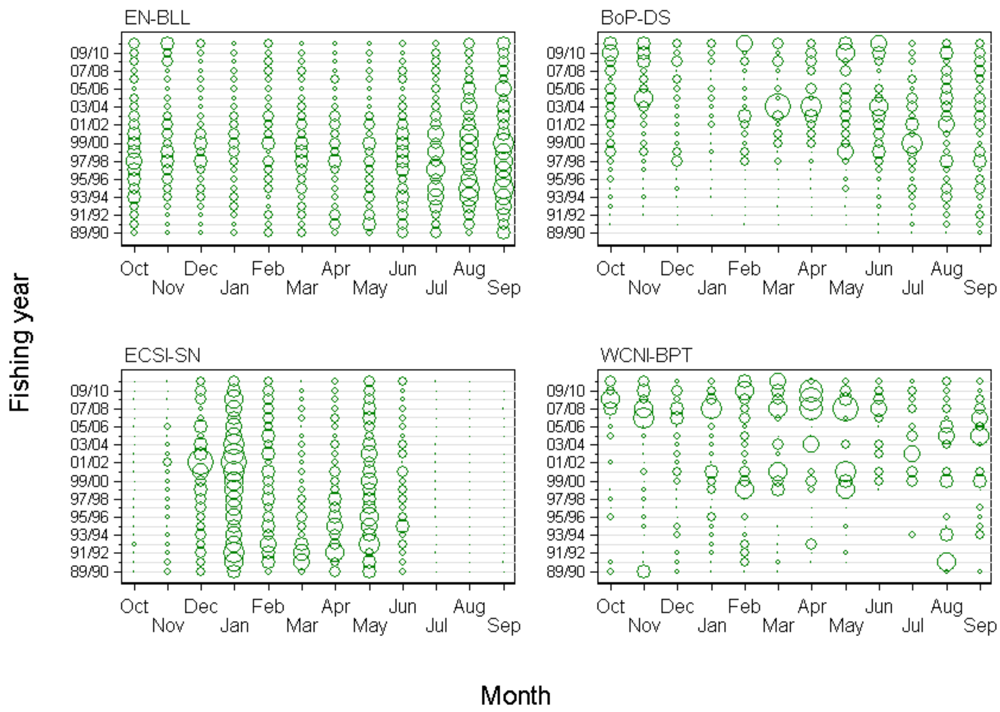

Figure 14: Distribution of landings by month and fishing year for second tier methods (defined in Appendix E) in the five defined Major Areas (Table 9) based on trips which landed tarakihi. Circle sizes are proportional within each panel: [EN-BLL]: largest circle= 22 t in 94/95 for Aug; [BoP-DS]: largest circle= 19 t in 03/04 for Mar; [ECSI-SN]: largest circle= 156 t in 01/02 for Dec; [WCNI-BPT]: largest circle= 21 t in 07/08 for May. Values for the plotted data are provided in Appendix F.

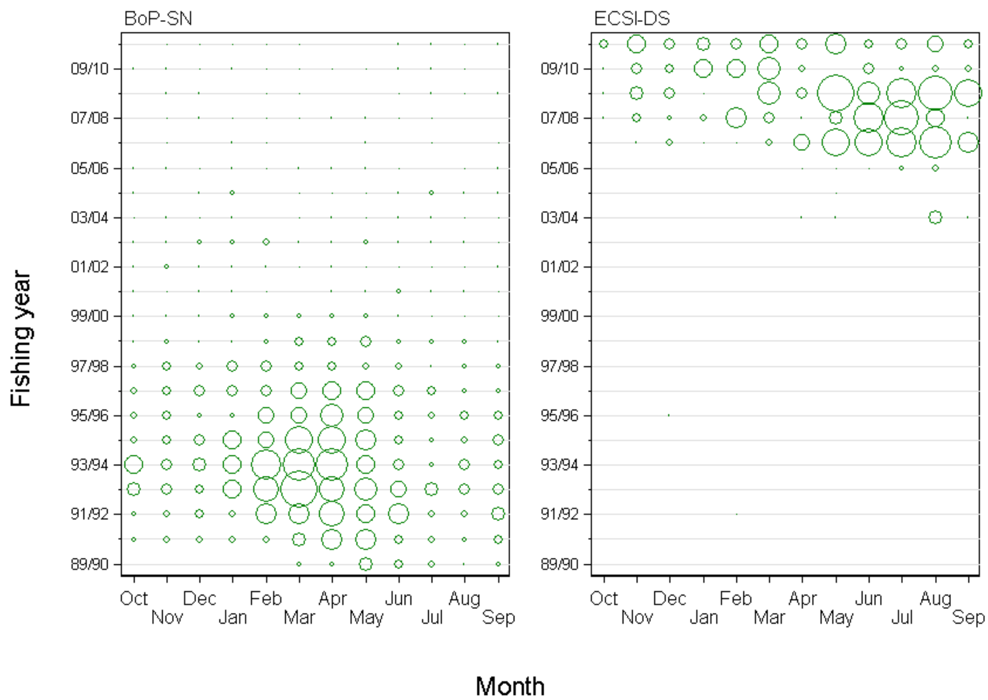

Figure 15: Distribution of landings by month and fishing year for third tier methods in the five defined Major Areas (Table 9) based on trips which landed tarakihi. Circle sizes are proportional within each panel: [BoP-SN]: largest circle= 34 t in 92/93 for Mar; [ECSI-DS]: largest circle= 35 t in 08/09 for May. Values for the plotted data are provided in Appendix F.

2.3.3.5 Distribution of landings by declared target species

The primary declared target species in each of the five major areas has been tarakihi, ranging from 53% of the total 22 year accumulated landings in EN to 83% in ECNI (Table 12). Most of the target tarakihi catch has been taken by the bottom trawl method, with the exception of the target setnet fishery occurring in ECSI. Other fisheries which have taken more than 15% of the total tarakihi in a major area have been the target red cod bottom trawl fishery operating in ECSI and the target snapper bottom longline fishery operating in EN. All other method/target species combinations have taken less than 10% of the total landed tarakihi catch (Table 12).

All the bottom trawl fisheries operating in each of the five major areas are predominantly target fishing for tarakihi, ranging from an average 43% of the total landed weight in ECSI to 84% in ECNI (Figure 16; Table G.1). The ECSI bottom trawl fishery has the greatest range of alternative target species among the five areas, with red cod and barracouta being the most important alternate species, but there has been a trend since the late 1990s for the relative importance of these two species to diminish in favour of an increasing trend to target tarakihi. Tarakihi target fishing has accounted for over 70% of the total tarakihi landings by bottom trawl in this area in the four years since 2007–08 (Table G.1). The bottom trawl fishery in WCNI, in addition to targeting tarakihi, also targets snapper (9% average of total landings) and trevally (6% average of total landings) (Table G.1). There is some targeting of snapper (11% average of total landings) and John dory (7% average of total landings) in the EN bottom trawl fishery (compared to 67% average of total landings for tarakihi target fishing, Table G.1).

Table 12: Total landings (t) and distribution of landings (%) for tarakihi by target species and method of capture for each Major Area (Table E.1) from trips which landed tarakihi, summed from 1989–90 to 2010–11. Cells in the final row for each area sum the column above it. Cells in the final column for each area sum the row.

Target	Method of Capture (t)							Method of Capture (%)						
species	BT	SN	BLL	DS	BPT	OTH	Total	BT	SN	BLL	DS	BPT	OTH	Total
Area: EN														
TAR	3 977	30	74	18	88	6	4 192	50.5	0.4	0.9	0.2	1.1	0.1	53
SNA	661	15	1 302	39	70	5	2 091	8.4	0.2	16.5	0.5	0.9	0.1	27
JDO	425	0	0	14	2	0	441	5.4	0.0	0.0	0.2	0.0	0.0	5.6
SKI	343	0	1	–	1	0	346	4.4	0.0	0.0	–	0.0	0.0	4.4
TRE	204	30	0	–	31	0	265	2.6	0.4	0.0	–	0.4	0.0	3.4
GUR	65	0	13	34	0	0	113	0.8	0.0	0.2	0.4	0.0	0.0	1.4
HPB	1	0	81	–	–	29	110	0.0	0.0	1.0	–	–	0.4	1.4
BAR	83	0	0	–	1	0	85	1.1	0.0	0.0	–	0.0	0.0	1.1
OTH	172	17	35	0	1	3	228	2.2	0.2	0.4	0.0	0.0	0.0	2.9
Total	5 929	94	1 507	104	194	42	7 870	75.3	1.2	19.1	1.3	2.5	0.5	100
Area: BoP														
TAR	10 219	461	10	201	0	3	10 894	70.7	3.2	0.1	1.4	0.0	0.0	75
SNA	878	15	237	267	24	2	1 423	6.1	0.1	1.6	1.9	0.2	0.0	10
TRE	497	33	0	5	1	0	536	3.4	0.2	0.0	0.0	0.0	0.0	3.7
SKI	447	10	0	0	0	1	458	3.1	0.1	0.0	0.0	0.0	0.0	3.2
GUR	202	1	24	100	0	0	326	1.4	0.0	0.2	0.7	0.0	0.0	2.3
HOK	240	6	–	2	–	0	247	1.7	0.0	–	0.0	–	0.0	1.7
BAR	224	0	–	0	–	0	225	1.6	0.0	–	0.0	–	0.0	1.6
JDO	167	0	0	2	0	0	170	1.2	0.0	0.0	0.0	0.0	0.0	1.2
OTH	109	27	30	2	1	4	173	0.8	0.2	0.2	0.0	0.0	0.0	1.2
Total	12 983	553	300	580	26	11	14 452	89.8	3.8	2.1	4.0	0.2	0.1	100

Table 12 (cont.):

Target species	Method of Capture (t)							Method of Capture (%)						
	BT	SN	BLL	DS	BPT	OTH	Total	BT	SN	BLL	DS	BPT	OTH	Total
Area: ECNI														
TAR	29 748	47	1	11	–	12	29 819	83.2	0.1	0.0	0.0	–	0.0	83
GUR	2 166	2	0	68	1	1	2 239	6.1	0.0	0.0	0.2	0.0	0.0	6.3
SKI	1 091	2	2	–	–	3	1 097	3.0	0.0	0.0	–	–	0.0	3.1
WAR	623	32	0	–	–	0	654	1.7	0.1	0.0	–	–	0.0	1.8
HOK	584	0	0	0	–	10	594	1.6	0.0	0.0	0.0	–	0.0	1.7
BAR	488	0	–	–	–	1	489	1.4	0.0	–	–	–	0.0	1.4
SNA	277	0	10	8	0	1	296	0.8	0.0	0.0	0.0	0.0	0.0	0.8
TRE	131	0	–	0	0	–	132	0.4	0.0	–	0.0	0.0	–	0.4
MOK	70	27	–	–	–	0	97	0.2	0.1	–	–	–	0.0	0.3
JDO	85	0	–	0	–	0	85	0.2	0.0	–	0.0	–	0.0	0.2
OTH	158	12	78	1	–	11	261	0.4	0.0	0.2	0.0	–	0.0	0.7
Total	35 421	123	92	88	1	39	35 763	99.0	0.3	0.3	0.2	0.0	0.1	100
Area: ECSI														
TAR	7 788	5 519	0	423	–	3	13 733	31.9	22.6	0.0	1.7	–	0.0	56
RCO	4 991	8	–	27	0	1	5 027	20.5	0.0	–	0.1	0.0	0.0	21
BAR	2 101	0	–	–	–	4	2 105	8.6	0.0	–	–	–	0.0	8.6
FLA	1 334	0	0	1	–	0	1 335	5.5	0.0	0.0	0.0	–	0.0	5.5
SQU	445	–	–	–	0	1	446	1.8	–	–	–	0.0	0.0	1.8
WAR	304	20	–	–	–	0	324	1.2	0.1	–	–	–	0.0	1.3
SPD	104	124	–	1	–	–	230	0.4	0.5	–	0.0	–	–	0.9
HOK	188	0	–	–	–	7	195	0.8	0.0	–	–	–	0.0	0.8
SPE	178	0	0	0	–	0	178	0.7	0.0	0.0	0.0	–	0.0	0.7
LIN	19	140	2	–	–	2	163	0.1	0.6	0.0	–	–	0.0	0.7
STA	134	0	–	–	–	–	134	0.6	0.0	–	–	–	–	0.6
OTH	391	115	6	2	0	10	524	1.6	0.5	0.0	0.0	0.0	0.0	2.1
Total	17 979	5 926	8	455	0	28	24 395	73.7	24.3	0.0	1.9	0.0	0.1	100
Area: WCNI														
TAR	5 322	7	26	5	388	4	5 750	63.6	0.1	0.3	0.1	4.6	0.0	69
SNA	687	1	66	5	85	3	846	8.2	0.0	0.8	0.1	1.0	0.0	10
TRE	507	4	1	–	124	3	638	6.1	0.0	0.0	–	1.5	0.0	7.6
GUR	200	10	2	89	15	0	316	2.4	0.1	0.0	1.1	0.2	0.0	3.8
BAR	221	0	–	–	17	0	238	2.6	0.0	–	–	0.2	0.0	2.8
JMA	161	0	–	–	0	21	182	1.9	0.0	–	–	0.0	0.2	2.2
HPB	2	0	77	–	–	34	112	0.0	0.0	0.9	–	–	0.4	1.3
SKI	109	–	–	–	1	0	110	1.3	–	–	–	0.0	0.0	1.3
OTH	123	17	21	0	0	10	171	1.5	0.2	0.3	0.0	0.0	0.1	2.0
Total	7 330	39	192	98	630	75	8 364	87.6	0.5	2.3	1.2	7.5	0.9	100

The setnet fishery operating in ECSI is a target tarakihi fishery, with target landings averaging over 90% of the total landings and approaching 99% of the landings in the last decade (Figure 17; Table G.1). This is in contrast to the EN bottom longline fishery and the BoP Danish seine fishery, both of which are primarily targeted at snapper, although target fishing for tarakihi has exceeded the target snapper landings in the BoP DS fishery in two of the three most recent fishing years (Figure 17). The BoP setnet fishery, when it existed in the early 1990s, was also targeted at tarakihi, as is the developing Danish seine fishery in ECSI (Figure 18).

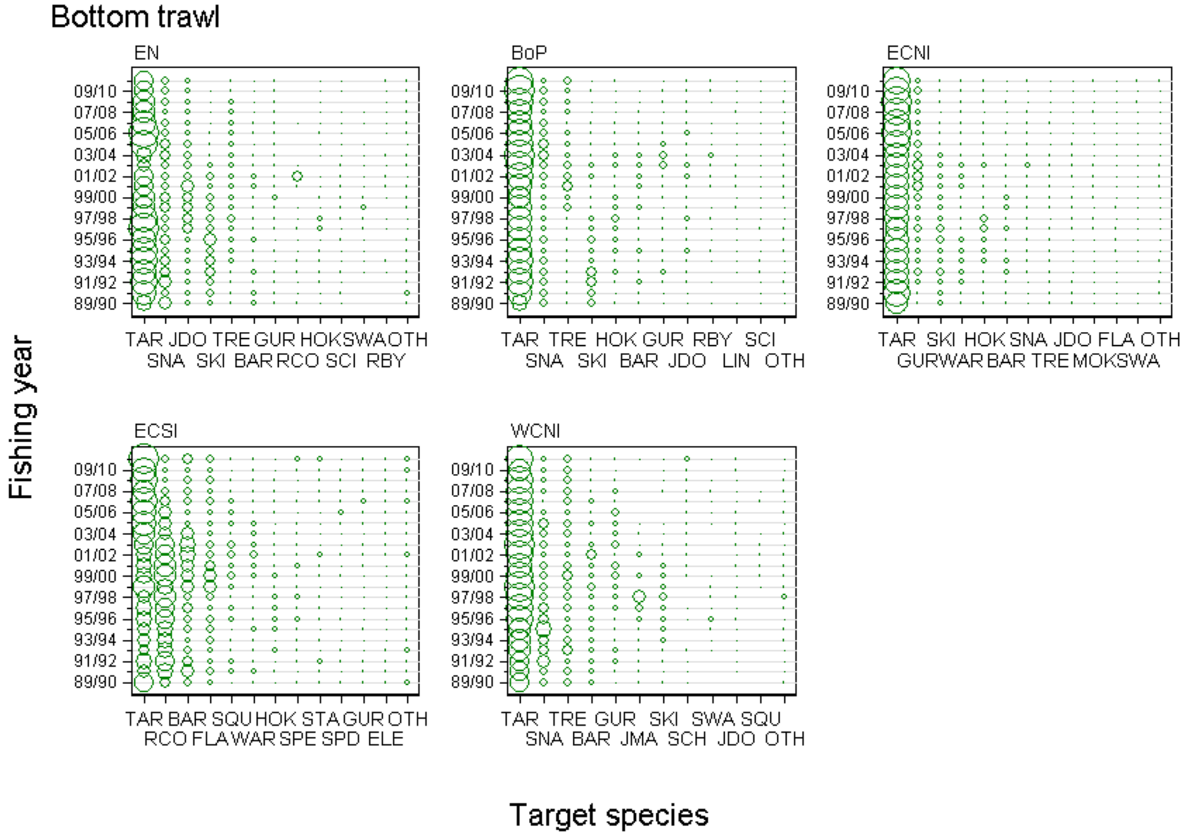

Figure 16: Distribution of landings by target species (ranked in terms of descending order of total landings) and fishing year for bottom trawl in the five defined Major Areas (Table 9) based on trips which landed tarakihi. Circle sizes are proportional within each panel: [EN]: largest circle= 304 t in 05/06 for TAR; [BoP]: largest circle= 635 t in 03/04 for TAR; [ECNI]: largest circle=1811 t in 05/06 for TAR; [ECSI]: largest circle= 796 t in 10/11 for TAR; [WCNI]: largest circle= 338 t in 02/03 for TAR.

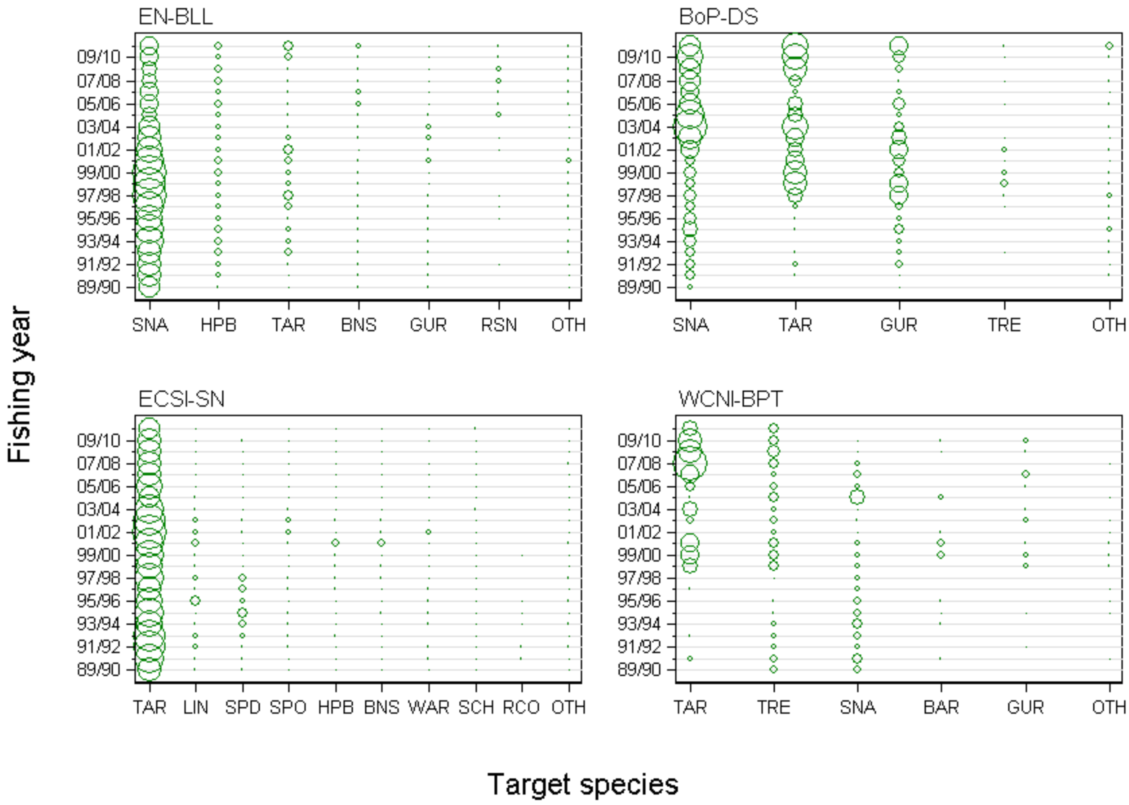

Figure 17: Distribution of landings by target species (ranked in terms of descending order of total landings) and fishing year for second tier methods in the defined Major Areas (Table 9) based on trips which landed tarakihi. Circle sizes are proportional within each panel: [EN-BLL]: largest circle= 109 t in 97/98 for SNA; [BoP-DS]: largest circle= 40 t in 03/04 for SNA; [ECSI-SN]: largest circle= 376 t in 01/02 for TAR; [WCNI-BPT]: largest circle= 102 t in 07/08 for TAR.

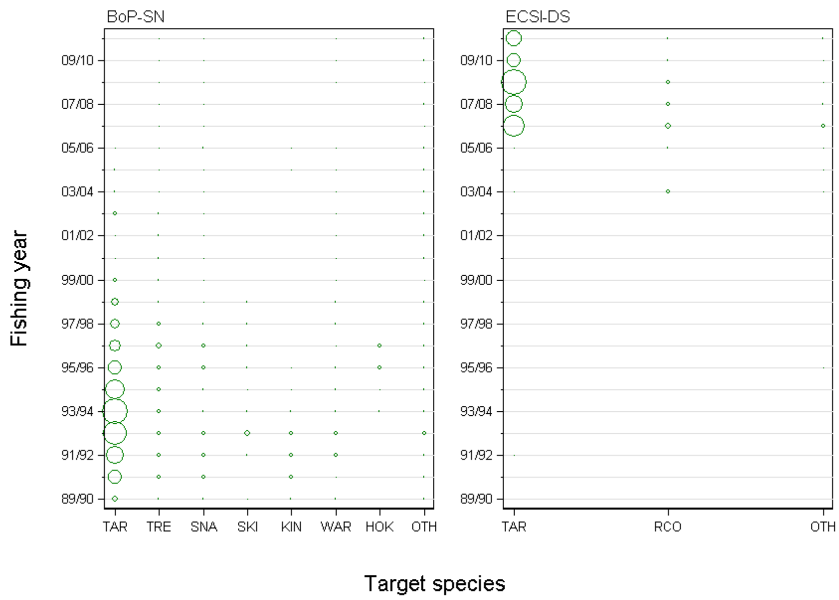

Figure 18: Distribution of landings by target species (ranked in terms of descending order of total landings) and fishing year for third tier methods in the defined Major Areas (Table 9) based on trips which landed tarakihi. Circle sizes are proportional within each panel: [BoP-SN]: largest circle= 106 t in 93/94 for TAR; [ECSI-DS]: largest circle= 144 t in 08/09 for TAR.

2.3.3.6 Preferred bottom trawl fishing depths for tarakihi

Depth information is available from TCEPR and TCER forms which report bottom trawl catches pertaining to tarakihi (either recording an estimated catch of tarakihi or declaring tarakihi as the target species). These data come either from the recently introduced (1 October 2007) TCER forms or the longstanding TCEPR forms, which are primarily used by the larger offshore vessels but have been in operation since the first year of data in this report (1989–90). Approximately one-third (over 43 000) of the depth observations reported in Table 13 originate from the TCER forms, accumulated in only four years and this form type accounts for about three quarters of the depth observations in those four years. This predominance of TCER reports reflects the inshore nature of the tarakihi bottom trawl fisheries. In addition, inshore bottom trawl fishers voluntarily undertook to report on tow-by-tow TCEPR forms in FMAs 1 and 9, beginning around 1995–96. Consequently, representative depth information is available from WCNI, EN and BoP from 1995–96.

Reported depth observations, summarised over both form types, show that the 5 to 95% quantiles for target tarakihi bottom trawl fishing tend to be shallow for the ECNI (40 to 175 m) and ECSI (46 to 130 m) fisheries compared to the equivalent depth range for EN (70 to 250 m), BoP (55 to 240 m) and WCNI (64 to 210 m) (Table 13). The distribution of tows which caught or targeted tarakihi varies according to the target fishery in all five areas, with deep fisheries such as squid, hoki and gemfish taking tarakihi at depths up to 500 m compared to the shallower depths for successful tarakihi catches for fisheries like red cod and flatfish (Figure 19).

The setnet forms (NCELR) introduced in 2006–07 do not request depth information (Ministry of Fisheries 2010).

Table 13: Summary statistics from distributions from all records (combined TCER and TCEPR formtypes) using the bottom trawl method for effort that targeted or caught tarakihi by target species category. Data for areas EN, BoP and WCNI include the period 1995–96 while data for areas ECNI and ECSI include the period 2007–08 to 2010–11.

					Depth (m)
Target species category	Number observations	Lower 5% of distribution	Mean of distribution	Median (50%) of distribution	Upper 95% of distribution
[EN]					
TAR	6 703	69	151	149	241
JDO	5 286	40	74	73	112
SNA	5 022	35	82	72	148
TRE	959	26	94	90	150
SKI	751	145	276	295	350
GUR	646	40	61	56	90
SCI	248	339	356	358	380
BAR	213	50	121	121	200
Other	154	68	255	294	405
Total	19 982	41	115	95	270
[BoP]					
TAR	16 617	55	147	140	240
SNA	5 180	23	63	55	120
TRE	3 094	25	57	50	112
GUR	1 200	30	74	70	124
JDO	1 200	39	81	80	130
BAR	588	72	129	120	202
SKI	384	120	261	270	400
HOK	361	120	256	240	410
Other	346	35	227	240	410
Total	28 970	30	120	110	240

Table 13 (cont).:

Target species category	Number observations	Depth (m) Lower 5% of distribution	Mean of distribution	Median (50%) of distribution	Upper 95% of distribution
[ECNI]					
TAR	20 849	40	95	88	170
GUR	4 610	27	55	50	92
WAR	610	49	85	85	125
SNA	281	21	53	48	100
SKI	250	104	198	197	310
HOK	179	92	199	190	310
SWA	138	91	184	192	255
MOK	129	53	98	100	126
BAR	106	40	105	90	203
FLA	105	12	27	26	42
Other	264	34	141	98	350
Total	27 521	34	90	80	178
[ECSI]					
TAR	6 488	46	87	87	130
FLA	3 165	20	43	45	64
RCO	928	40	71	62	124
BAR	864	43	73	65	125
STA	302	64	103	101	150
ELE	180	22	47	46	82
WAR	179	46	78	70	130
GUR	167	36	48	46	62
SPE	163	68	92	91	122
GSH	102	55	111	112	185
Other	317	45	135	111	294
Total	12 855	25	74	70	128
[WCNI]					
TAR	6 603	64	138	140	207
SNA	2 334	36	83	85	130
TRE	1 829	30	71	70	120
GUR	669	30	61	58	110
BAR	621	56	116	117	190
JMA	284	114	139	135	175
SKI	224	164	304	320	390
JDO	124	30	80	79	130
SCH	107	55	145	156	218
Other	107	50	247	250	400

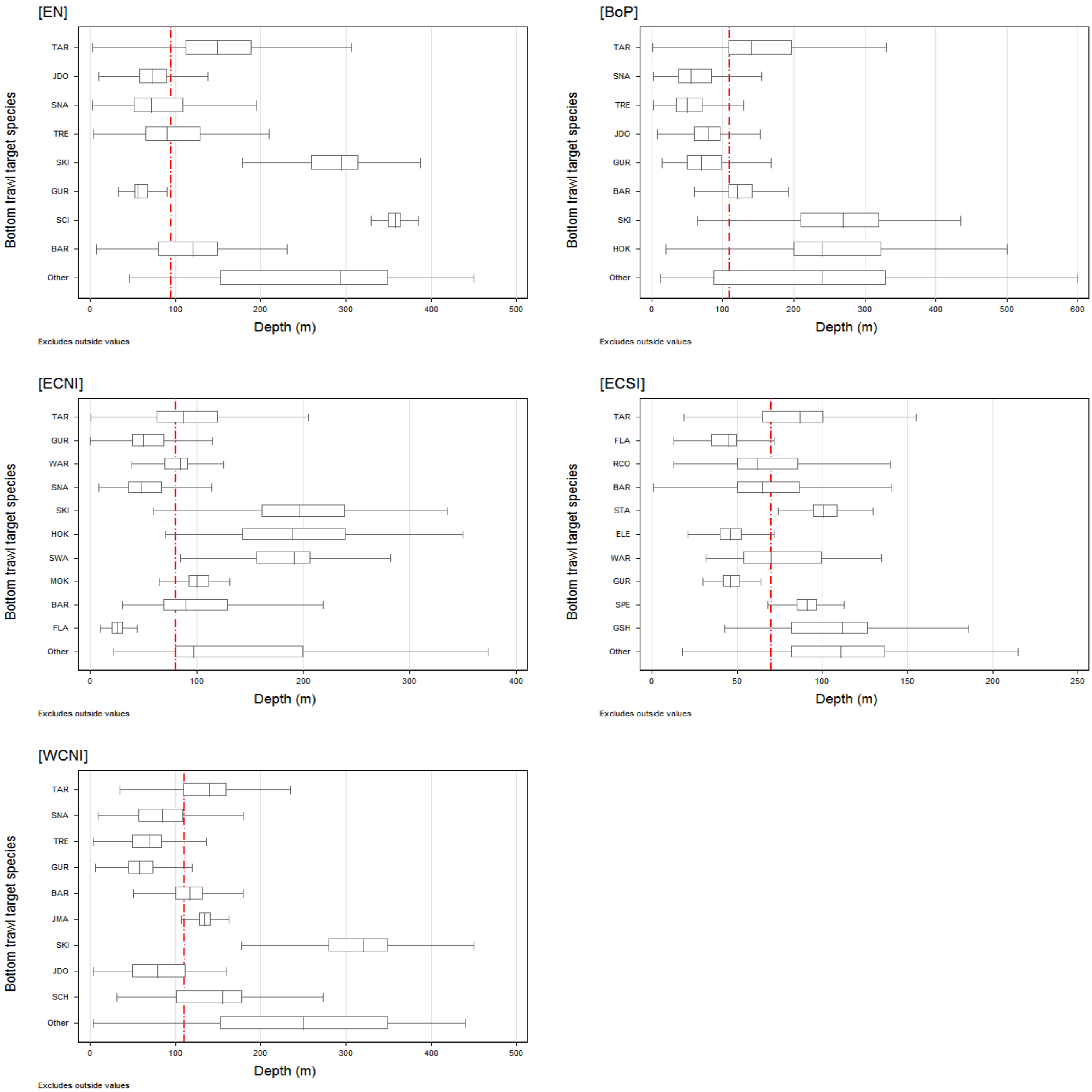

Figure 19: Box plot distributions of bottom depth from all records (combined TCER and TCEPR formtypes) using the bottom trawl method for effort that targeted or caught tarakihi by target species category. Data for areas EN, BoP and WCNI include the period 1995–96 while data for areas ECNI and ECSI include the period 2007–08 to 2010–11. Vertical line in each sub graph indicates the median depth from all tows which caught or targeted tarakihi in the indicated area.

3. STANDARDISED CPUE ANALYSIS, EAST COASTS NORTH AND SOUTH ISLANDS

Three fisheries were selected for detailed analysis to be included as biomass index series in a stock assessment of tarakihi on the east coasts of the North and South Islands of New Zealand (Langley & Starr 2012). These fisheries were:

a) **TAR2_BT_MIX: East coast, North Island mixed species bottom trawl–**bottom single trawl in Statistical Areas 011 to 016 inclusive, target TAR, SNA, BAR, SKI, WAR, or GUR.

b) **TAR3_BT_MIX: East coast, South Island mixed species bottom trawl–**bottom single trawl in Statistical Areas 017, 018, 020, 022, 024, 026, target TAR, BAR, RCO, WAR, or GUR.

c) **TAR3_SN_TAR: Kaikoura target tarakihi setnet–**setnet in Statistical Area 018, target TAR.

Fisheries b) and c) were updates of equivalent analyses done in 2009 (Starr et al. 2009). Fishery a) was a broader definition of the target tarakihi fishery analysed by Bentley & Jiang (2008). This change was added because work done in the intervening years indicated that these inshore CPUE series were less sensitive to data form issues if a broadening of the target species definition which characterised the fishery was used. Data were prepared in the same manner as described in Section 2.3.1 and detailed results, including all diagnostics, are presented for each of the above CPUE series in Appendix H and Appendix I.

These three fisheries show a considerable shift away from the unstandardised series, particularly the two mixed target species bottom trawl series (Figure 20). The TAR 2_BT_MIX series goes from a flat series with virtually no trend, to a complex series with a strong broad peak spanning the end of the 1990s and the first 3–4 years of the 2000s ([upper left panel] Figure 20). Similarly, a strong increasing trend in the unstandardised series for the TAR 3_BT_MIX series, beginning from the early 2000s, is transformed by the standardisation process into a flat series after a five-year decline from a peak in 1999–2000 ([upper right panel] Figure 20). The TAR3_SN_TAR series based on the target TAR setnet fishery, operating near Kaikoura, shows a lesser shift away from the unstandardised series attributable to the standardisation procedure. However, recent years are pulled down and the first three years are pulled up relative to the unstandardised TAR3_SN_TAR series ([lower left panel] Figure 20).

There is good agreement between previous series prepared for AMP reviews and the series generated for the 2012 tarakihi stock assessment (Figure 21). Because the definition of the TAR 2_BT_MIX series has been changed, the comparison for the east coast North Island series was done using the previous target TAR fishery definition (this analysis is not documented; [upper left panel] Figure 21). Note that there is reasonably good agreement between the previous TAR 3_BT_MIX series (Starr et al. 2009) and the equivalent 2012 series ([upper right panel] Figure 21), even though the latter series contained data from Area 017 while the 2009 series did not.

A direct comparison of all three series prepared for the 2012 tarakihi stock assessment shows that the TAR 3_BT_MIX series has the earliest peak, peaking about two years sooner than the TAR 2_BT_MIX series (Figure 22). The TAR 3_BT_MIX series also shows a strong 50% increase in 2010–11, which coincides with the strong increase in the TAR 3 2010–11 LFR landings (see [lower left] Figure 2). This figure also shows that the peak for the TAR 2_BT_MIX series is much broader than the peak seen in the TAR 3_SN_TAR series, although both have the same peak year (Figure 22). Closer examination of the comparison between the TAR 2_BT_TAR target tarakihi series with the TAR 2_BT_MIX series, shows that the abundance peak for the TAR 2_BT_TAR series is also less broad and slightly lower than the equivalent indices for the TAR 2_BT_MIX series (see [upper left panel] Figure 21).

A similar comparison is made in Figure 23, where the TAR 2_BT_MIX series is compared with the TAR 3_SN_TAR and TAR 2_BT_TAR series. This comparison shows that the two target TAR series are almost identical, except for a lot of variation in the setnet indices at the beginning of the series. Both target series have narrow bands of peak abundance in the early 2000s, and don’t scale as high as the TAR 2_BT_MIX series. Finally, Figure 24 shows that the Bay-of-Plenty_BT_MIX series (documented in Appendix J) is nearly identical to the TAR 2_BT_MIX series. The other series in Figure 24 (EN_BT_MIX, also documented in Appendix J) more closely resembles the TAR 3_BT_MIX, although this area is not known as a nursery area and tarakihi migration direction is thought to be mainly from South to North (Langley & Starr 2012).

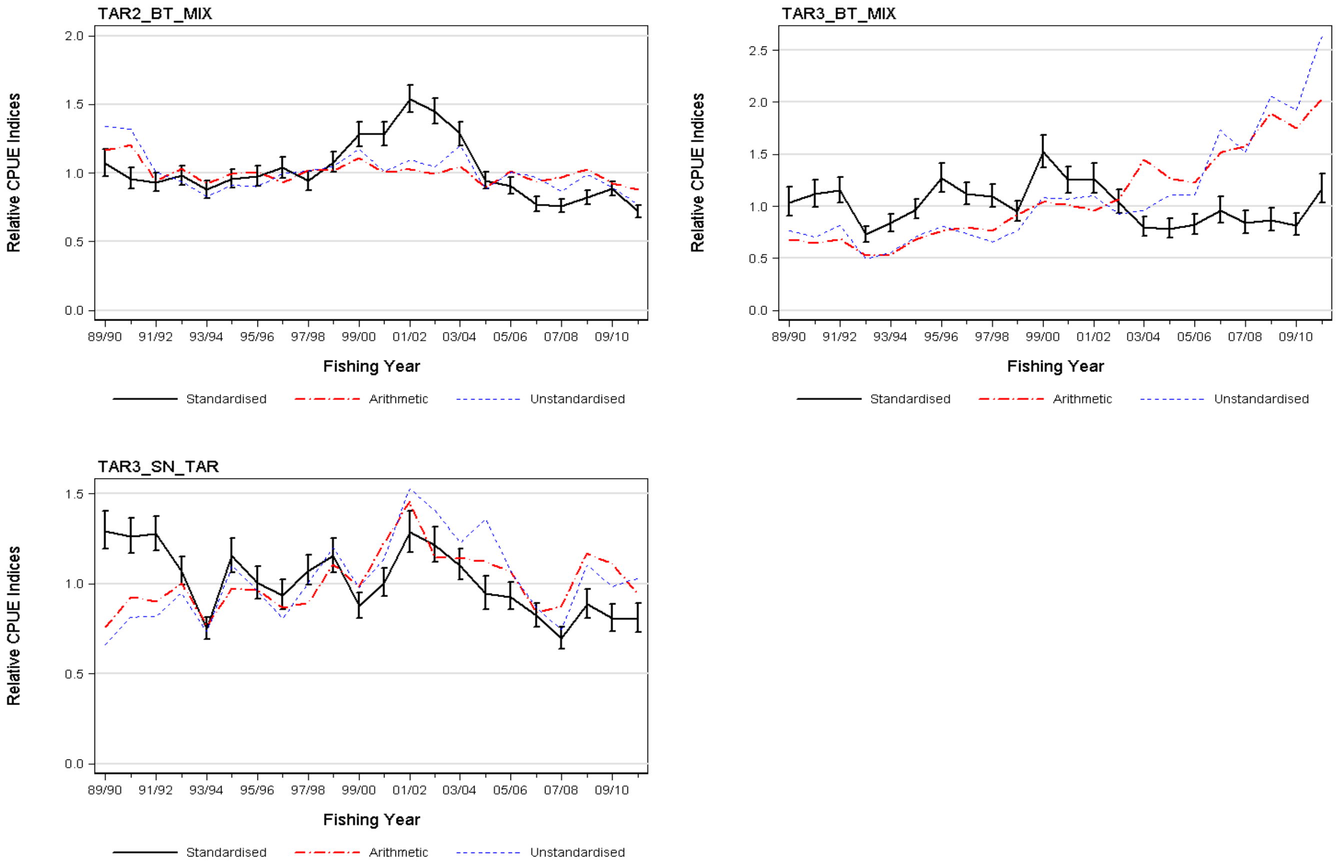

Figure 20: Standardised CPUE models for three East Coast tarakihi data sets: [upper left panel] TAR 2_BT_MIX: mixed target species bottom trawl from Areas 011–016; [upper right panel] TAR 3_BT_MIX: mixed target species bottom trawl from Areas 017–026; [lower left panel] TAR 3_SN_TAR: tarakihi target species setnet from Area 018. Error bars are ±2*SE. Also shown are two unstandardised series (arithmetic and geometric) using the same data that generated each standardised series. The effort variable for these unstandardised series was tows for the two bottom trawl fisheries and net length for the setnet fishery.

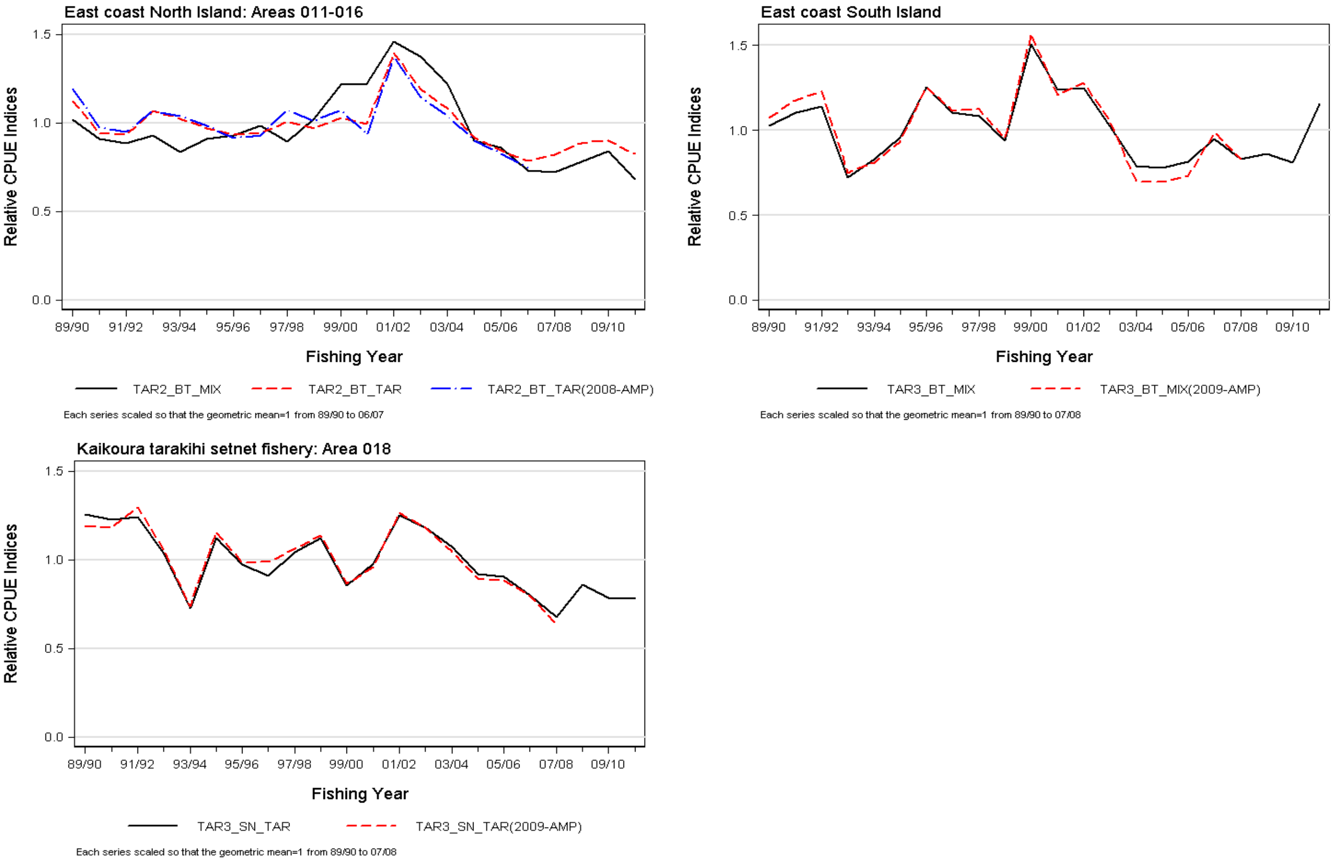

Figure 21: Comparison of previous standardised CPUE analyses with those prepared for this report: [upper left panel]: East coast North Island bottom trawl fishery, 2008 AMP target TAR with 2012 TAR and MIX target series; [upper right panel] East coast South Island bottom trawl fishery, 2009 AMP MIX (without Area 017) with 2012 MIX target series (with Area 017); [lower left panel]: Kaikoura target TAR setnet fishery, 2009 AMP with 2012 series.

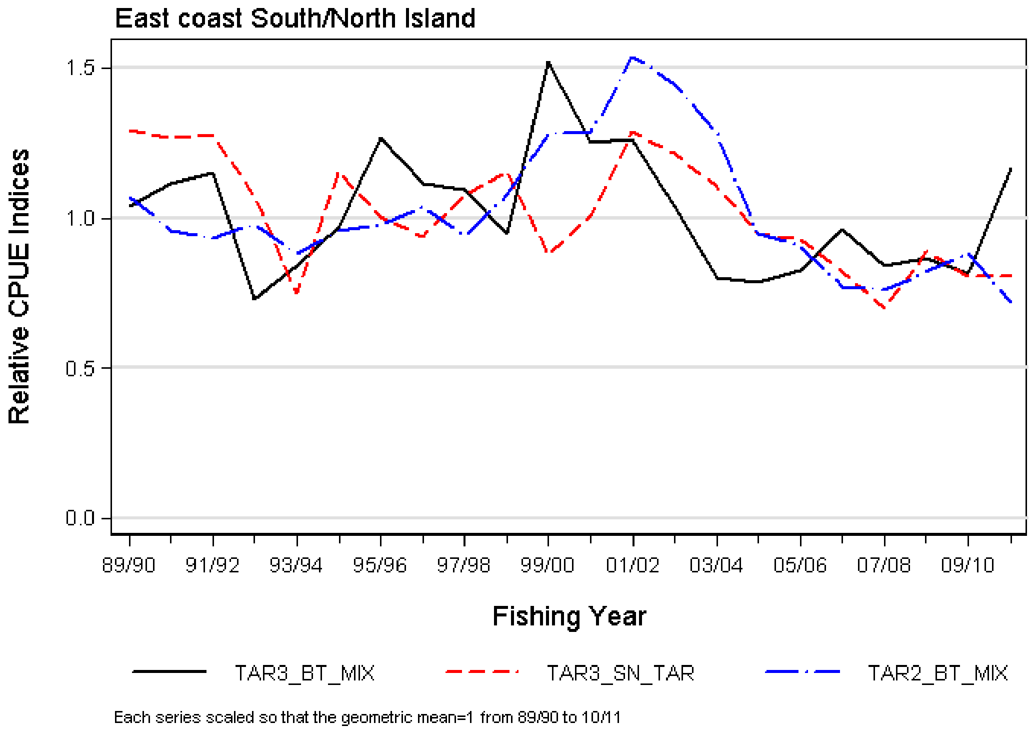

Figure 22: Comparison of 2012 standardised CPUE series: a) east coast South Island bottom trawl fishery, MIX target series; b) Kaikoura target TAR setnet fishery; c) east coast North Island bottom trawl fishery, MIX target series.

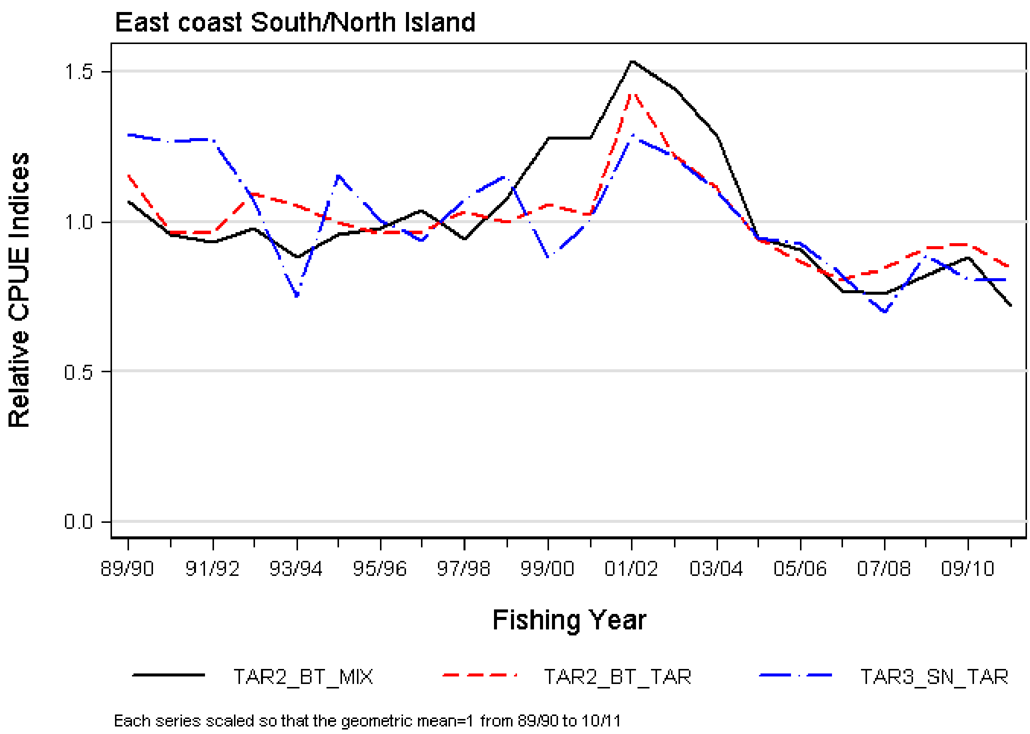

Figure 23: Comparison of 2012 standardised CPUE series: a) east coast North Island bottom trawl fishery, MIX target series; b) east coast North Island bottom trawl fishery, TAR target series; c) Kaikoura target TAR setnet fishery.

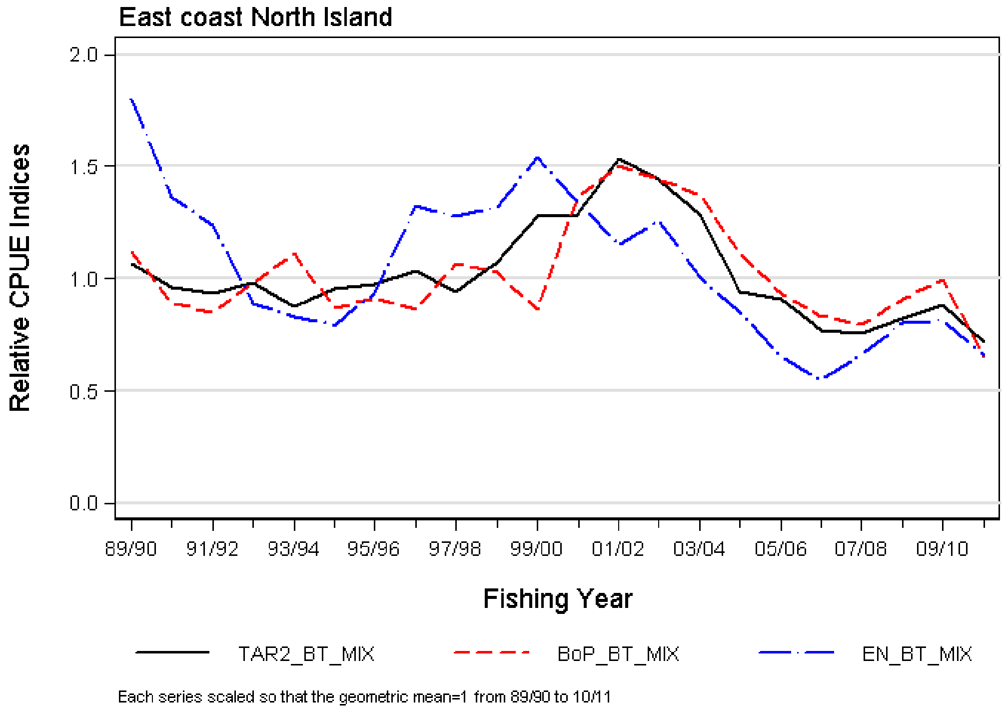

Figure 24: Comparison of 2012 standardised CPUE series: a) east coast North Island bottom trawl fishery, MIX target series; b) Bay of Plenty bottom trawl fishery, MIX target series; c) East Northland bottom trawl fishery, MIX target series.

4. STANDARDISED CPUE ANALYSIS, TAR 1

Standardised CPUE analyses are presented for three additional fisheries in Appendix J. These fisheries were not used in the stock assessment (Langley & Starr 2012) for reasons presented in Appendix Section J.1, but are included in this report because they are used to monitor the tarakihi populations in this QMA. These fisheries were:

a) **WCNI_BT_MIX–West coast North Island mixed species bottom trawl:** bottom single trawl in statistical areas 041, 042, 045–048, and targeted TAR, SNA, or TRE.

b) **EN_BT_MIX–East Northland mixed species bottom trawl:** bottom single trawl in statistical areas 002–007, and targeted TAR, SNA, TRE, BAR, JDO, or GUR.

c) **BoP_BT_MIX–Bay of Plenty mixed species bottom trawl:** bottom single trawl fishing events in statistical areas 008–010, and targeted TAR, SNA, TRE, BAR, SKI, JDO, or GUR.

Three standardised CPUE models (Table K.2; Figure 25) are used to track the abundance of tarakihi populations in TAR 1 due to the wide and diverse area covered by this QMA as well as there being different trends among the three areas. The WCNI_BT_MIX model showed almost no trend, fluctuating around the long-term mean with fairly wide error bars on the annual indices, indicating that the model is not well determined (Figure 25 [upper left panel]). The East Northland (EN_BT_MIX) series dropped sharply after the first year, which is likely to be due to data issues in the first year of operation (Figure 25 [upper right panel]). After that drop, the series showed a long gradual declining trend from the late 1990s. This decline has now stabilised at about 60% of the long-term mean from 2006–07. Finally the Bay of Plenty (BoP_BT_MIX) series shows no long-term trend, with current levels near to the levels observed at the beginning of the series, interrupted by five years of increased CPUE in the early 2000s (Figure 25 [lower left panel]). The BoP_BT_MIX series very closely resembles the TAR 2_BT_MIX reported in Section 3 (see Figure 24).

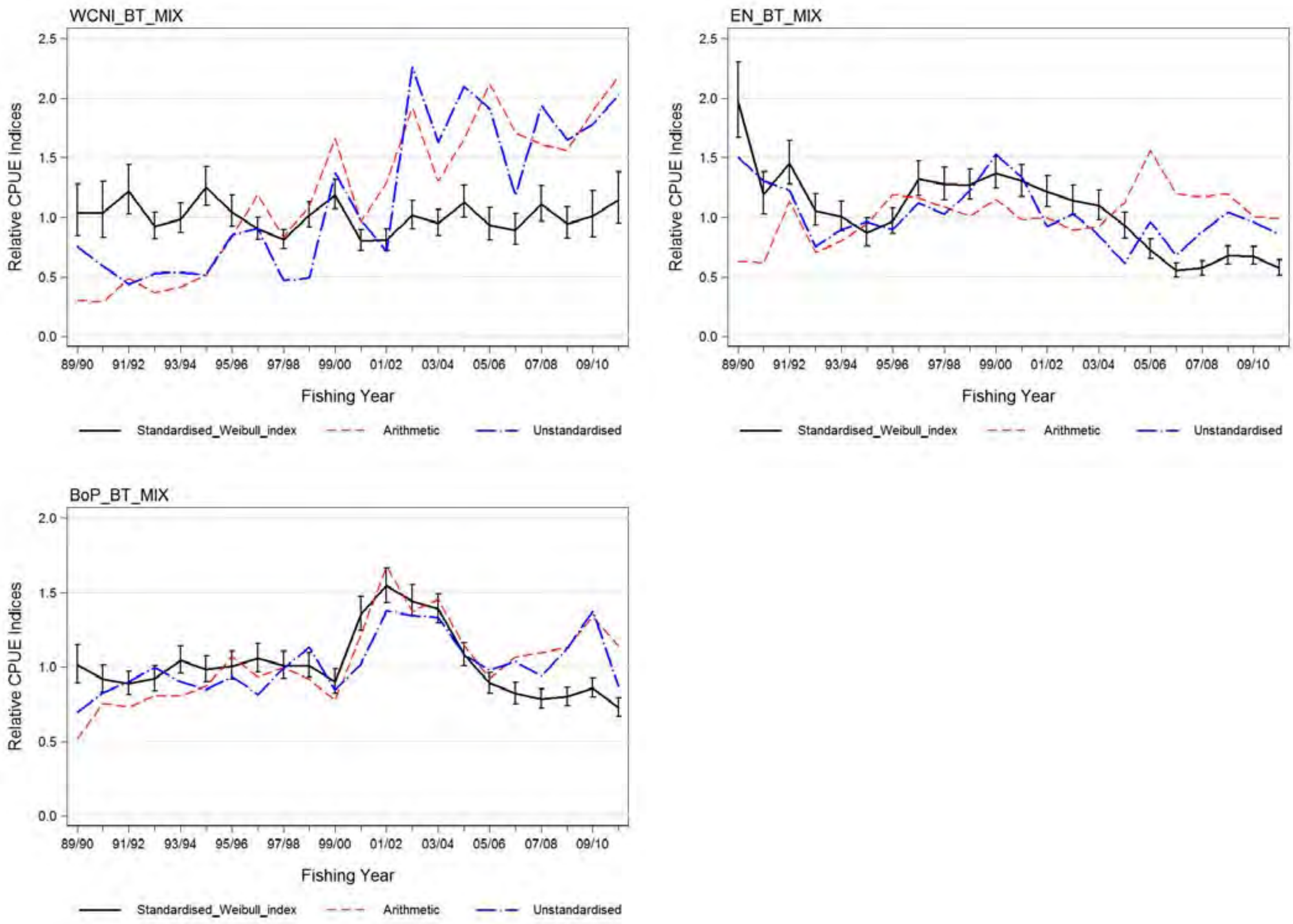

Figure 25: Standardised CPUE models for the three TAR 1 tarakihi data sets: [upper left panel] WCNI_BT_MIX: mixed target species bottom trawl from Areas 041, 042, 045–048; [upper right panel] EN_BT_MIX: mixed target species bottom trawl from Areas 002–007; [lower left panel] BoP_BT_MIX: mixed target species bottom trawl from Areas 008–010. Error bars are ±2*SE. Also shown are two unstandardised series (arithmetic and unstandardised or geometric) using the same data that generated each standardised series.

The three TAR 1 CPUE series were analysed with software which selected the distributional assumption which best fit the available data, instead of always using the Lognormal distribution as was done in previous standardisation analyses (the TAR 2 and TAR 3 series reported in Section 3 were repeated using the same procedure; those results are reported in Section 5 and Appendix L). The methods used for this procedure are described in Appendix Section J.2.2, with the Weibull distribution selected as having the best fit to the data for each dataset (WCNI_BT_MIX: Figure K.12; EN_BT_MIX: Figure K.8; BoP_BT_MIX: Figure K.4) and these results are compared with a series calculated from the same data, but based on the Lognormal distribution (see Figure 26). Figure 26 also compares these two alternative series with previous series (Kendrick 2009) reviewed by the NINSWG for the same three areas. Although the three series based on the Weibull distribution appear to have less year-to-year variability (particularly in the WCNI_BT_MIX series), the general trends are very similar among the two distributional assumptions and these series would be interpreted similarly if used in a stock assessment population model. The correspondence with the earlier series (Kendrick 2009) (labelled '2008' in Figure 26) is relatively poor, particularly for the WCNI_BT_MIX series, even when comparing the two series which use the Lognormal distribution (Figure 26). These divergences are likely to reflect underlying differences in the data and show why it is important to regularly update these analyses.

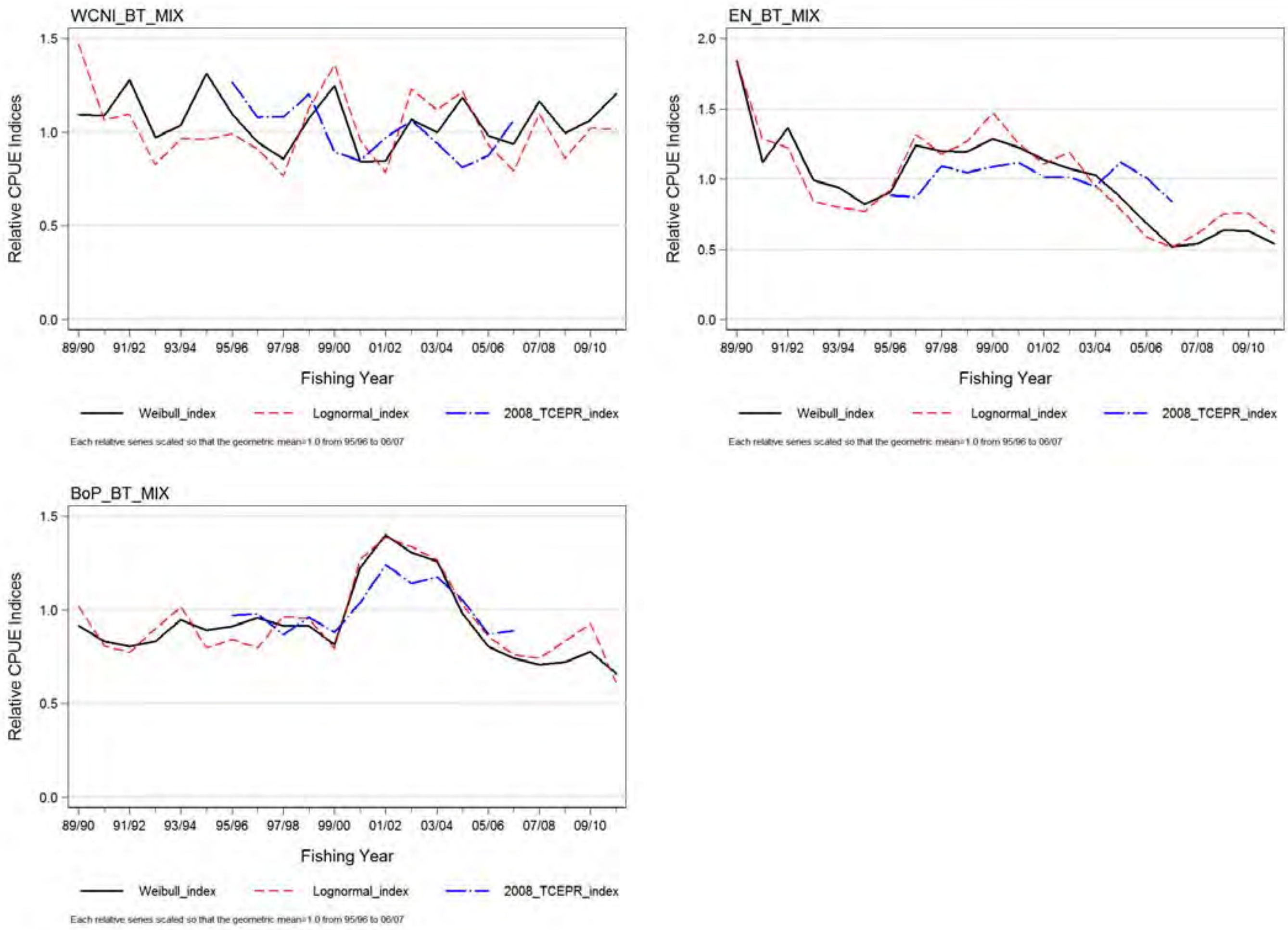

Figure 26: Comparison of previous standardised CPUE analyses (Kendrick 2009) with the series prepared for this report, along with a comparison of the Weibull series with the equivalent Lognormal series: [upper left panel]: West coast North Island bottom trawl; [upper right panel] East Northland bottom trawl; [lower left panel]: Bay of Plenty bottom trawl.

5. ADDITIONAL ANALYSES

Appendix L documents analyses performed to explore the change from a daily formtype (CELR: Ministry of Fisheries 2010) to "event-based" formtypes (primarily TCER and NCELR for the inshore tarakihi fisheries in this report). There have been some disturbing changes in reporting behaviour by fishers associated with this shift in reporting format and there is concern that these shifts have the potential to bias the CPUE trends estimated in the standardisation procedure. None of the analyses reported in Appendix L can definitely rule out this potential for bias. However, there is some evidence in these analyses, particularly the similarity of the "influence" trends (Bentley et al. 2011) with the trend of mean effort per day for each standardisation analysis which suggest that the standardisation procedure is compensating reasonably well for these changes. A comparison of these two measures is made for the three northern New Zealand BT fisheries in Figure L.15 and for the four east coast fisheries in Figure L.16.

The three CPUE series presented in Appendix H were repeated, at the request of the NINSWG, using the "distributional" software that was also used to analyse the three TAR 1 CPUE series, but which was not available when the Appendix H series were initially done. These updated analyses are presented in Appendix L, along with full diagnostics for the two series (TAR 2_BT_MIX and

TAR 3_SN_TAR) which obtained a better fit to the data with the Weibull distributional assumption. The TAR 3_BT_MIX series remained unchanged because it was based on the Lognormal distribution which turned out to be the best fit to the data. The change in distributional assumption had very little effect on the TAR 2_BT_MIX series ([left panel] Figure 27), but the differences between the two distributions for the TAR 3_SN_TAR series is the greatest among the five CPUE series which shifted from the Weibull to the Lognormal distributions (compare [right panel] Figure 27 with the other panel in the same figure and all three panels in Figure 26). While the peak year in the two versions of the TAR 3_SN_TAR series was the same, the preceding year is much lower in the Weibull version and the following years are higher until 2007–08.

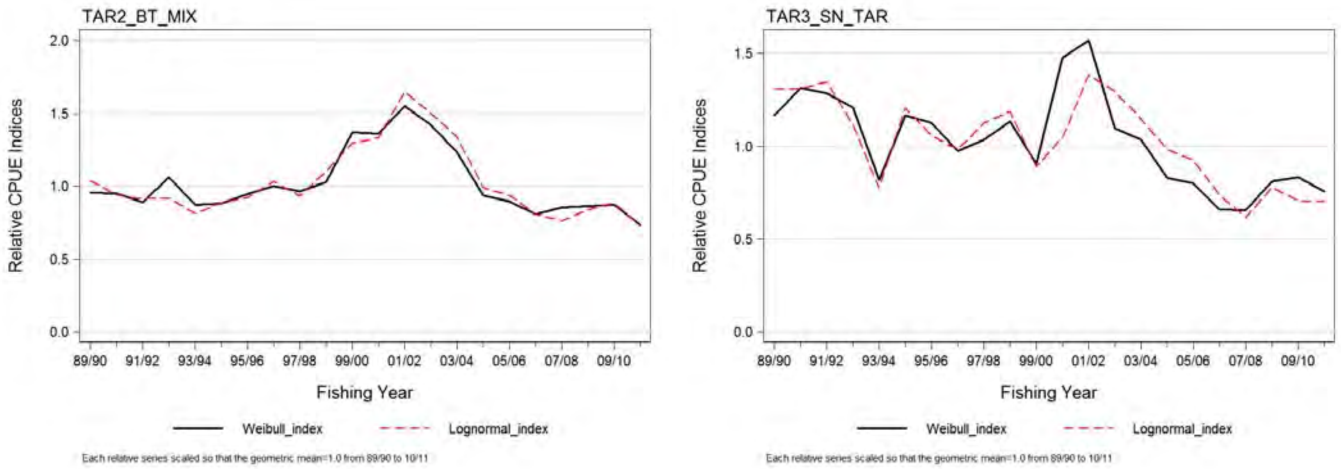

Figure 27: Comparison of standardised CPUE analyses based on the Weibull series with the equivalent Lognormal series: [left panel]: East coast North Island bottom trawl, mixed target species; [right panel] TAR 3 target TAR setnet fishery.

6. ACKNOWLEDGMENTS

This work was funded by MPI Research Project TAR2011/02. We thank the MPI Information and Data Management team for providing the catch/effort data in a timely manner. Members of the Northern Inshore Working Group provided important input and advice through several iterations of the analyses contained in this report.

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Appendix A. GLOSSARY OF ABBREVIATIONS, CODES, AND DEFINITIONS OF TERMS

Table A.1: Table of abbreviations and definitions of terms

Term/Abbreviation	Definition
AIC	Akaike Information Criterion: used to select between different models (lower is better)
AMP	Adaptive Management Programme
analysis dataset	data set available after completion of grooming procedure (Starr 2007)
arithmetic CPUE	Sum of catch/sum of effort, usually summed over a year within the stratum of interest
CDI plot	Coefficient-distribution-influence plot (see Figure I.10 for an example) (Bentley et al. 2011)
CELR	Catch/Effort Landing Return (Ministry of Fisheries 2010): active since July 1989 for all vessels less than 28 m. Fishing events are reported on a daily basis on this form
CLR	Catch Landing Return (Ministry of Fisheries 2010): active since July 1989 for all vessels not using the CELR or NCELR forms to report landings
CPUE	Catch Per Unit Effort
destination code	code indicating how each landing was directed after leaving vessel (see Table 4)
EEZ	Exclusive Economic Zone: marine waters under control of New Zealand
estimated catch	an estimate made by the operator of the vessel of the weight of tarakihi captured, which is then recorded as part of the "fishing event". Only the top 5 species are required for any fishing event in the CELR and TCEPR data (expanded to 8 for the TCER form type)
fishing event	a "fishing event" is a record of activity in trip. It is a day of fishing within a single statistical area, using one method of capture and one declared target species (CELR data) or a unit of fishing effort (usually a tow or a line set) for fishing methods using other reporting forms
fishing year	1 October – 30 September for tarakihi
landing event	weight of tarakihi off-loaded from a vessel at the end of a trip. Every landing has an associated destination code and there can be multiple landing events with the same destination code for a trip
LCER	Lining Catch Effort Return (Ministry of Fisheries 2010): active since October 2003 for lining vessels larger than 28 m and reports set-by-set fishing events
LFR	Licensed Fish Receiver: processors legally allowed to receive commercially caught species
LTCER	Lining Trip Catch Effort Return (Ministry of Fisheries 2010): active since October 2007 for lining vessels between 6 and 28 m and reports individual set-by-set fishing events
MHR	Monthly Harvest Return: monthly returns used after 1 October 2001. Replaced QMRs but have same definition and utility
MPI	New Zealand Ministry for Primary Industries
NCELR	Netting Catch Effort Landing Return (Ministry of Fisheries 2010): active since October 2006 for inshore vessels using setnet gear between 6 and 28 m and reports individual fishing events
NINSWG	Northern Inshore Fisheries Assessment Working Group: MPI Working Group overseeing the work presented in this report
QMA	Quota Management Area: legally defined unit area used for tarakihi management (see Appendix B)
QMR	Quota Management Report: monthly harvest reports submitted by commercial fishermen to MPI. Considered to be best estimates of commercial harvest. In use from 1986 to 2001.
QMS	Quota Management System: name of the management system used in New Zealand to control commercial and non-commercial catches
replog	data extract identifier issued by MPI data unit
residual implied coefficient plots	plots which mimic interaction effects between the year coefficients and a categorical variable by adding the mean of the categorical variable residuals in each fishing year to the year coefficient, creating a plot of the "year effect" for each value of the categorical variable
rollup	a term describing the average number of records per "trip-stratum"
RTWG	MPI Recreational Technical Working Group
standardised CPUE	procedure used to remove the effects of explanatory variables such as vessel, statistical area and month of capture from a data set of catch/effort data for a species; annual abundance is usually modelled as an explanatory variable representing the year of capture and, after removing the effects of the other explanatory variables, the resulting year coefficients represent the relative change in species abundance

Term/Abbreviation	**Definition**
statistical area	sub-areas (Appendix B) within a tarakihi QMA which are identified in catch/effort returns. The boundaries for these statistical areas do not always coincide with the QMA boundaries, leading to ambiguity in the assignment of effort to a QMA.
TACC	Total Allowable Commercial Catch: catch limit set by the Minister responsible for Fisheries for a QMA that applies to commercial fishing
TCEPR	Trawl Catch Effort Processing Return (Ministry of Fisheries 2010): active since July 1989 for deepwater vessels larger than 28 m and reports tow-by-tow fishing events
TCER	Trawl Catch Effort Return (Ministry of Fisheries 2010): active since October 2007 for inshore vessels between 6 and 28 m and reports tow-by-tow fishing events
trip	a unit of fishing activity by a vessel consisting of "fishing events" and "landing events", which are activities assigned to the trip. MPI generates a unique database code to identify each trip, using the trip start and end dates and the vessel code (Ministry of Fisheries 2010)
trip-stratum	summarisation within a trip by fishing method used, the statistical area of occupancy and the declared target species
unstandardised CPUE	geometric mean of all individual CPUE observations, usually summarised over a year within the stratum of interest

Table A.2: Code definitions used in Appendix E, Appendix F, Appendix H, Appendix J and in the body of the main report.

Code	Definition	Code	Description
BLL	Bottom longlining	BAR	Barracouta
BPT	Bottom trawl—pair	BCO	Blue Cod
BS	Beach seine/drag nets	BNS	Bluenose
BT	Bottom trawl—single	BYX	Alfonsino & Long-finned Beryx
CP	Cod potting	ELE	Elephant Fish
DL	Drop/dahn lines	FLA	Flats
DS	Danish seining—single	GSH	Ghost Shark
HL	Handlining	GUR	Gurnard
MW	Midwater trawl—single	HOK	Hoki
RLP	Rock lobster potting	HPB	Hapuku & Bass
SLL	Surface longlining	JDO	John Dory
SN	Set netting (including Gill nets)	JMA	Jack Mackerel
T	Trolling	KIN	Kingfish
TL	Trot lines	LIN	Ling
		MOK	Moki
EN	East Northland	RBY	Ruby Fish
BoP	Bay of Plenty	RCO	Red Cod
ECNI	East Coast North Island	RSN	Red Snapper
ECSI	East Coast South Island	SCH	School Shark
WCNI	West Coast North Island	SCI	Scampi
		SKI	Gemfish
		SNA	Snapper
		SPD	Spiny Dogfish
		SPE	Sea Perch
		SQU	Arrow Squid
		STA	Giant Stargazer
		SWA	Silver Warehou
		TAR	Tarakihi
		TRE	Trevally
		WAR	Blue Warehou

Appendix B. MAP OF MPI STATISTICAL AND MANAGEMENT AREAS

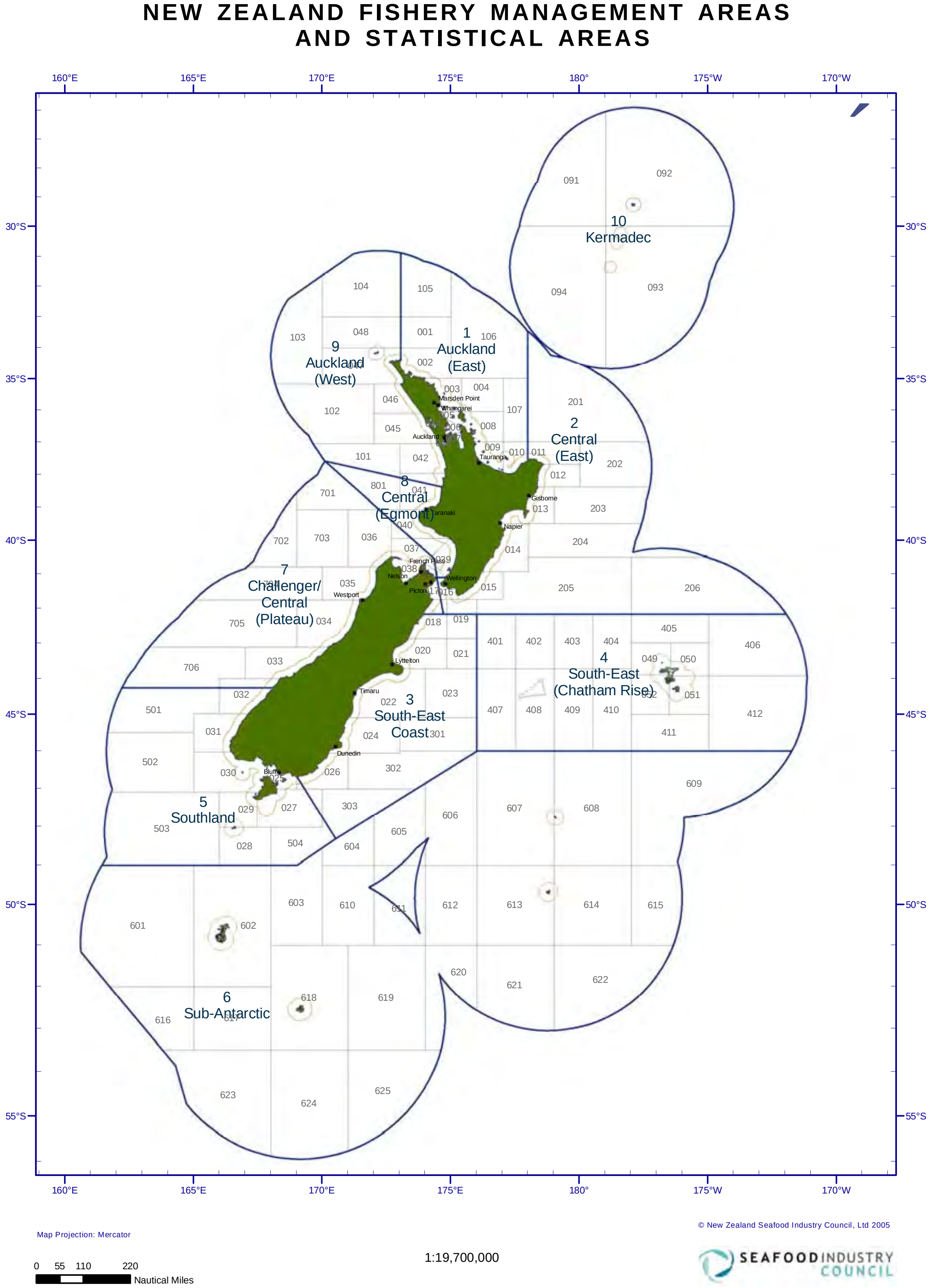


Figure B.1: Map of Ministry for Primary Industries statistical areas and Quota Management Area (QMA) boundaries, showing locations where QMA boundaries are not contiguous with the statistical area boundaries

Appendix C. METHOD USED TO EXCLUDE "OUT-OF-RANGE" LANDINGS

C.1 Introduction

The method previously used to identify "implausibly large" landings used arithmetic CPUE, with the presumption that trips with extremely large arithmetic CPUE values existed because the contributing landings were implausibly large. This method had two major problems: one was that the arithmetic CPUE for mixed-method trips could not be easily calculated and the other was that there was a lot of subjectivity in the process (how does one identify an "implausibly large" arithmetic CPUE?). Dropping "implausibly large" landings is necessary because there often are large landings which are due to data errors (possibly at the data entry step), with landings from single trips occasionally exceeding 100–300 t for some species. These errors can result in substantial deviations from the accepted QMR/MHR catches and affect the credibility of the characterisation and CPUE analyses. The previous method transferred the problem of identifying "implausibly large" landings to identifying unreasonably large CPUE values. A further problem with the procedure was that the CPUE method was difficult to automate, requiring intermediate evaluations.

C.2 Methods

The method use for this new procedure is less subjective and can be automated, evaluating trips with very large landings based on internal evidence within the trip that potentially corroborate the landings. The method proceeds in two steps:

Step 1 Trips with large landings were selected using the empirical distribution of trip landing totals from all trips in the data set (for instance, all trips in the largest 1% quantile in terms of total trip landings);

Step 2 Internal evidence substantiating the landings within each trip was derived from summing the estimated catch for the species in question, as well as summing the "calculated green weight" (=*number_bins*avg_weight_bin*conversion_factor*) (Eq. C.1). The ratio of each these totals is taken with the declared green weight for the trip, with the minimum of the two ratios taken as the "best" validation (Eq. C.2). High values for this ratio (for instance, greater than 9.0 with declared green weight in the numerator) would be evidence that the declared greenweight landing for the trip is not corroborated from the other data available, making the trip a candidate for dropping.

A two-way grid search was implemented for this procedure across a range of empirical quantiles (Step 1) and test ratio values (Step 2). For each pair of values, the "fit" of the annual sum of the landings was evaluated against the QMR/MHR totals, using a least-squares criterion. The pair of "Step 1" and "Step 2" values which gave the lowest SSq^2 was used to select the set of candidate trips to drop because the resulting landings totals would be the closest overall to the QMR/MHR total catch. The search was stopped at a maximum value for the ratio ($rat_{t,s}$: Eq. C.2)=9.0, on the premise that trips where the corroborating evidence was an order of magnitude less than the declared landings were implausible.

C.3 Equations

For every trip, there exist three estimates of total greenweight catch for species *s*:

Eq. C.1

$$G_{t,s}^{d} = \sum_{i=1}^{n_t} gwt_{t,s,i}$$

$$G_{t,s}^{c} = \sum_{i=1}^{n_t} CF_s * W_{t,i} * B_{t,i}$$

$$G_{t,s}^{e} = \sum_{j=1}^{m_t} est_{t,s,j}$$

where $G^d_{t,s}$ = sum of declared greenweight (*gwt*) for trip t over all n_t landing records;

$G^c_{t,s}$ = sum of calculated greenweight for trip t over all n_t landing records, using conversion factor CF_s, weight of bin $W_{t,i}$ and number of bins $B_{t,i}$;

$G^e_{t,s}$ = sum of estimated catch (*est*) for trip t over all m_t effort records.

Assuming that $G^d_{t,s}$ is the best available estimate of the total landings of species s for trip t, calculate the following ratios:

Eq. C.2
$$r1_{t,s} = G^d_{t,s} \big/ G^c_{t,s}$$
$$r2_{t,s} = G^d_{t,s} \big/ G^e_{t,s}$$
$$rat_{t,s} = \min(r1_{t,s}, r2_{t,s})$$

where $G^d_{t,s}$, $G^c_{t,s}$ and $G^e_{t,s}$ are defined in Eq. C.1, and ignoring $r1_{t,s}$ or $r2_{t,s}$ if missing when calculating $rat_{t,s}$.

The ratio $rat_{t,s}$ can be considered the “best available information” to corroborate the landings declared in the total $G^d_{t,s}$, with ratios exceeding a threshold value (e.g. $rat_{t,s} > 9.0$) considered to be uncorroborated. This criterion can be applied to a set of trips selected using a quantile of the empirical distribution of total trip greenweights. The set of trips to drop was selected on the basis of the pair of criteria (quantile and ratio threshold) which gave the lowest SSq^2 (Eq. C.3) relative to the annual QMR/MHR totals.

Eq. C.3
$$gg^z_y = \sum_1^{p^z_y} L^z_y$$
$$Ssq^z = \sum_{y=89/90}^{y=10/11} \left(gg^z_y - MHR_y \right)^2$$

where p^z_y is the number landing records in year y for iteration z (i.e.: a combination of a ratio threshold criterion with an empirical quantile cut-off criterion);

L^z_y is a landing record included in year y for iteration z.

MHR_y is the corresponding MHR/QMR landing total for (TAR 1 or TAR 2 or TAR 3) in year y.

C.4 Results

This approach conservatively dropped 12 trips from the combined TAR 1 (3 trips for 393 t), TAR 2 (5 trips for 497 t) and TAR 3 (4 trips for 163 t) landing data set (Table C.1). There were a total of 183 000 trips in the combined data set, but these 12 dropped trips accounted for 1053 t of landings with two trips each having more than 300 t of landings. The total landings from these three QMAs in this data set was about 89 000 t (after dropping the 12 trips), but the presence of the two trips with very large landings is quite noticeable in the “raw landings” plots for TAR 1 and TAR 2 (Figure C.1).

Table C.1: Results from a search over two parameters defined above: A) a quantile cut-off which selected the set of large landings over which to search and B) the ratio (Eq. C.2) defining the maximum criterion for accepting a landing. The quantile/ratio pair with the lowest *Ssq*^{2} (Eq. C.3) is highlighted in colour (maximum ratio accepted=9.0 and quantile cut-off=97%).

	Minimum ratio cut-off						Minimum ratio cut-off					
Quantile	4	5	6	7	8	9	4	5	6	7	8	9
cut-off:	TAR 1: Number trips dropped						TAR 1: Least squares fit to the QMR/MHR					
97	14	12	12	10	9	9	60 539	60 592	60 592	58 385	58 381	58 381
98	13	11	11	9	8	8	60 507	60 560	60 560	58 353	58 350	58 350
99	13	11	11	9	8	8	60 507	60 560	60 560	58 353	58 350	58 350
99.5	11	10	10	8	7	7	60 526	60 527	60 527	58 320	58 469	58 469
99.9	8	7	7	5	5	5	57 116	57 123	57 123	54 917	54 917	54 917
99.99	4	4	4	**3**	3	3	49 807	49 807	49 807	**47 633**	47 633	47 633
TAR2	TAR 2: Number trips dropped						TAR 2: Least squares fit to the QMR/MHR					
97	13	12	11	10	10	9	84 690	85 267	85 215	84 548	84 548	84 306
98	13	12	11	10	10	9	84 690	85 267	85 215	84 548	84 548	84 306
99	13	12	11	10	10	9	84 690	85 267	85 215	84 548	84 548	84 306
99.5	11	10	9	8	8	8	81 468	82 044	81 992	81 325	81 325	81 325
99.9	8	7	6	6	6	**5**	78 920	79 496	79 444	79 444	79 444	**78 777**
99.99	4	4	3	3	3	3	78 927	78 927	78 916	78 916	78 916	78 916
TAR3	TAR 3: Number trips dropped						TAR 3: Least squares fit to the QMR/MHR					
97	16	16	14	14	13	13	54 899	54 899	56 035	56 035	54 624	54 624
98	15	15	13	13	12	12	54 897	54 897	56 033	56 033	54 622	54 622
99	13	13	12	12	11	11	54 440	54 440	55 667	55 667	54 256	54 256
99.5	12	12	11	11	10	10	54 520	54 520	55 747	55 747	54 336	54 336
99.9	9	9	8	8	7	7	53 097	53 097	54 323	54 323	52 912	52 912
99.99	4	**4**	3	3	3	3	50 888	**50 888**	53 330	53 330	53 330	53 330

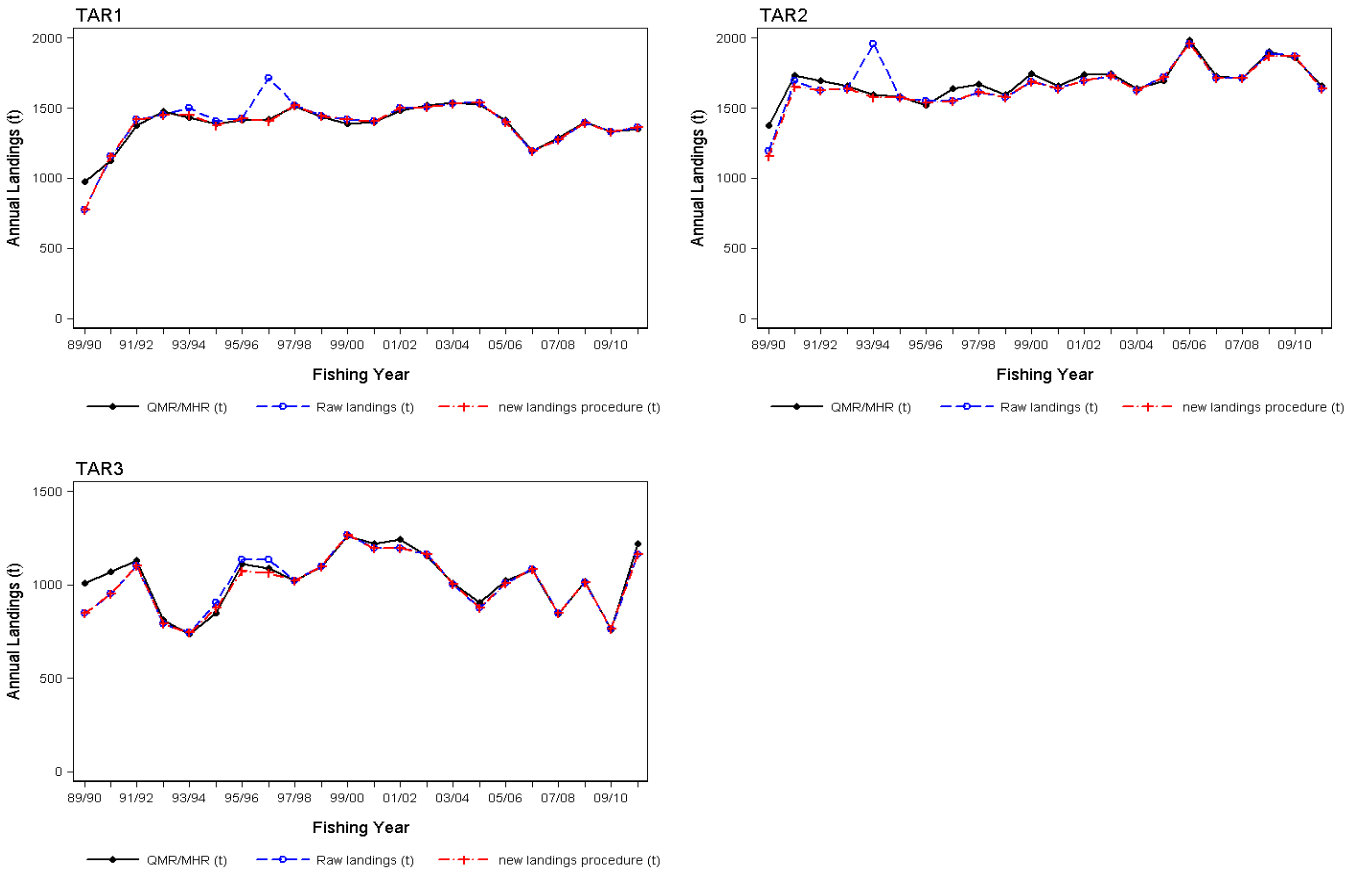


Figure C.1: Comparison of QMR/MHR annual total landings for TAR 1, TAR 2, and TAR 3 with two extracts A: total or "raw" landings; B: "best" fit after dropping landings identified using the two-way search algorithm described in Table C.1 using data provided by MPI data extract replog 8360.

Appendix D. COMPARISON BY STATISTICAL AREA OF TWO DATA PREPARATION METHODS

This appendix compares TAR 1, TAR 2 and TAR 3 landings by statistical area from data sets prepared in two ways:

1. "Fishstock expansion": uses the method of Starr (2007) where trips are dropped which fished in statistical areas valid for more than one Fishstock and which declared more than one Fishstock in the landing data;
2. "Statistical area expansion": scales all estimated catches by statistical area within a trip by the total trip landings, without reference to the Fishstock of capture.

Table D.1 provides a measure of how much data are lost as a consequence of dropping trips which fished in ambiguous statistical areas and landed to multiple TAR Fishstocks. The "Fishstock expansion" procedure is necessary to provide Fishstock-specific advice because catches using the "Statistical Area expansion" procedure will potentially contain catches from multiple Fishstocks. The latter procedure retains landings from ambiguous statistical areas, but the capacity to trace the landings to specific Fishstocks has been lost.

Approximately 5300 t are dropped when using the "Fishstock expansion" method compared to "Statistical area expansion" method, comprising about 6% of the total valid landings in the dataset (Table D.1). Statistical areas 017, 018, and 016, all in eastern Cook Strait (Appendix B), account for 60% of the dropped landings. This is because the boundaries of these three statistical areas encompass three QMAs and there is considerable opportunity for ambiguity in the assignment of QMA-specific catches. The problem is especially acute in Area 017, where over 90% of the landings are discarded by the "Fishstock expansion" method. Consequently, the "Statistical area" expansion method was used for the analyses presented in this report.

Table D.1: Total catch (1989–90 to 2010–11) by statistical area, comparing the "Fishstock expansion" data preparation procedure with the catch resulting from the "Statistical Area expansion" preparation procedure (described above), sorted in descending order of dropped landings. Only statistical areas valid for the TAR 1, TAR 2, and TAR 3 characterisation analyses are shown. Statistical areas where more than 40% of the total (1989–90 to 2010–11) landings have been dropped using the "Fishstock expansion" method are indicated with coloured cells.

Statistical Area	Statistical area expansion	Fishstock expansion	Difference (t)	Difference (%)
017	1 651.2	112.2	1 539.0	-93%
018	8 017.9	6 864.8	1 153.1	-14%
016	1 932.0	1 443.2	488.8	-25%
041	579.8	109.5	470.3	-81%
002	3 702.4	3 325.7	376.7	-10%
015	1 854.6	1 533.5	321.1	-17%
020	5 536.7	5 352.9	183.8	-3%
011	6 641.4	6 500.9	140.5	-2%
012	8 510.3	8 405.3	105.0	-1%
042	436.4	334.0	102.4	-23%
013	11 846.3	11 755.0	91.3	-1%
014	4 957.1	4 873.4	83.7	-2%
001	371.0	296.2	74.8	-20%
022	7 125.5	7 051.7	73.8	-1%
003	2 713.1	2 655.1	58.0	-2%
046	1 568.6	1 541.6	27.0	-2%
024	1 581.5	1 556.7	24.8	-2%
045	1 167.1	1 148.2	18.9	-2%
047	4 514.1	4 500.9	13.2	0%

Table D.1 (cont.):

Statistical Area	Statistical area expansion	Fishstock expansion	Difference (t)	Difference (%)
008	2 142.4	2 135.4	7.0	0%
021	61.7	55.5	6.2	-10%
026	333.0	327.0	6.0	-2%
044	8.0	2.5	5.5	-69%
048	71.5	67.3	4.2	-6%
106	20.5	16.4	4.1	-20%
019	9.9	6.4	3.5	-35%
103	3.0	0.1	2.9	-97%
201	3.5	0.6	2.9	-83%
007	36.5	34.9	1.6	-4%
205	1.6	0.7	0.9	-56%
005	469.0	468.1	0.9	0%
202	0.8	0.0	0.8	-100%
101	5.3	4.6	0.7	-13%
107	3.6	2.9	0.7	-19%
204	14.6	14.1	0.5	-3%
006	68.3	68.0	0.3	0%
203	1.2	1.1	0.1	-8%
023	26.9	26.8	0.1	0%
043	5.1	5.1	0.0	0%
102	1.0	1.0	0.0	0%
104	4.1	4.1	0.0	0%
105	0.7	0.7	0.0	0%
206	0.0	0.0	0.0	–
301	0.0	0.0	0.0	–
302	6.1	6.1	0.0	0%
303	0.0	0.0	0.0	–
004	488.2	489.4	- 1.2	0%
009	5 477.4	5 502.4	- 25.0	0%
010	6 828.7	6 863.5	- 34.8	1%
Total	90 799.6	85 465.5	5 334.1	-6%

Appendix E. DATA SUMMARIES BY MAJOR AREA AND TOTAL, ALL AREAS: COMBINED TAR 1, TAR 2, AND TAR 3

Table E.1: Statistical areas for each of the five major areas selected for the combined TAR 1, TAR 2 and TAR 3 characterisation and the total across all areas, showing each statistical area in descending rank order of total landings and the number (N) of trip stratum records over the period 1989–90 to 2010–11. The statistical areas shaded in grey have been combined into a "plus" category for graphical and tabular presentation. '0': <0.5 t of total landings.

	East Northland			Bay of Plenty			East coast, North Island			East coast, South Island			West coast, North Island			Total, all areas		
Rank order	Stat. Area	N(trip strata)	Land-ings (t)	Stat. Area	N(trip strata)	Land-ings (t)	Stat. Area	N(trip strata)	Land-ings (t)	Stat. Area	N(trip strata)	Land-ings (t)	Stat. Area	N(trip strata)	Land-ings (t)	Stat. Area	N(trip strata)	Land-ings (t)
1	002	23 040	3 702	010	12 371	6 829	013	20 576	11 846	018	37 129	8 018	047	10 102	4 514	013	20 576	11 846
2	003	25 909	2 713	009	22 512	5 477	012	7 199	8 510	022	19 050	7 126	046	4 133	1 569	012	7 199	8 510
3	004	2 154	488	008	17 906	2 142	011	5 020	6 641	020	12 416	5 537	045	5 473	1 167	018	37 129	8 018
4	005	13 448	469	107	64	4	014	11 707	4 957	017	2 642	1 651	041	1 711	580	022	19 050	7 126
5	001	1 961	371				016	8 489	1 932	024	14 967	1 581	042	4 247	436	010	12 371	6 829
6	006	4 762	68				015	4 621	1 855	026	3 832	333	048	518	72	011	5 020	6 641
7	007	912	37				204	613	15	021	687	62	044	53	8	020	12 416	5 537
8	106	218	21				201	90	4	025	476	34	101	52	5	009	22 512	5 477
9	105	13	1				205	46	2	023	547	27	043	46	5	014	11 707	4 957
10							203	24	1	027	749	11	104	15	4	047	10 102	4 514
11							202	6	1	019	278	10	103	36	3	002	23 040	3 702
12							206	2	0	302	19	6	102	12	1	003	25 909	2 713
13										303	11	0				008	17 906	2 142
14										301	10	0				016	8 489	1 932
15																015	4 621	1 855
16																017	2 642	1 651
17																024	14 967	1 581
18																046	4 133	1 569
19																045	5 473	1 167
20																041	1 711	580
21																004	2 154	488
22																005	13 448	469
23																042	4 247	436
24																001	1 961	371
25																026	3 832	333
Plus																Plus	10 259	402
Total		72 417	7 870		52 853	14 452		58 393	35 763		92 813	24 395		26 398	8 364		302 874	90 845

Table E.2: Method of capture for each of the five major areas selected for the TAR 1, TAR 2 and TAR 3 characterisation and the total across all areas, showing each method in descending rank order of total landings and the number (N) of trip stratum records over the period 1989–90 to 2010–11. The methods shaded in grey have been combined into a "plus" category for graphical and tabular presentation. Pink cells reference methods for which the ranked target species by major area are reported in Table E.3 (bottom trawl capture method) and Table E.4 (mixed second and third ranked methods).'0': <0.5 t of total landings; definitions of codes used in this table can be found in Appendix A.

	East Northland			Bay of Plenty			East coast, North Island			East coast, South Island			West coast, North Island			Total, all areas		
Rank order	Method	N(trip strata)	Landings (t)	Method	N(trip strata)	Landings (t)	Method	N(trip strata)	Landings (t)	Method	N(trip strata)	Landings (t)	Method	N(trip strata)	Landings (t)	Method	N(trip strata)	Landings (t)
1	BT	23 003	5 929	BT	27 054	12 983	BT	46 459	35 421	BT	54 539	17 979	BT	17 459	7 330	BT	168 514	79 642
2	BLL	40 064	1 507	DS	4 359	580	SN	3 556	123	SN	30 300	5 926	BPT	3 055	630	SN	44 236	6 734
3	BPT	1 336	194	SN	5 072	553	BLL	4 224	92	DS	432	455	BLL	2 474	192	BLL	61 254	2 098
4	DS	1 699	104	BLL	13 723	300	DS	302	88	MW	1 610	16	DS	380	98	DS	7 172	1 325
5	SN	3 766	94	BPT	336	26	MW	2 634	22	CP	1 795	9	SN	1 542	39	BPT	4 743	852
6	TL	278	29	HL	1 252	4	T	290	8	BLL	769	8	HL	327	25	MW	4 650	61
7	DL	473	6	TL	47	2	DL	384	4	RLP	1 926	1	MW	269	21	TL	457	35
8	HL	1 054	3	DL	258	1	BPT	12	1	DL	1 253	0	DL	227	14	HL	2 911	33
9	SLL	190	2	T	329	1	SLL	34	1	T	25	0	RLP	393	8	DL	2 595	26
10	T	223	1	MW	99	1	BS	1	1	BPT	4	0	TL	51	3	CP	1 879	12
11	BS	13	1	RLP	302	0	TL	54	1	TL	27	0	CP	29	3	RLP	3 146	11
12	RLP	257	1	BS	4	0	HL	145	1	HL	133	0	SLL	28	0	T	1 030	10
13	MW	38	0	SLL	16	0	RLP	268	0				T	163	0	SLL	268	4
14	CP	23	0	CP	2	0	CP	30	0				BS	1	0	BS	19	2
Total		72 417	7 870		52 853	14 452		58 393	35 763		92 813	24 395		26 398	8 364		302 874	90 845

Table E.3: Target species for the bottom trawl method of capture for each of the five major areas selected for the TAR 1, TAR 2 and TAR 3 characterisation, showing each target species in descending rank order of total landings and the number (N) of trip stratum records over the period 1989–90 to 2010–11. This list has been truncated at 5 tonnes in each major area, with the lesser species not reported. The target species shaded in grey have been combined into a "plus" category for graphical and tabular presentation (as well as the unlisted species where <5 t was taken). '0': <0.5 t of total landings.

	East Northland			Bay of Plenty			East coast, North Island			East coast, South Island			West coast, North Island		
Rank order	Target species	N(trip strata)	Landings (t)	Target species	N(trip strata)	Landings (t)	Target species	N(trip strata)	Landings (t)	Target species	N(trip strata)	Landings (t)	Target species	N(trip strata)	Landings (t)
1	TAR	3 798	3 977	TAR	8 481	10 219	TAR	19 397	29 748	TAR	6 374	7 788	TAR	3 721	5 322
2	SNA	8 457	661	SNA	6 181	878	GUR	11 146	2 166	RCO	16 975	4 991	SNA	5 037	687
3	JDO	5 694	425	TRE	4 021	497	SKI	2 702	1 091	BAR	5 598	2 101	TRE	4 456	507
4	SKI	716	343	SKI	1 467	447	WAR	2 311	623	FLA	12 149	1 334	BAR	614	221
5	TRE	1 553	204	HOK	1 287	240	HOK	2 495	584	SQU	2 721	445	GUR	2 160	200
6	BAR	383	83	BAR	968	224	BAR	1 082	488	WAR	1 077	304	JMA	65	161
7	GUR	1 443	65	GUR	1 343	202	SNA	1 530	277	HOK	2 950	188	SKI	617	109
8	RCO	165	56	JDO	1 628	167	TRE	841	131	SPE	1 193	178	SCH	106	28
9	HOK	151	31	RBY	161	45	JDO	469	85	STA	697	134	SWA	84	24
10	SCI	113	23	LIN	336	16	MOK	202	70	SPD	485	104	JDO	134	19
11	SWA	82	11	SCI	341	11	FLA	1 643	44	GUR	663	87	SQU	32	18
12	RBY	44	10	SWA	73	7	SWA	142	36	ELE	858	79	HOK	56	11
13	RSN	20	9				RCO	121	22	SKI	209	59	LIN	172	6
14	LIN	64	9				RBY	165	18	SWA	661	41			
15	SQU	23	6				BYX	302	9	GSH	224	31			
16	FLA	52	5				LIN	233	8	JMA	119	24			
17										BCO	95	22			
18										LIN	429	19			
19										TRE	20	12			
20										SCH	49	8			
21										HPB	103	7			
Total		23 003	5 929		27 054	12 983		46 459	35 421		54 539	17 979		17 459	7 330

Table E.4: Target species for the second and third methods of capture (in rank order of total landings by method: see C) for each of the five major areas selected for the TAR 1, TAR 2 and TAR 3 characterisation, showing each target species in descending rank order of total landings and the number (N) of trip stratum records over the period 1989–90 to 2010–11. This list has been truncated at 5 tonnes per major area, with the lesser species not reported. The target species shaded in grey have been combined into a “plus” category for graphical and tabular presentation (as well as the unlisted species where <5 t was taken). ‘0’: <0.5 t of total landings.

	East Northland			Bay of Plenty			East coast, North Island			East coast, South Island			West coast, North Island		
Rank order	Target species	N(trip strata)	Landings (t)	Target species	N(trip strata)	Landings (t)	Target species	N(trip strata)	Landings (t)	Target species	N(trip strata)	Landings (t)	Target species	N(trip strata)	Landings (t)
Method	**BLL**			**DS**						**SN**			**BPT**		
1	SNA	35 520	1 302	SNA	2 684	267				TAR	13 828	5 519	TAR	419	388
2	HPB	1 745	81	TAR	409	201				LIN	5 201	140	TRE	1 435	124
3	TAR	400	74	GUR	1 057	100				SPD	2 675	124	SNA	889	85
4	BNS	1 169	17	TRE	59	5				SPO	2 948	39	BAR	70	17
5	GUR	482	13							HPB	2 123	36	GUR	185	15
6	RSN	191	10							BNS	631	21			
7										WAR	749	20			
8										SCH	1 271	9			
9										RCO	120	8			
10										MOK	442	5			
Total		**40 064**	**1 507**		**4 359**	**580**					**30 300**	**5 926**		**3 055**	**630**
Method				**SN**						**DS**					
1				TAR	1 758	461				TAR	187	423			
2				TRE	1 337	33				RCO	157	27			
3				SNA	749	15									
4				SKI	70	10									
5				KIN	135	7									
6				WAR	144	6									
7				HOK	32	6									
Total					**5 072**	**553**					**432**	**455**			

Appendix F. MONTHLY SUMMARIES BY MAJOR AREA AND METHOD OF CAPTURE

Table F.1: Distribution of landings (%) by month and fishing year for bottom trawl in the five defined major areas based on trips which landed tarakihi. The final column gives the annual total landings for bottom trawl in each major area. These values are plotted in Figure 13.

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
												Month	
EN													
89/90	3.3	2.1	3.2	3.4	3.4	10.4	6.3	17.7	11.3	11.8	7.0	19.8	196
90/91	10.1	3.6	2.9	3.1	6.2	5.9	12.9	22.3	9.7	9.9	5.8	7.7	277
91/92	5.1	2.4	3.2	2.3	6.2	6.8	28.4	20.7	12.4	2.4	4.0	6.2	369
92/93	4.4	4.6	1.8	0.7	2.6	3.5	26.5	17.0	14.5	14.4	5.0	4.9	284
93/94	12.9	5.3	3.5	3.4	5.6	10.9	17.8	12.8	13.6	5.0	5.0	4.3	353
94/95	5.5	12.2	5.2	2.7	4.1	5.7	14.3	18.7	9.9	5.8	4.3	11.5	306
95/96	4.4	4.1	2.1	2.3	3.6	7.2	9.5	27.5	12.2	9.8	9.7	7.6	316
96/97	7.7	5.1	6.0	6.1	4.3	8.4	14.2	13.3	15.0	6.7	3.7	9.4	409
97/98	4.0	4.7	4.2	5.0	5.7	11.6	16.9	12.0	11.0	6.7	10.3	8.0	374
98/99	8.7	6.0	9.2	3.4	1.9	4.9	7.2	18.5	11.4	11.0	8.7	9.2	281
99/00	9.1	6.1	5.5	3.4	4.6	7.6	13.5	14.1	10.6	5.7	7.7	12.1	315
00/01	13.8	4.0	5.7	8.7	6.4	3.7	4.9	7.8	13.5	8.8	14.3	8.4	243
01/02	4.4	9.7	5.2	8.6	2.6	3.5	8.5	19.6	18.6	7.3	7.7	4.2	256
02/03	8.2	6.2	8.1	4.1	7.1	14.2	3.2	5.8	9.7	12.8	11.6	9.1	133
03/04	5.1	5.0	4.3	3.6	8.3	7.2	14.9	6.6	12.9	9.8	12.2	10.0	175
04/05	1.4	2.6	9.7	13.3	1.8	1.7	24.5	22.4	10.5	2.9	5.8	3.4	331
05/06	5.9	12.7	7.4	8.4	10.8	13.8	13.1	6.7	3.4	4.0	6.8	7.0	358
06/07	7.0	10.9	7.5	13.8	12.2	6.5	7.4	13.2	3.7	3.4	8.5	5.8	226
07/08	5.1	7.2	6.6	5.7	19.0	12.1	8.0	16.3	5.3	5.7	4.5	4.4	186
08/09	8.5	11.7	11.6	2.2	4.0	12.7	7.9	10.7	13.0	6.1	7.6	4.1	199
09/10	4.9	9.9	14.1	4.5	1.3	3.0	5.8	9.7	14.0	19.8	7.8	5.1	167
10/11	5.1	13.8	3.6	1.0	10.6	7.1	8.1	6.3	18.1	7.3	10.2	8.9	177
Mean	6.6	6.5	5.7	5.1	5.7	7.6	13.7	15.2	11.5	7.5	7.3	7.7	5 929
BOP													
89/90	0.3	2.2	4.3	7.4	3.8	2.7	4.7	19.6	16.6	14.9	8.7	14.8	289
90/91	2.4	4.8	4.0	3.7	5.8	9.2	16.0	19.2	5.2	15.4	7.1	7.4	511
91/92	2.7	4.7	5.0	3.2	3.1	9.3	20.0	10.8	18.0	6.2	7.4	9.7	633
92/93	9.1	7.2	3.3	4.0	6.0	10.2	17.6	21.6	6.5	7.1	4.9	2.7	630
93/94	5.2	6.4	7.2	7.3	8.9	16.0	16.9	11.7	8.4	3.5	4.6	4.1	638
94/95	3.4	4.1	4.3	5.4	4.8	12.6	11.1	20.6	8.2	6.3	9.6	9.7	530
95/96	6.9	6.7	2.8	3.9	8.4	10.3	14.8	23.2	7.7	4.0	3.8	7.5	544
96/97	5.1	6.3	3.8	7.3	12.3	13.5	12.9	12.1	8.0	8.5	6.1	4.2	488
97/98	5.2	5.2	5.5	7.4	7.4	14.4	18.7	18.2	6.1	3.8	3.3	5.0	540
98/99	2.8	9.8	8.5	7.8	4.7	13.3	8.1	18.7	8.8	6.9	6.7	3.9	515
99/00	7.6	10.3	5.1	3.4	10.3	14.8	14.3	15.8	6.3	3.1	4.6	4.3	397
00/01	8.3	6.8	8.5	5.3	5.7	18.0	16.1	9.9	6.9	6.8	4.6	3.1	613
01/02	5.9	7.4	2.9	9.8	12.5	10.7	14.8	12.2	9.0	5.9	3.4	5.4	734
02/03	7.5	8.5	5.2	6.7	9.1	11.4	12.5	13.7	10.7	3.4	5.3	5.9	789
03/04	7.0	7.4	6.8	6.2	7.0	14.8	15.5	11.2	9.4	4.9	5.4	4.5	852
04/05	5.1	8.7	3.9	9.1	8.7	11.2	14.9	18.8	8.9	3.8	4.5	2.2	706
05/06	3.7	6.7	6.3	7.1	6.7	11.1	22.7	20.1	5.6	3.3	3.2	3.6	621
06/07	4.4	8.1	8.4	2.9	2.6	14.9	17.7	22.3	5.2	3.9	4.7	5.0	507
07/08	3.7	7.5	5.2	4.4	7.1	11.7	20.1	13.0	11.4	4.8	3.9	7.1	500
08/09	5.2	4.9	4.8	3.3	4.2	13.4	16.5	13.8	11.6	7.0	7.0	8.3	645
09/10	5.1	5.1	6.9	4.5	6.4	14.3	18.0	13.1	10.1	6.0	5.6	5.0	700
10/11	7.1	7.9	3.2	3.2	9.2	17.7	20.2	11.0	7.2	3.5	5.1	4.7	602
Mean	5.4	6.8	5.3	5.7	7.1	12.7	16.0	15.6	8.9	5.7	5.3	5.6	12 983

Table F.1: (cont.)

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
												Month	
ECNI													
89/90	3.9	7.2	7.5	8.3	10.8	8.7	6.4	3.9	10.3	8.2	8.3	16.6	1 153
90/91	11.5	9.7	4.6	4.7	7.5	8.1	10.7	10.9	4.0	14.4	3.7	10.0	1 636
91/92	9.1	8.9	5.4	4.8	10.2	17.1	9.0	6.3	10.0	8.6	4.6	6.1	1 600
92/93	13.8	12.0	7.2	4.9	8.4	19.9	5.5	6.3	6.6	7.6	4.1	3.7	1 602
93/94	12.6	13.0	7.4	8.6	9.2	10.6	7.8	3.8	6.7	3.9	9.9	6.6	1 428
94/95	9.5	14.1	9.5	7.6	10.8	9.1	6.5	6.9	8.0	6.1	2.7	9.3	1 476
95/96	10.9	12.0	7.3	6.0	7.7	9.1	7.3	7.0	7.3	7.3	6.1	11.8	1 438
96/97	9.6	12.5	7.9	8.4	7.9	7.5	9.0	7.7	4.9	8.4	6.1	10.1	1 431
97/98	14.7	12.0	5.7	5.7	7.9	11.2	6.5	8.2	7.3	6.3	6.3	8.3	1 521
98/99	9.1	13.0	9.2	3.6	7.2	9.1	7.4	7.9	9.1	8.9	5.8	9.6	1 562
99/00	7.7	10.7	9.5	4.3	8.9	10.0	7.6	11.8	6.9	5.2	9.7	7.7	1 704
00/01	12.4	6.3	5.6	6.9	8.4	8.5	8.6	8.0	6.4	12.0	9.0	7.9	1 600
01/02	8.0	8.5	5.8	6.4	5.1	6.6	8.6	9.1	11.8	9.4	10.2	10.6	1 690
02/03	9.2	10.6	9.8	6.5	6.1	8.1	6.1	7.6	8.3	9.5	7.4	10.8	1 725
03/04	9.9	8.2	9.7	4.7	6.7	9.7	5.2	5.3	9.9	10.2	10.1	10.4	1 602
04/05	10.2	9.4	6.5	6.8	6.7	10.4	5.4	5.1	7.2	9.2	12.2	11.0	1 665
05/06	7.1	7.7	7.5	4.9	7.6	9.1	7.5	8.1	9.8	9.3	11.4	10.0	1 937
06/07	7.6	6.3	4.2	8.7	10.3	10.7	10.3	9.3	8.1	11.8	6.8	5.8	1 674
07/08	7.7	9.9	6.5	4.4	7.8	10.5	9.0	8.6	10.0	6.7	6.4	12.4	1 676
08/09	8.2	9.0	6.1	7.0	8.2	9.4	5.3	7.7	12.3	10.5	6.2	10.1	1 845
09/10	12.9	10.3	6.8	4.5	6.5	11.3	6.3	6.0	10.5	8.7	8.8	7.4	1 843
10/11	14.1	14.0	5.6	4.9	7.5	7.1	8.7	6.8	9.2	6.6	10.0	5.5	1 614
Mean	10.0	10.2	7.0	6.0	8.0	10.1	7.5	7.5	8.5	8.7	7.6	9.1	35 421
ECSI													
89/90	1.7	2.2	4.1	6.8	17.3	14.8	8.8	9.5	4.2	14.9	12.1	3.5	589
90/91	5.8	5.5	3.5	12.2	19.8	18.7	14.1	9.6	2.8	3.5	2.3	2.2	640
91/92	6.1	8.0	9.2	11.5	9.6	8.9	20.5	6.5	4.1	6.9	5.8	2.9	777
92/93	2.0	9.5	8.6	7.5	22.8	13.5	11.5	10.0	4.0	4.3	1.6	4.6	476
93/94	4.1	6.9	3.6	5.9	13.1	9.1	7.7	13.8	9.1	8.3	10.2	8.2	505
94/95	1.8	5.5	7.7	18.4	15.8	9.9	11.0	6.3	5.6	2.4	11.2	4.3	588
95/96	3.8	4.4	4.4	7.2	17.7	17.1	12.0	6.8	13.5	5.8	3.2	4.3	791
96/97	3.3	10.3	7.7	12.5	9.2	7.9	7.9	16.6	9.3	7.6	3.4	4.4	872
97/98	4.7	9.4	5.2	10.0	10.4	11.2	6.6	9.2	6.0	4.7	14.3	8.2	854
98/99	2.1	2.7	4.2	8.1	12.9	11.2	9.8	9.4	7.4	6.3	13.0	12.9	995
99/00	3.0	5.7	9.5	14.1	15.0	15.8	11.1	9.3	5.7	4.2	2.3	4.4	1 165
00/01	3.1	13.6	9.3	12.4	11.5	14.0	12.6	8.2	5.2	3.5	4.4	2.3	1 023
01/02	5.1	13.0	4.9	11.9	12.9	10.2	12.2	12.4	8.3	2.6	2.3	4.1	999
02/03	5.1	6.4	5.6	12.3	11.0	11.6	8.3	10.9	5.5	15.9	4.2	3.1	1 040
03/04	9.7	5.2	6.6	8.6	5.7	8.5	10.8	10.2	11.3	5.0	5.8	12.6	829
04/05	4.2	3.8	4.3	7.6	8.7	13.0	6.3	6.8	13.2	3.9	4.4	23.8	872
05/06	1.9	2.6	7.4	5.8	7.1	9.9	15.7	14.2	9.5	6.8	7.8	11.4	898
06/07	1.8	5.2	6.9	10.1	17.0	16.9	13.4	6.8	8.7	6.3	2.5	4.4	932
07/08	3.0	3.9	5.6	4.5	17.4	12.0	11.1	15.4	6.3	4.7	4.7	11.3	646
08/09	3.4	3.8	4.6	11.6	21.4	10.3	7.7	7.8	9.7	8.2	4.6	6.8	752
09/10	2.1	4.9	6.5	17.1	15.4	9.4	10.5	7.6	7.8	7.9	5.1	5.7	659
10/11	3.7	2.1	2.2	12.4	13.5	15.2	12.5	16.1	8.3	5.4	7.0	1.8	1 080
Mean	3.8	6.2	6.0	10.5	13.4	12.3	11.1	10.2	7.6	6.3	5.9	6.7	17 979

Table F.1: (cont.)

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
WCNI													
89/90	1.4	5.3	2.5	1.2	6.2	13.7	8.8	10.5	12.0	7.8	10.2	20.4	181
90/91	2.3	1.9	1.7	2.2	7.1	8.4	13.9	24.5	15.2	6.4	3.3	13.2	189
91/92	5.1	2.0	5.3	4.2	16.4	5.8	24.2	12.5	7.7	3.6	5.2	8.0	219
92/93	1.6	4.1	4.9	2.6	10.0	26.5	15.5	3.2	7.2	4.9	11.0	8.5	304
93/94	7.8	5.5	7.0	9.1	7.7	12.5	13.2	6.8	10.1	9.1	9.2	2.1	278
94/95	1.5	2.6	3.6	7.0	7.3	7.7	30.2	11.8	4.7	3.6	6.6	13.5	334
95/96	4.4	10.0	8.3	11.8	12.5	10.2	9.2	15.4	6.1	7.0	1.9	3.2	381
96/97	3.4	4.0	9.2	5.7	12.2	2.6	8.2	8.1	16.4	9.2	9.5	11.5	411
97/98	2.2	4.2	17.4	11.5	9.3	11.6	10.0	9.9	3.4	7.8	5.4	7.3	439
98/99	6.3	10.3	4.3	9.4	13.2	15.7	12.3	9.7	3.9	2.1	6.7	6.1	424
99/00	8.6	5.2	4.7	8.9	12.9	13.9	11.6	10.3	8.2	4.5	8.0	3.4	420
00/01	2.1	4.0	1.9	8.5	8.3	26.6	13.4	9.9	7.6	6.0	5.6	6.3	322
01/02	3.5	4.6	9.7	8.2	8.7	9.2	11.0	16.3	8.7	7.8	6.1	6.2	393
02/03	2.3	5.6	4.7	4.1	11.7	9.6	22.1	16.3	8.1	4.3	7.8	3.3	421
03/04	4.5	4.9	7.1	7.2	11.4	16.1	16.4	6.4	5.7	2.4	5.9	11.9	363
04/05	5.9	3.4	3.2	3.1	12.2	19.2	15.4	15.6	3.0	7.7	6.0	5.5	390
05/06	3.5	4.4	5.0	7.7	10.2	21.9	20.9	7.1	8.2	3.4	6.1	1.6	321
06/07	3.2	2.1	2.8	7.8	9.2	31.4	18.6	6.7	4.0	6.2	4.7	3.3	316
07/08	1.7	3.2	1.2	4.0	9.0	22.0	18.0	17.6	7.2	6.7	6.0	3.5	357
08/09	5.1	5.2	3.4	4.0	3.6	25.8	26.9	9.1	4.4	4.4	4.4	3.7	341
09/10	1.5	3.1	2.4	4.7	14.5	17.9	33.0	1.4	0.8	4.4	9.1	7.2	219
10/11	2.5	5.0	3.1	4.3	5.1	22.4	29.7	5.9	4.4	5.2	7.6	4.8	312
Mean	3.8	4.8	5.5	6.6	10.1	15.8	16.9	10.8	7.0	5.7	6.6	6.6	7 331

Table F.2: Distribution of landings (%) by month and fishing year for second tier methods (defined in Appendix E) in the five defined major areas based on trips which landed tarakihi. The final column gives the annual total landings for each method/area combination. These values are plotted in Figure 14.

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
EN–BLL													
89/90	4.4	3.0	3.0	7.1	7.6	7.4	5.9	6.8	12.2	16.1	3.7	22.8	48
90/91	7.3	2.8	3.0	2.4	3.7	4.5	10.3	17.7	11.1	8.5	14.2	14.4	57
91/92	6.6	2.0	2.4	4.0	7.9	7.2	11.9	10.8	10.5	6.9	11.5	18.3	56
92/93	5.7	3.4	2.7	5.9	2.6	7.1	3.6	4.9	11.1	17.6	15.1	20.1	65
93/94	11.2	5.0	5.3	4.1	1.8	2.8	3.4	6.7	11.6	13.6	19.7	14.7	89
94/95	6.5	4.9	5.0	1.8	3.8	8.1	3.0	5.5	6.1	12.3	22.3	20.7	99
95/96	12.9	9.6	3.3	4.2	5.0	6.6	2.9	5.2	7.0	9.5	16.7	17.1	76
96/97	10.4	8.1	5.2	2.5	4.0	6.2	4.7	5.1	12.0	17.0	11.8	13.2	97
97/98	11.0	8.6	7.3	4.1	6.4	7.8	7.0	6.9	7.9	5.7	12.3	15.1	121
98/99	11.3	10.5	4.3	6.7	1.5	8.9	3.4	4.9	10.1	12.1	14.8	11.5	103
99/00	8.6	4.0	7.6	6.0	8.3	8.3	5.1	7.1	8.2	5.7	13.5	17.5	118
00/01	11.5	7.1	7.5	8.0	4.0	3.6	4.4	2.6	10.6	13.7	17.0	9.9	99
01/02	10.9	9.1	3.9	6.3	5.5	8.4	8.2	7.6	10.2	9.3	12.4	8.3	76
02/03	8.9	7.2	3.9	6.7	11.3	5.3	10.5	6.0	7.5	9.5	9.9	13.4	67
03/04	8.4	4.3	1.8	4.7	5.8	9.2	5.0	2.2	8.2	7.6	22.6	20.3	52
04/05	13.7	7.3	4.4	4.4	6.8	7.3	2.7	3.4	8.1	9.5	16.8	15.6	34
05/06	4.0	2.2	4.8	4.6	4.6	3.1	2.8	2.4	4.1	10.3	25.1	31.9	42
06/07	12.0	5.6	4.7	5.8	8.4	6.6	9.0	6.1	9.3	8.1	12.8	11.8	40
07/08	6.1	3.6	2.5	8.0	11.8	10.0	3.2	5.5	10.3	11.0	12.5	15.4	37
08/09	9.3	14.8	2.9	4.0	9.1	7.0	4.1	2.8	8.0	10.5	7.3	20.0	39
09/10	10.2	10.8	5.0	5.5	5.9	7.7	4.1	6.1	2.7	9.4	13.2	19.3	40
10/11	13.2	18.6	7.1	3.2	7.7	2.2	2.5	1.4	5.3	6.6	12.9	19.2	51
Mean	9.5	6.9	4.8	5.0	5.6	6.6	5.3	5.9	9.0	10.6	14.7	16.1	1 507

Table F.2: (cont.)

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
												Month	
BoP-DS													
89/90	–	–	–	–	–	–	–	–	9.3	8.8	17.2	64.7	1
90/91	5.6	–	0.0	–	5.7	0.0	–	0.8	4.4	9.4	36.3	37.8	5
91/92	3.6	1.0	0.3	0.0	0.0	0.0	0.1	0.1	4.9	3.7	31.6	54.6	6
92/93	16.4	5.7	0.3	–	0.1	1.4	0.2	1.6	9.5	27.8	29.7	7.4	6
93/94	10.8	5.6	1.4	2.1	0.1	0.0	0.5	0.1	7.9	13.7	40.1	17.9	9
94/95	1.7	1.2	7.1	2.8	0.2	0.2	0.8	8.1	0.6	16.0	28.4	33.0	13
95/96	15.3	2.5	3.6	0.5	0.0	0.0	1.5	10.1	11.0	10.7	15.7	29.1	8
96/97	8.9	8.9	3.8	2.5	0.3	0.6	2.6	0.5	20.1	20.7	18.3	12.8	7
97/98	3.8	2.1	13.4	0.9	9.1	6.4	1.8	4.3	8.6	11.1	19.0	19.4	29
98/99	11.1	6.7	9.2	1.7	7.4	0.4	0.1	23.0	14.6	10.4	5.0	10.4	36
99/00	8.5	5.1	2.3	1.0	3.1	6.6	9.1	10.0	8.7	38.2	5.0	2.5	34
00/01	7.1	4.3	2.6	1.0	9.0	11.7	11.8	14.1	17.8	8.5	6.7	5.4	21
01/02	6.1	3.9	1.5	4.4	7.3	2.5	7.0	8.4	10.7	16.8	21.9	9.5	36
02/03	10.3	3.9	2.0	1.5	13.2	8.7	12.2	10.5	16.4	3.2	8.8	9.4	43
03/04	3.4	4.9	0.8	1.1	0.7	28.0	19.5	5.8	16.7	6.3	5.8	7.1	69
04/05	11.3	24.6	2.9	3.2	2.5	2.5	1.7	10.6	8.1	9.6	14.3	8.6	42
05/06	14.3	9.0	4.8	7.1	2.2	5.7	14.8	12.5	8.9	1.9	14.8	4.1	29
06/07	4.7	18.3	16.3	1.1	1.9	0.5	–	–	0.1	15.3	22.0	19.8	16
07/08	15.9	8.1	1.0	1.2	1.7	3.0	11.0	20.3	3.3	1.6	17.1	15.9	24
08/09	11.0	13.9	9.1	4.1	7.2	12.7	9.5	5.2	6.8	5.1	4.7	10.7	39
09/10	14.8	11.1	2.5	2.9	1.6	1.8	7.7	21.8	11.3	2.7	12.9	8.9	54
10/11	10.4	11.5	4.5	5.5	14.8	8.9	5.5	9.7	15.5	2.6	5.5	5.5	54
Mean	9.3	8.5	4.3	2.6	5.4	7.8	8.0	10.6	11.2	9.2	12.3	10.9	580
ECSI–SN													
89/90	0.5	8.3	12.3	24.1	5.0	5.4	15.6	23.0	5.7	0.1	0.0	0.0	198
90/91	0.3	3.0	8.1	28.2	14.6	21.5	7.6	13.7	2.8	0.0	0.0	0.2	311
91/92	0.8	1.3	9.4	27.8	14.7	15.4	20.0	6.9	3.6	0.1	0.1	0.0	387
92/93	1.2	0.9	5.1	20.1	19.6	11.1	7.8	27.2	6.9	0.1	0.0	0.0	373
93/94	0.2	3.5	14.1	28.0	11.8	5.3	13.5	19.2	4.3	0.1	0.1	0.0	244
94/95	0.1	0.8	7.2	16.7	14.9	7.0	18.5	20.5	14.1	0.1	0.0	0.0	336
95/96	0.4	1.1	5.8	20.4	12.0	9.1	15.9	27.6	7.3	0.4	0.0	0.0	315
96/97	0.6	1.3	13.8	27.9	11.1	4.2	11.6	24.2	4.9	0.3	0.0	0.0	235
97/98	0.2	1.3	10.4	24.8	18.9	5.6	14.4	18.6	5.5	0.2	0.1	0.1	302
98/99	0.1	1.4	16.3	30.4	12.9	5.7	7.7	16.9	8.4	0.2	0.0	0.0	251
99/00	0.0	1.3	14.8	35.6	11.7	3.1	6.5	21.2	5.6	0.3	0.0	0.0	273
00/01	0.2	1.9	16.3	31.8	14.3	3.8	8.7	12.4	10.5	0.1	0.0	0.0	377
01/02	0.1	5.3	38.8	38.5	3.1	0.8	3.6	9.0	0.7	0.1	0.0	0.0	402
02/03	0.2	1.5	16.3	33.2	15.2	3.6	4.9	18.2	6.8	0.1	0.0	0.0	336
03/04	0.0	1.3	16.4	37.4	8.7	4.6	7.9	16.7	6.9	0.3	–	–	314
04/05	0.0	0.5	6.9	45.1	26.1	2.0	2.3	12.8	4.2	0.0	0.0	0.0	160
05/06	0.2	4.8	24.2	34.3	8.1	0.9	5.9	16.1	5.4	0.0	0.0	0.0	214
06/07	0.0	1.1	8.2	24.0	15.4	4.9	11.8	26.1	8.4	0.0	0.0	0.0	179
07/08	0.1	0.1	3.5	34.1	17.2	6.5	8.1	22.1	7.3	0.0	0.0	1.1	186
08/09	0.8	0.8	15.8	39.8	14.1	3.2	7.0	16.2	2.3	0.0	0.0	0.0	206
09/10	0.1	0.2	16.1	31.4	16.5	3.9	5.7	22.0	4.2	0.0	0.0	0.0	179
10/11	0.0	1.4	14.3	24.2	12.3	2.0	6.4	26.3	12.1	1.0	0.0	–	148
Mean	0.3	2.0	13.8	29.5	13.3	6.4	9.9	18.3	6.2	0.2	0.0	0.1	5 926

Table F.2: (cont.)

Fishing												Month	
year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
WCNI-BPT													
89/90	13.5	53.8	7.8	3.1	1.3	0.7	–	–	–	–	10.4	9.4	11
90/91	6.0	2.2	6.3	0.7	13.5	5.1	0.3	0.0	–	–	65.9	–	18
91/92	–	1.1	12.3	15.8	50.5	7.1	0.3	13.0	–	–	–	–	5
92/93	–	–	–	5.8	38.9	1.8	53.5	–	–	–	–	–	9
93/94	–	0.1	9.9	3.3	4.6	0.1	–	0.0	–	10.2	52.0	19.8	14
94/95	–	17.2	30.6	12.0	0.1	1.4	0.5	16.8	–	–	2.5	19.0	7
95/96	16.7	5.1	0.1	29.7	22.4	–	0.2	–	–	–	16.8	9.0	9
96/97	0.7	3.8	13.6	9.1	–	–	0.3	0.6	–	–	–	72.0	2
97/98	27.0	57.7	11.0	0.8	3.5	–	–	–	–	–	–	–	2
98/99	0.4	2.5	1.0	10.1	33.7	17.1	4.4	29.7	1.0	–	–	0.0	37
99/00	–	0.0	3.0	7.2	11.5	8.5	9.6	13.6	5.3	9.2	16.7	15.3	45
00/01	–	2.3	4.2	10.3	8.0	19.8	2.6	28.6	5.2	9.2	4.7	5.2	56
01/02	21.5	0.3	32.5	13.1	30.4	2.2	–	–	–	–	–	–	2
02/03	–	1.3	9.3	3.4	14.0	4.1	–	–	15.4	52.7	–	–	15
03/04	–	0.7	2.6	3.8	8.0	18.4	34.2	9.0	11.0	–	8.6	3.8	27
04/05	3.5	2.5	5.3	2.4	8.3	0.0	0.5	–	–	13.3	25.3	38.9	34
05/06	2.9	2.1	1.1	11.6	5.2	–	0.0	–	1.3	10.1	44.0	21.7	17
06/07	0.4	32.4	15.9	0.4	9.9	4.5	0.0	2.7	7.7	–	2.2	23.8	42
07/08	5.4	10.3	6.1	12.7	2.5	10.7	15.0	19.2	9.0	2.2	2.3	4.8	112
08/09	18.0	3.8	2.9	7.0	7.2	7.4	26.7	9.8	5.8	2.9	3.1	5.4	67
09/10	3.8	9.7	6.6	4.4	16.7	8.9	30.6	6.0	4.2	5.6	2.2	1.3	64
10/11	11.1	11.6	2.0	3.8	17.4	23.8	4.7	5.3	3.7	1.9	9.8	4.9	37
Mean	5.0	8.1	5.7	7.4	11.3	9.8	12.3	11.5	5.1	5.3	9.6	9.0	630

Table F.3: Distribution of landings (%) by month and fishing year for third tier methods (defined in Appendix E) in the five defined major areas based on trips which landed tarakihi. The final column gives the annual total landings for each method/area combination. These values are plotted in Figure 15.

Fishing												Month	
year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
BoP–SN													
89/90	–	–	–	–	–	7.0	3.6	45.6	24.0	12.3	2.6	4.8	10
90/91	2.1	4.2	2.3	3.7	2.6	13.9	29.5	28.1	4.7	3.0	0.9	4.8	35
91/92	1.0	1.7	3.7	2.0	15.2	15.2	22.4	12.4	16.4	1.8	1.4	6.7	68
92/93	4.7	3.3	1.8	7.4	12.5	29.1	14.8	10.2	5.9	4.4	2.8	3.1	117
93/94	8.1	2.4	4.3	7.4	20.1	20.8	21.5	7.9	2.9	0.6	2.5	1.5	116
94/95	1.9	2.8	4.0	9.5	7.4	24.8	25.9	13.4	3.4	0.7	1.1	5.0	78
95/96	3.0	5.4	1.5	1.8	13.5	15.5	30.9	13.0	4.6	2.9	3.9	4.1	43
96/97	2.8	5.7	9.2	6.9	7.2	14.0	19.8	21.1	6.9	3.8	1.3	1.3	42
97/98	3.2	10.2	5.6	15.3	17.3	13.7	9.2	8.7	8.6	1.3	2.6	4.4	18
98/99	0.8	6.1	2.0	1.1	3.3	22.4	21.6	27.4	6.2	3.6	3.2	2.2	11
99/00	2.6	1.9	7.1	14.0	16.9	22.6	10.8	17.6	4.9	0.9	0.2	0.6	4
00/01	4.5	1.6	3.0	3.0	0.1	–	21.9	23.5	31.9	2.9	5.3	2.3	1
01/02	8.0	36.6	10.2	23.3	4.3	1.6	3.3	2.8	2.6	2.0	0.8	4.5	1
02/03	2.3	6.8	19.6	17.1	24.7	4.0	3.2	7.1	4.8	4.9	4.8	0.7	4
03/04	1.8	6.7	3.4	27.1	–	1.2	35.5	3.2	12.2	6.4	1.3	1.2	1
04/05	2.3	–	5.3	44.7	–	1.0	1.0	0.4	6.4	27.0	3.3	8.7	1
05/06	14.4	15.5	2.1	10.8	0.1	4.5	19.6	24.7	1.2	–	0.1	7.1	1
06/07	–	0.3	–	42.3	2.2	–	–	41.2	–	6.0	–	8.1	0
07/08	–	2.2	16.6	3.6	2.6	0.2	49.5	17.1	3.4	4.8	–	–	0
08/09	–	24.1	18.6	–	2.2	0.4	–	–	10.2	12.4	5.8	26.3	0
09/10	12.2	16.2	3.2	19.7	3.7	0.6	1.4	2.3	27.5	11.1	2.1	–	1
10/11	–	10.8	1.7	2.1	2.1	4.1	–	–	16.2	39.7	9.3	13.9	0
Mean	3.9	3.6	3.8	6.6	12.5	20.3	20.9	13.6	6.6	2.6	2.2	3.6	553

Table F.3: (cont.)

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
												Month	
ECSI–DS													
89/90	–	–	–	–	–	–	–	–	–	–	–	–	–
90/91	–	–	–	–	–	–	–	–	–	–	–	–	–
91/92	–	–	–	–	100.0	–	–	–	–	–	–	–	0
92/93	–	–	–	–	–	–	–	–	–	–	–	–	–
93/94	–	–	–	–	–	–	–	–	–	–	–	–	–
94/95	–	–	–	–	–	–	–	–	–	–	–	–	–
95/96	–	–	100.0	–	–	–	–	–	–	–	–	–	0
96/97	–	–	–	–	–	–	–	–	–	–	–	–	–
97/98	–	–	–	–	–	–	–	–	–	–	–	–	–
98/99	–	–	–	–	–	–	–	–	–	–	–	–	–
99/00	–	–	–	–	–	–	–	–	–	–	–	–	–
00/01	–	–	–	–	–	–	–	–	–	–	–	–	–
01/02	–	–	–	–	–	–	–	–	–	–	–	–	–
02/03	–	–	–	–	–	–	–	–	–	–	–	–	–
03/04	–	–	–	–	–	–	1.6	1.5	–	–	95.6	1.3	5
04/05	–	–	–	–	–	–	–	100.0	–	–	–	–	0
05/06	–	–	–	–	–	–	1.5	0.2	0.9	40.8	56.6	–	2
06/07	–	0.1	1.0	0.0	0.0	1.2	6.2	18.6	17.6	21.0	25.2	9.2	113
07/08	0.1	2.7	0.7	1.1	12.0	4.5	0.1	6.1	28.6	33.6	10.4	0.2	86
08/09	0.1	3.3	2.3	0.0	–	8.6	2.5	23.7	8.7	15.6	21.3	13.9	149
09/10	0.1	7.6	5.0	18.7	22.7	29.0	3.1	–	7.6	1.6	2.3	2.3	43
10/11	3.1	14.5	5.3	9.3	5.2	13.9	5.5	17.7	4.2	7.0	10.7	3.5	57
Mean	0.4	4.2	2.3	3.2	5.1	8.5	3.4	15.8	13.8	17.8	18.0	7.6	455

Appendix G. SUMMARIES FOR TARGET SPECIES BY MAJOR AREA AND METHOD OF CAPTURE

Table G.1: Distribution of landings (%) by month and fishing year by target species category for the indicated capture method and defined major areas (see Appendix A for definitions of codes in the table) based on trips which landed tarakihi. The final column gives the annual total landings for bottom trawl in each major area. These values are plotted in Figure 16, Figure 17 and Figure 18.

Target species

EN–BT

	TAR	SNA	JDO	SKI	TRE	BAR	GUR	RCO	HOK	SCI	SWA	RBY	OTH	Total
89/90	47.9	28.3	5.8	7.1	1.7	5.5	0.8	1.2	0.0	0.0	–	–	1.6	196
90/91	67.9	10.8	2.6	6.0	1.9	4.5	1.1	0.0	0.1	1.8	–	–	3.2	277
91/92	71.9	13.8	3.1	6.8	1.1	0.3	1.1	0.0	0.4	0.1	–	–	1.4	369
92/93	68.1	12.1	3.2	11.2	0.4	2.4	0.8	0.6	0.3	0.2	0.0	0.0	0.5	284
93/94	67.2	12.7	2.7	10.9	3.9	1.1	0.1	0.2	0.4	0.0	0.0	0.6	0.3	353
94/95	74.2	7.8	2.8	8.4	2.9	1.3	0.5	0.0	1.5	0.1	0.0	–	0.5	306
95/96	59.7	11.3	4.0	18.0	4.3	1.9	0.0	0.1	0.1	0.2	0.1	–	0.4	316
96/97	72.8	4.7	7.7	7.2	3.0	0.6	1.3	0.6	1.4	0.0	0.6	0.0	0.1	409
97/98	66.9	5.5	9.2	4.4	7.4	1.4	1.4	0.0	3.0	0.4	0.2	0.1	0.0	374
98/99	55.7	17.9	12.5	6.0	3.4	0.4	0.6	0.0	0.2	0.5	2.4	–	0.4	281
99/00	53.4	14.0	15.0	5.9	4.7	1.7	3.0	–	0.5	0.8	0.2	0.1	0.7	315
00/01	48.8	9.5	23.3	4.8	3.1	4.1	2.0	0.3	0.1	1.8	0.0	0.9	1.3	243
01/02	44.2	6.9	12.0	8.5	3.1	2.8	1.5	18.6	0.0	1.8	0.0	0.5	0.0	256
02/03	52.8	13.9	14.4	7.2	6.5	0.6	2.3	0.0	–	0.9	0.2	0.4	0.9	133
03/04	55.5	21.4	9.6	1.8	7.0	1.6	1.6	–	0.0	0.1	0.0	0.7	0.8	175
04/05	75.6	9.5	7.6	1.6	4.5	0.0	1.0	–	0.1	0.0	0.0	–	0.1	331
05/06	84.8	7.8	2.2	0.4	2.2	0.6	0.9	–	0.3	0.0	–	0.0	0.6	358
06/07	80.2	9.9	3.6	0.0	3.9	0.4	0.6	0.0	0.2	0.0	0.0	0.0	1.3	226
07/08	82.7	6.0	6.4	0.1	3.5	0.1	0.7	–	0.0	0.0	0.0	0.1	0.3	186
08/09	78.5	10.6	5.5	0.1	3.9	0.1	0.7	–	0.1	–	–	0.0	0.7	199
09/10	75.5	10.5	8.3	0.2	2.6	0.1	2.2	–	0.1	0.0	–	0.1	0.4	167
10/11	79.5	13.2	3.3	–	1.8	0.1	0.7	–	0.1	0.0	–	0.7	0.7	177
Mean	67.1	11.1	7.2	5.8	3.4	1.4	1.1	0.9	0.5	0.4	0.2	0.2	0.7	5 929

BoP–BT

	TAR	SNA	TRE	SKI	HOK	BAR	GUR	JDO	RBY	LIN	SCI	OTH	Total
89/90	59.6	21.4	3.0	12.6	0.6	2.0	0.1	0.3	0.0	0.0	0.0	0.4	289
90/91	78.9	11.1	0.6	7.3	0.0	1.9	0.0	0.1	–	–	0.1	0.1	511
91/92	75.4	7.4	0.6	10.9	1.1	2.9	0.5	0.8	0.0	–	0.1	0.3	633
92/93	71.2	5.6	1.8	13.6	2.0	1.8	2.2	1.2	–	0.0	0.4	0.2	630
93/94	84.2	5.9	1.8	3.4	1.0	0.9	1.4	0.8	0.0	0.0	0.4	0.1	638
94/95	78.0	4.4	1.2	5.9	2.9	4.1	0.3	2.3	0.3	0.0	0.1	0.3	530
95/96	78.7	8.9	0.4	6.7	2.4	0.8	0.4	1.0	0.0	0.0	0.0	0.8	544
96/97	80.1	5.3	1.8	4.6	4.7	0.8	1.5	0.4	0.1	0.0	0.4	0.3	488
97/98	72.4	5.8	1.6	2.8	10.1	2.0	1.5	2.6	1.0	0.0	0.0	0.2	540
98/99	75.1	5.4	6.8	1.3	5.8	4.2	0.2	0.9	0.0	0.3	0.0	0.1	515
99/00	76.7	4.4	5.5	2.5	4.3	1.6	2.6	1.9	–	0.1	0.0	0.3	397
00/01	70.2	3.6	14.9	1.3	1.5	3.1	1.7	1.5	1.1	0.6	0.0	0.5	613
01/02	73.0	7.3	8.4	2.6	0.3	2.9	1.5	2.2	1.0	0.4	0.1	0.3	734
02/03	72.8	5.5	6.5	3.2	1.5	3.1	4.6	1.6	0.4	0.3	0.0	0.5	789
03/04	74.5	8.4	3.1	1.1	2.7	3.1	4.5	0.9	1.4	0.1	0.0	0.2	852
04/05	80.0	9.5	3.9	1.1	0.5	0.2	3.0	1.6	0.0	0.0	0.0	0.1	706
05/06	86.1	5.9	2.6	0.3	0.2	1.0	1.5	1.9	0.1	0.0	0.0	0.3	621
06/07	86.3	7.2	1.3	0.5	0.6	0.6	1.2	1.5	0.0	0.1	0.0	0.8	507
07/08	87.8	6.0	3.2	0.0	0.1	0.3	0.3	2.0	–	0.3	0.0	0.0	500
08/09	87.3	7.7	2.6	0.0	0.1	0.0	0.9	0.6	0.2	0.0	0.0	0.5	645
09/10	88.4	5.3	4.0	0.2	0.1	0.1	0.6	0.9	0.2	0.1	0.0	0.0	700
10/11	88.6	3.0	5.8	0.1	0.4	–	0.1	1.1	0.8	0.0	0.0	0.0	602
Mean	78.7	6.8	3.8	3.4	1.8	1.7	1.6	1.3	0.3	0.1	0.1	0.3	12 983

Table G.1: (cont.)

	Target species													
ECNI–BT														
	TAR	GUR	SKI	WAR	HOK	BAR	SNA	TRE	JDO	MOK	FLA	SWA	OTH	Total
89/90	90.6	1.2	2.9	0.6	0.8	2.1	0.3	0.6	0.4	0.0	0.1	0.0	0.3	1 153
90/91	90.5	1.9	2.4	1.2	0.7	1.7	0.1	0.4	0.7	0.0	0.1	0.0	0.3	1 636
91/92	84.0	5.0	4.9	2.9	0.5	1.5	0.1	0.5	0.4	0.0	0.0	–	0.2	1 600
92/93	80.5	6.0	6.2	2.6	0.4	2.1	0.7	1.0	0.2	0.0	0.1	–	0.2	1 602
93/94	79.7	2.7	3.7	2.5	3.6	4.4	1.2	1.2	0.2	0.0	0.1	0.0	0.7	1 428
94/95	83.4	3.0	4.5	2.5	2.6	1.4	1.0	0.8	0.2	0.0	0.3	0.0	0.2	1 476
95/96	75.5	3.5	9.3	2.4	4.9	1.9	1.2	0.3	0.2	0.2	0.4	0.0	0.1	1 438
96/97	68.2	7.8	8.6	1.8	6.8	3.8	0.7	0.5	0.4	0.5	0.7	0.1	0.2	1 431
97/98	76.4	5.8	5.5	1.8	6.6	1.5	0.9	0.2	0.5	0.5	0.2	0.1	0.1	1 521
98/99	83.8	5.9	3.2	1.2	1.2	2.2	1.2	0.5	0.3	0.1	0.4	0.1	0.1	1 562
99/00	78.2	9.7	3.6	1.8	1.5	2.3	1.2	0.3	0.4	0.7	0.1	0.1	0.2	1 704
00/01	74.9	12.8	2.6	3.2	1.5	2.0	1.2	0.5	0.2	0.5	0.0	0.2	0.5	1 600
01/02	78.1	12.0	2.4	3.3	0.8	1.2	0.7	0.6	0.3	0.2	0.0	0.2	0.3	1 690
02/03	75.7	12.0	3.5	2.5	2.0	0.8	2.0	0.4	0.3	0.4	0.1	0.0	0.3	1 725
03/04	82.5	8.9	2.4	1.4	1.0	1.9	1.3	0.2	0.3	0.1	0.0	0.0	0.1	1 602
04/05	87.8	5.8	1.7	1.9	0.8	0.1	1.3	0.1	0.3	0.0	0.0	0.1	0.1	1 665
05/06	93.5	3.6	0.5	1.0	0.2	0.2	0.5	0.1	0.0	0.0	0.0	0.0	0.1	1 937
06/07	92.3	3.3	1.3	1.1	0.9	0.1	0.5	0.2	0.0	0.0	0.1	0.0	0.1	1 674
07/08	93.5	3.9	0.1	1.1	0.2	0.1	0.4	0.0	0.2	0.3	0.1	0.1	0.2	1 676
08/09	93.1	4.3	0.3	0.6	0.3	0.3	0.2	0.0	0.0	0.2	0.0	0.5	0.1	1 845
09/10	88.9	8.3	0.5	0.8	0.6	0.2	0.1	0.0	0.0	0.1	0.0	0.2	0.1	1 843
10/11	91.0	5.0	0.7	0.8	0.3	0.1	0.5	0.0	0.1	0.4	0.0	0.5	0.5	1 614
Mean	84.0	6.1	3.1	1.8	1.6	1.4	0.8	0.4	0.2	0.2	0.1	0.1	0.2	35 421
ECSI–BT														
	TAR	RCO	BAR	FLA	SQU	WAR	HOK	SPE	STA	SPD	GUR	ELE	OTH	Total
89/90	50.1	22.1	12.8	5.8	0.2	0.9	0.2	1.3	1.3	0.3	0.3	1.4	3.3	589
90/91	27.5	31.0	23.6	7.8	2.8	2.5	0.8	0.1	0.4	0.2	0.8	0.4	2.2	640
91/92	27.6	43.4	13.8	5.3	2.8	0.6	0.1	1.0	2.7	0.5	0.5	0.6	1.1	777
92/93	21.7	46.9	9.2	4.1	1.1	0.5	5.1	1.7	0.1	1.7	0.3	0.6	7.0	476
93/94	35.9	43.1	4.0	9.1	1.5	2.1	0.2	1.9	1.6	0.0	0.3	0.1	0.3	505
94/95	28.3	43.8	10.8	7.5	0.2	2.5	4.0	1.0	0.1	0.2	0.6	0.1	1.1	588
95/96	26.1	43.3	10.0	8.8	3.1	0.7	4.0	2.3	0.5	0.3	0.1	0.0	0.8	791
96/97	31.8	41.4	11.6	4.1	4.4	1.3	2.8	1.0	0.9	0.1	0.0	0.0	0.4	872
97/98	21.1	54.1	8.4	9.4	0.8	0.9	1.9	1.8	0.5	0.0	0.2	0.0	0.8	854
98/99	37.4	23.4	14.8	16.9	3.0	0.7	1.0	1.3	0.0	0.0	0.1	0.0	1.3	995
99/00	21.9	36.5	12.5	15.5	5.1	2.7	1.3	1.2	0.7	1.2	0.0	0.1	1.1	1 165
00/01	21.6	41.8	16.3	11.4	2.8	1.5	0.4	1.7	0.9	0.0	0.3	0.1	1.2	1 023
01/02	24.3	29.6	21.7	6.1	6.8	4.4	0.3	1.0	1.8	0.3	0.5	0.5	2.6	999
02/03	34.7	29.0	19.6	5.6	4.4	3.3	0.6	0.3	0.1	0.0	1.1	0.7	0.5	1 040
03/04	51.1	22.7	16.8	2.1	0.2	3.3	1.0	0.5	0.0	0.0	0.2	1.6	0.5	829
04/05	64.6	21.8	4.7	2.8	1.7	2.2	0.1	0.5	0.1	0.3	0.3	0.5	0.2	872
05/06	61.7	18.5	4.5	4.5	2.8	1.0	0.3	0.1	0.1	4.5	1.1	0.7	0.2	898
06/07	65.5	12.2	7.6	6.0	2.4	0.8	0.2	0.2	0.5	0.7	1.6	0.7	1.6	932
07/08	71.4	6.4	8.0	5.9	1.8	1.3	0.3	0.1	0.4	0.7	1.5	0.4	1.7	646
08/09	80.1	2.2	6.9	6.1	0.6	0.9	0.5	0.1	0.2	0.7	0.4	0.6	0.7	752
09/10	79.9	2.3	4.7	5.9	0.0	1.3	0.1	0.3	1.0	0.9	0.6	0.7	2.3	659
10/11	73.8	4.1	7.6	6.4	0.6	0.6	0.1	2.2	2.2	0.1	0.2	0.2	1.9	1 080
Mean	43.3	27.8	11.7	7.4	2.5	1.7	1.0	1.0	0.7	0.6	0.5	0.4	1.4	17 979

Table G.1: (cont.)

WCNI–BT	TAR	SNA	TRE	BAR	GUR	JMA	SKI	SCH	SWA	JDO	SQU	OTH	Total
	Target species												
89/90	65.5	17.1	10.0	4.6	0.0	1.3	0.6	0.0	–	–	–	0.8	181
90/91	63.7	13.7	14.1	6.6	0.6	0.8	0.3	0.0	–	0.0	–	0.0	189
91/92	56.0	28.6	6.5	3.2	3.6	1.1	0.8	0.0	–	0.0	–	0.1	219
92/93	59.3	18.3	13.9	2.6	3.5	0.7	1.0	0.3	0.1	0.0	–	0.2	304
93/94	63.8	18.2	7.2	5.4	1.1	0.7	2.8	–	0.1	0.1	–	0.5	278
94/95	54.1	28.7	7.4	3.5	1.7	0.6	2.8	–	0.4	0.1	–	0.8	334
95/96	71.0	11.1	2.6	1.9	0.3	3.7	4.4	0.0	4.6	0.2	–	0.1	381
96/97	69.3	9.3	4.9	2.2	2.7	8.0	2.9	0.0	0.2	0.1	–	0.3	411
97/98	57.4	7.5	7.4	1.8	1.6	17.1	4.3	–	0.4	0.9	–	1.6	439
98/99	74.4	6.5	6.2	4.8	3.8	–	3.2	–	0.2	0.1	0.1	0.7	424
99/00	68.3	6.5	11.1	3.4	4.5	2.1	2.7	0.3	0.0	0.0	0.9	0.2	420
00/01	66.1	6.5	10.2	5.0	8.2	–	2.4	0.2	–	0.2	0.6	0.6	322
01/02	74.5	4.4	4.0	8.9	0.9	3.9	0.5	0.2	–	0.2	1.3	1.3	393
02/03	80.2	6.3	3.0	2.8	5.2	0.1	0.4	0.3	–	0.4	1.3	0.1	421
03/04	81.8	7.5	5.1	0.7	2.7	0.7	0.0	0.3	–	0.7	0.0	0.4	363
04/05	77.1	11.2	5.2	2.6	3.0	0.0	0.1	0.4	0.0	0.2	–	0.1	390
05/06	84.0	2.4	4.0	1.0	6.4	–	–	1.0	0.0	0.4	–	0.7	321
06/07	86.6	1.0	7.2	2.5	1.6	–	–	0.5	0.0	0.1	0.4	0.2	316
07/08	82.3	4.6	7.5	1.1	3.4	–	0.2	0.3	0.2	0.0	0.0	0.3	357
08/09	86.4	3.0	6.6	0.9	0.8	–	0.1	1.5	0.0	0.1	–	0.6	341
09/10	81.0	6.3	10.0	0.8	0.2	–	0.1	1.1	–	0.5	–	0.0	219
10/11	84.7	3.4	6.0	1.5	0.7	0.0	0.0	2.3	0.1	1.4	–	0.0	312
Mean	72.6	9.4	6.9	3.0	2.7	2.2	1.5	0.4	0.3	0.3	0.2	0.5	7 331

EN–BLL	SNA	HPB	TAR	BNS	GUR	RSN	OTH	Total
89/90	95.9	0.8	0.2	1.9	1.0	–	0.2	48
90/91	92.2	4.5	0.1	2.1	1.0	–	0.0	57
91/92	90.8	4.2	1.2	1.0	2.7	0.0	0.1	56
92/93	80.5	9.3	7.5	0.6	1.6	–	0.4	65
93/94	85.5	8.2	4.3	0.8	0.9	–	0.3	89
94/95	89.4	4.8	4.4	1.0	0.4	–	0.1	99
95/96	91.7	3.5	1.7	0.7	0.3	0.2	1.9	76
96/97	90.6	3.5	4.5	0.5	0.3	0.0	0.6	97
97/98	90.6	1.3	7.2	0.3	0.2	0.1	0.3	121
98/99	93.4	2.0	3.6	0.4	0.0	–	0.5	103
99/00	91.8	4.0	3.2	0.3	0.0	–	0.6	118
00/01	83.2	5.3	6.4	0.7	2.3	–	2.2	99
01/02	83.0	2.7	12.6	0.1	1.2	0.0	0.3	76
02/03	89.9	2.7	4.3	0.6	2.4	0.0	0.1	67
03/04	89.6	4.2	2.2	0.6	3.2	–	0.2	52
04/05	77.4	8.7	2.1	3.8	2.8	4.9	0.3	34
05/06	83.9	10.6	0.5	3.8	0.1	0.5	0.6	42
06/07	84.0	9.5	0.8	4.1	0.3	0.8	0.5	40
07/08	68.1	21.0	1.9	2.3	0.1	5.8	0.8	37
08/09	70.9	12.9	2.8	3.0	0.2	8.9	1.3	39
09/10	74.0	7.0	12.9	2.2	0.2	2.3	1.3	40
10/11	65.1	9.4	19.9	3.2	0.0	1.5	0.8	51
Mean	86.4	5.4	4.9	1.2	0.9	0.7	0.6	1 507

Table G.1: (cont.)

BoP–DS	Target species					
	SNA	TAR	GUR	TRE	OTH	Total
89/90	99.4	–	0.6	–	–	1.4
90/91	92.4	5.2	0.9	–	1.5	4.9
91/92	52.7	14.2	32.9	–	0.3	6.2
92/93	68.5	1.4	20.9	0.5	8.7	5.8
93/94	80.0	–	15.6	–	4.5	8.9
94/95	63.2	4.0	26.8	–	6.0	13
95/96	77.2	3.9	14.7	–	4.2	8.1
96/97	45.9	17.2	32.1	0.2	4.6	7.1
97/98	21.0	36.2	39.5	1.0	2.3	29
98/99	12.5	51.8	29.2	5.3	1.1	36
99/00	20.5	63.1	13.5	2.8	0.2	34
00/01	19.7	50.0	29.9	0.3	0.1	21
01/02	33.2	27.9	35.4	3.0	0.4	36
02/03	50.4	28.8	20.8	0.0	0.0	43
03/04	57.1	36.5	6.4	–	0.1	69
04/05	75.7	21.4	2.9	–	–	42
05/06	51.0	26.7	21.6	0.0	0.8	29
06/07	84.5	6.6	8.7	–	0.2	16
07/08	71.9	25.8	1.5	0.0	0.7	24
08/09	43.7	50.9	5.4	–	–	39
09/10	43.5	42.4	13.7	0.0	0.5	54
10/11	32.7	42.9	20.1	1.0	3.3	54
Mean	46.1	34.7	17.3	0.8	1.1	580

ECSI–SN											
	TAR	LIN	SPD	SPO	HPB	BNS	WAR	SCH	RCO	OTH	Total
89/90	96.3	2.5	0.6	0.1	0.1	0.1	0.1	0.3	–	0.1	198
90/91	96.5	1.1	0.5	0.0	0.2	0.0	0.3	0.0	1.2	0.2	311
91/92	93.9	3.0	1.3	0.2	0.0	0.0	0.2	0.0	1.0	0.3	387
92/93	94.8	2.1	2.1	0.2	0.8	0.0	–	0.1	–	0.0	373
93/94	89.8	0.6	6.8	0.7	0.0	0.0	1.0	0.1	0.0	1.0	244
94/95	87.7	0.1	10.5	0.7	0.1	0.3	0.4	0.1	0.0	0.2	336
95/96	80.6	14.4	3.4	0.1	0.1	0.0	1.0	0.1	0.0	0.2	315
96/97	84.3	0.8	11.8	1.0	0.3	0.1	1.6	0.1	–	0.1	235
97/98	90.0	2.8	4.9	1.1	0.4	0.2	0.0	0.1	–	0.5	302
98/99	97.6	1.6	0.1	0.0	0.3	0.2	0.0	0.1	–	0.0	251
99/00	97.7	1.3	0.1	0.1	0.4	0.0	0.1	0.2	0.0	0.1	273
00/01	82.3	5.9	0.0	0.9	6.5	4.0	0.1	0.1	–	0.2	377
01/02	93.5	2.0	0.3	2.0	0.0	0.4	1.7	0.1	–	0.0	402
02/03	93.7	2.7	0.2	2.5	0.6	0.2	0.0	0.0	–	0.0	336
03/04	96.3	1.4	0.0	1.5	0.1	0.1	–	0.6	–	0.0	314
04/05	97.5	2.1	0.0	0.1	0.1	0.0	0.0	0.1	–	0.0	160
05/06	99.4	0.0	0.1	0.1	0.1	0.0	0.0	0.2	–	0.1	214
06/07	99.1	0.0	0.0	0.3	0.1	0.1	0.0	0.2	–	0.2	179
07/08	99.0	0.1	0.1	0.1	0.1	0.0	0.0	0.3	–	0.3	186
08/09	99.2	0.0	0.0	0.2	0.0	0.0	–	0.2	–	0.3	206
09/10	98.9	0.1	0.6	0.1	0.1	0.0	0.0	0.1	–	0.1	179
10/11	98.9	0.2	–	0.1	0.0	0.0	0.0	0.4	–	0.4	148
Mean	93.1	2.4	2.1	0.7	0.6	0.4	0.3	0.1	0.1	0.2	5 926

Table G.1: (cont.)

	Target species								Total
WCNI–BPT									
	TAR	TRE	SNA	BAR	GUR	OTH			Total
89/90	–	52.5	47.5	–	–	–			11
90/91	14.4	26.7	53.5	5.3	–	0.1			18
91/92	–	39.0	61.0	–	0.0	–			5.3
92/93	8.4	36.2	55.3	–	–	–			8.9
93/94	–	10.5	79.7	9.8	–	–			14
94/95	–	20.4	79.4	0.2	0.0	0.0			6.7
95/96	–	5.5	81.5	12.8	–	0.3			9.0
96/97	13.3	–	84.3	–	–	2.4			2.4
97/98	–	0.8	99.2	–	–	–			1.7
98/99	66.3	22.9	5.8	–	3.9	1.2			37
99/00	61.6	17.6	4.2	10.7	3.9	2.0			45
00/01	63.6	20.9	4.7	10.1	0.3	0.3			56
01/02	–	70.5	6.6	21.5	–	1.3			2.0
02/03	39.0	47.1	4.1	–	9.7	0.1			15
03/04	86.8	9.0	0.2	–	4.0	–			27
04/05	0.7	37.4	57.4	4.6	–	0.0			34
05/06	48.7	34.5	11.1	–	5.7	–			17
06/07	70.6	3.6	10.4	–	15.4	–			42
07/08	90.8	7.3	1.9	–	–	0.0			112
08/09	74.9	24.4	0.0	0.2	0.4	–			67
09/10	81.4	14.7	0.1	1.2	2.6	–			64
10/11	67.2	32.8	–	–	–	–			37
Mean	61.5	19.7	13.5	2.7	2.4	0.3			630
BoP–SN									
	TAR	TRE	SNA	SKI	KIN	WAR	HOK	OTH	Total
89/90	80.7	4.2	2.3	0.8	4.3	2.5	–	5.2	10
90/91	80.9	5.0	4.7	–	5.5	0.3	–	3.5	35
91/92	85.1	3.4	3.6	0.7	2.9	2.4	–	1.9	68
92/93	84.0	3.5	1.8	5.3	1.9	1.3	–	2.2	117
93/94	91.8	3.3	0.6	1.2	0.5	0.4	1.1	1.2	116
94/95	93.4	3.2	0.5	0.2	0.0	0.8	0.1	1.8	78
95/96	76.6	8.4	5.3	1.8	0.1	1.0	4.6	2.2	43
96/97	64.2	16.0	9.5	1.6	–	0.1	5.3	3.4	42
97/98	78.7	13.8	1.1	1.9	–	2.1	–	2.4	18
98/99	79.6	12.0	0.0	2.2	–	2.8	–	3.4	11
99/00	68.3	27.9	0.6	–	–	0.3	–	2.8	3.5
00/01	6.6	56.8	1.9	–	–	0.0	–	34.7	1.1
01/02	5.6	68.9	8.4	–	–	0.5	–	16.5	1.1
02/03	64.9	25.5	2.5	–	–	0.1	–	7.0	4.2
03/04	42.9	3.7	13.5	–	–	1.7	–	38.3	0.6
04/05	37.7	0.3	2.3	–	0.2	5.1	–	54.3	1.4
05/06	12.5	14.9	37.3	–	4.9	4.7	–	25.7	0.8
06/07	–	31.2	1.6	–	–	–	–	67.2	0.2
07/08	–	23.1	15.1	–	–	–	–	61.8	0.4
08/09	–	53.6	5.8	–	–	4.4	–	36.1	0.3
09/10	–	12.7	10.0	–	–	4.7	–	72.6	0.8
10/11	–	11.7	0.0	–	–	6.7	–	81.6	0.2
Mean	83.4	6.0	2.7	1.9	1.3	1.1	1.0	2.7	553

Table G.1: (cont.)

ECSI–DS	Target species			
	TAR	RCO	OTH	Total
89/90	–	–	–	–
90/91	–	–	–	–
91/92	100.0	–	–	0.0
92/93	–	–	100.0	0.1
93/94	–	–	–	–
94/95	–	–	–	–
95/96	–	–	–	–
96/97	–	–	–	–
97/98	–	–	–	–
98/99	–	–	–	–
99/00	–	–	–	–
00/01	–	–	–	–
01/02	–	–	–	–
02/03	–	–	–	–
03/04	1.5	96.9	1.6	5.2
04/05	–	–	100.0	0.0
05/06	0.9	97.5	1.6	1.6
06/07	90.0	8.2	1.8	113
07/08	92.8	5.7	1.5	86
08/09	96.5	3.5	0.0	149
09/10	97.3	2.3	0.4	43
10/11	98.8	0.8	0.5	57
Mean	93.1	6.0	0.9	455

Appendix H. EAST COAST NORTH/SOUTH ISLAND TARAKIHI CPUE ANALYSIS

H.1 General overview

This study was prompted by simultaneous declines in standardised CPUE for tarakihi from two separate QMA based studies reported in 2008 and 2009 for adjacent Fishstocks (TAR 2 and TAR 3) along the east coast of both the north and south islands. On the basis of known spawning grounds and migration patterns, it seemed clear that tarakihi biological stocks extended beyond the scale of current QMAs and that a coordinated approach for monitoring the wider stock was desirable.

Three standardised CPUE analyses are presented in detail in this Appendix, with full documentation for each series. These series were used as input to a stock assessment of tarakihi on the east coasts of the North and South Islands (Langley & Starr 2012).

Studies that are QMA based can suffer from a loss of data when they include straddling statistical areas (shared by more than one Fishstock). Trips that fish in these statistical areas and land to more than one Fishstock are excluded from the analysis if the integrity of the Fishstock identification is to be maintained because the landed catch cannot be allocated unambiguously. Unfortunately, such ambiguous catches are important in the TAR 2 and TAR 3 fisheries, which share Areas 017, 018, and 019, and which also share Area 017 with TAR 7. Consequently, it was decided to abandon the integrity of the Fishstock information so that catches in these shared statistical areas could be retained, resulting in CPUE analyses that are defined by statistical area of capture, rather than to a specific QMA.

The standardisation procedure in each of the three defined fisheries reported here demonstrates how fishing behaviour can affect tarakihi catch rates, with the statistical procedure resulting in considerable modification of the unstandardised CPUE series. In TAR 2, there is evidence of active avoidance of tarakihi during a peak of abundance in the early 2000s, and in TAR 3 there is evidence of improved targeting of the species over the whole study period, but particularly during much of the 2000s when abundance in the underlying population appears to have been in decline.

H.2 Methods

H.2.1 Data Preparation

The identification of candidate trips for these analyses and the methods used to prepare the data have been described in Section 2.3.1. The potential data variables available from each trip include estimated and landed catch of tarakihi, the number of tows, total duration of fishing, fishing year, statistical area, target species, month of landing, and a unique vessel identifier. Data might not represent an entire fishing trip; just those portions of it that qualified, but the amount of landed catch assigned to the part of the trip that was kept would be proportional to the total landed catch for the trip based on the estimated catches which apportion the landings to each trip stratum. Trips were not dropped because they targeted more than one species or fished in more than one statistical area. Trips landing more than one Fishstock from one of the straddling statistical areas were not dropped

Those groups of events that satisfied the criteria of target species, method and statistical areas defining the defined fisheries were selected from available fishing trips. Any effort strata that were matched to a landing of tarakihi were termed “successful”, and included any relevant but unsuccessful effort, so that the analysis of catch rates in successful strata also incorporates much of the relevant zero catch information. Strata which did not include any landed tarakihi were assigned a value of zero so that the effort data associated with them could be included in the analysis that considered total effort (as differentiated from successful effort only).

H.2.2 Analytical methods for standardisation

Arithmetic CPUE $\left(\hat{A}_y\right)$ in year *y* was calculated as the total catch for the year divided by the total effort in the year:

Eq. H.1
$$\hat{A}_y = \frac{\sum_{i=1}^{n_y} C_{i,y}}{\sum_{i=1}^{n_y} E_{i,y}}$$

where $C_{i,y}$ is the [*catch*] and $E_{i,y} = T_{i,y}$ ([*tows*]) or $E_{i,y} = H_{i,y}$ ([*hours_fished*]) for record *i* in year *y*, and n_y is the number of records in year *y*.

Unstandardised CPUE $\left(\hat{G}_y\right)$ in year *y* is the geometric mean of the ratio of catch to effort for each record *i* in year *y*:

Eq. H.2
$$\hat{G}_y = \exp\left[\frac{\sum_{i=1}^{n_y} \ln\left(C_{i,y} / E_{i,y}\right)}{n_y}\right]$$

where C_i, $E_{i,y}$ and n_y are as defined for Eq. H.1. Unstandardised CPUE makes the same log-normal distributional assumption as the standardised CPUE, but does not take into account changes in the fishery. This index is the same as the "year index" calculated by the standardisation procedure, when not using additional explanatory variables and using the same definition for $E_{i,y}$. Presenting the arithmetic and unstandardised CPUE indices in this report provide measures of how much the standardisation procedure has modified the series from these two sets of indices.

A standardised abundance index (Eq. H.3) was calculated from a generalised linear model (GLM) (Quinn & Deriso 1999) using a range of explanatory variables including [*year*], [*month*], [*vessel*] and other available factors:

Eq. H.3
$$\ln(I_i) = B + Y_{y_i} + \alpha_{a_i} + \beta_{b_i} + ... + f\left(\chi_i\right) + f\left(\delta_i\right) .... + \varepsilon_i$$

where $I_i = C_i$ for the i^{th} record, Y_{y_i} is the year coefficient for the year corresponding to the i^{th} record, α_{a_i} and β_{b_i} are the coefficients for factorial variables *a* and *b* corresponding to the i^{th} record, and $f\left(\chi_i\right)$ and $f\left(\delta_i\right)$ are polynomial functions (to the 3rd order) of the continuous variables χ_i and δ_i corresponding to the i^{th} record, *B* is the intercept and ε_i is an error term. The actual number of factorial and continuous explanatory variables in each model depends on the model selection criteria. Fishing year was always forced as the first variable, and month (of landing), statistical area, target species, and a unique vessel identifier were also offered as categorical variables. Tows $\left(\ln\left(T\right)_i\right)$ and fishing duration $\left(\ln\left(H_i\right)\right)$ were offered to the model as continuous third order polynomial variables.

Each model was fit to log(catch) against the full set of explanatory variables in a stepwise procedure and assuming a lognormal distribution, selecting variables one at a time until the improvement in the model R^2 was less than 0.01. The order of the variables in the selection process was based on the variable with the lowest AIC, so that the degrees of freedom were minimised. Datasets were restricted to core fleets of vessels, defined by their activity in the fishery, thus selecting only the most active vessels without unduly constraining the amount of catch and effort available for analysis.

Canonical coefficients and standard errors were calculated for each categorical variable (Francis 1999). Standardised analyses typically set one of the coefficients to 1.0 without an error term and estimate the remaining coefficients and the associated error relative to the fixed coefficient. This is required because of parameter confounding. The Francis (1999) procedure rescales all coefficients so that the geometric mean of the coefficients is equal to 1.0 and calculates a standard error for each coefficient, including the fixed coefficient.

The procedure described by Eq. H.3 is necessarily confined to the positive catch observations in the data set because the logarithm of zero is undefined. Observations with zero catch were modelled by fitting a linear regression model based on a binomial distribution and using the presence/absence of tarakihi as the dependent variable (where 1 is substituted for $\ln(I_i)$ in Eq. H.3 if it is a successful catch record and 0 if it is not successful), using the same data set. Explanatory factors were estimated in the model in the same manner as described for Eq. H.3. Such a model provides an alternative series of standardised coefficients of relative annual changes that is analogous to the equivalent series estimated from the positive catch regression.

A combined model, which integrates the lognormal and binomial annual abundance coefficients, was estimated using the delta distribution, which allows zero and positive observations (Vignaux 1994):

Eq. H.4
$$^{C}Y_y = \frac{^{L}Y_y}{\left(1 - P_0\left[1 - \frac{1}{^{B}Y_y}\right]\right)}$$

where $^{C}Y_y$ = combined index for year *y*

$^{L}Y_y$ = lognormal index for year *i*

$^{B}Y_y$ = binomial index for year *i*

P_0 = proportion zero for base year *0*

Confidence bounds, while straightforward to calculate for the binomial and lognormal models, were not calculated for the combined model because a bootstrap procedure (recommended by Francis 2001) had not yet been implemented in the available software. The positive catch model almost always represents the major portion of the signal in the combined model and there is concern that the information added by the binomial model may be an artefact of the data amalgamation procedure and not always interpretable as a biomass index. The binomial model is presented here for information and to contrast with the positive catch model.

H.2.3 Fishery definitions for CPUE analysis

Three fisheries have been modelled to cover different components of the east coast tarakihi population. Other fisheries were examined during the exploratory work done for this project but are described in Appendix J.

Tarakihi is an important bycatch of most inshore bottom trawl fisheries along the east coast of both islands and there are also well defined target fisheries, however the choice of which target fisheries to include was intended to be inclusive rather than selective, so as to be compatible with previously accepted series and also to reduce the sensitivity of the analysis to trends in reporting of target species in these fisheries and to lessen the impact of the shift from daily to tow-by-tow reporting.

While the definitions in the defined three fisheries below make reference to the predominant QMA represented in each analysis, the selection of data for these fisheries was based on the statistical area of capture rather than the QMA. The choice of statistical areas in each defined fishery is based mainly on the characterisation work presented in Section 2.3.3, but was additionally evaluated using "residual implied coefficients" (see Appendix A) which can be used to approximate year×area interactions (for example, see Figure I.5). Because of the decision to drop QMA integrity in this analysis, catch from

Area 017, which would have been dropped in previous versions of these analyses, has been retained in this analysis. In this study it is included in the TAR 3 mixed target trawl dataset. Only catches from the inshore statistical areas were kept, and the small amounts taken in adjacent offshore areas were dropped.

TAR2_BT_MIX – East coast, North Island mixed species bottom trawl – The fishery is defined from bottom single trawl fishing events which fished in statistical Areas 011 to 016 inclusive, and targeted TAR, SNA, BAR, SKI, WAR, or GUR. This definition allows the use of total effort in the analysis of catch rates.

TAR3_BT_MIX – East coast, South Island mixed species bottom trawl – The fishery is defined from bottom single trawl fishing events which fished in statistical Areas 017, 018, 020, 022, 024, and 026, and targeted TAR, BAR, RCO, WAR, or GUR. This definition allows the use of total effort in the analysis of catch rates.

TAR3_SN_TAR – Kaikoura target tarakihi setnet -- The fishery is defined from set net fishing events which fished in statistical area 018, and targeted TAR. This definition allows the use of total effort in the analysis of catch rates.

H.3 Unstandardised CPUE

H.3.1 TAR2_BT_MIX: East coast, North Island mixed species bottom trawl

There has been relatively little change in the number of successful trips which reported TAR in this fishery, apart from a strong increase in the first two years of the series (Figure H.1). There has been little trend in the nominal catch rate of successful trips. There has been a slight declining trend in the proportion of trip-strata with zero tarakihi catch ([left panel] Figure H.2) and a very large effect in the number of events per trip-stratum after the introduction of the TCER form at the beginning of 2007–08 ([right panel] Figure H.2).

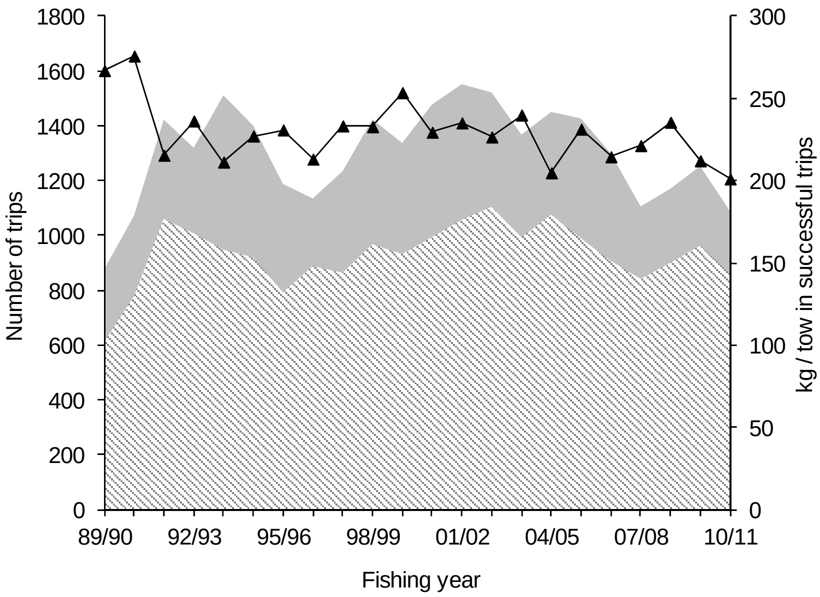


Figure H.1: Number of qualifying trips in TAR2_BT_MIX) (dark area), the number of those trips that landed tarakihi (light area) and the simple catch rate (kg/tow) of tarakihi in successful trip-strata, by fishing year.

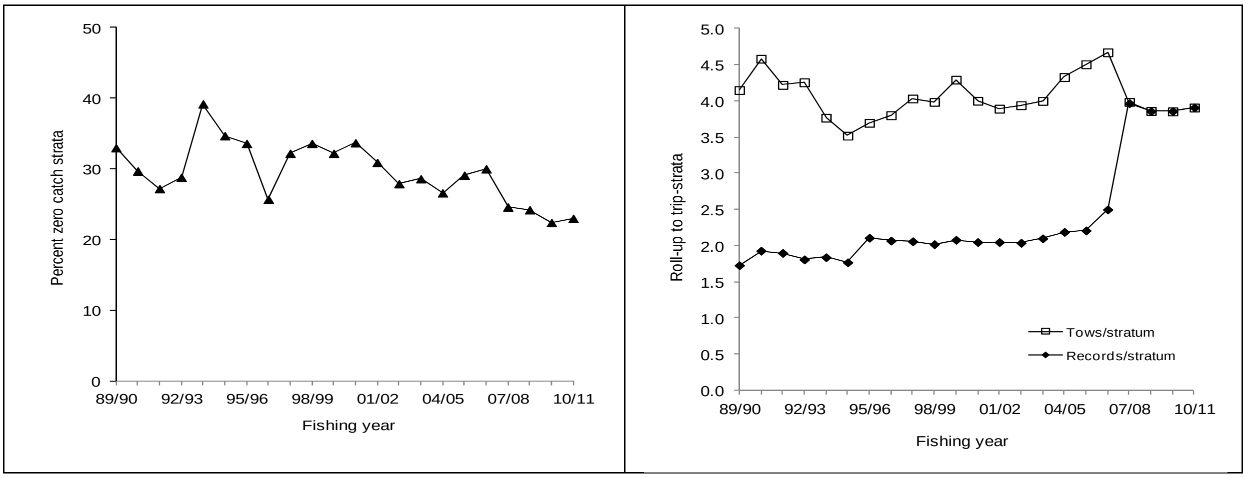


Figure H.2: The proportion of qualifying trips in TAR2_BT_MIX, that landed zero tarakihi (left), and the effect of amalgamation to trip-strata on the number of original records per trip-stratum and the number of tows per trip-stratum, by fishing year.

H.3.2 TAR3_BT_MIX: East coast, South Island mixed species bottom trawl

There has been a large change in this fishery, with a long-term declining trend in the number of reporting trips and with a strong increasing trend in nominal catch per trip (Figure H.3). There is a step down in the proportion of trip-strata reporting no tarakihi catch ([left panel] Figure H.4) and again a very strong response in the number of events per trip-stratum after the introduction of the TCER form at the beginning of the 2007–08 fishing year ([right panel] Figure H.4).

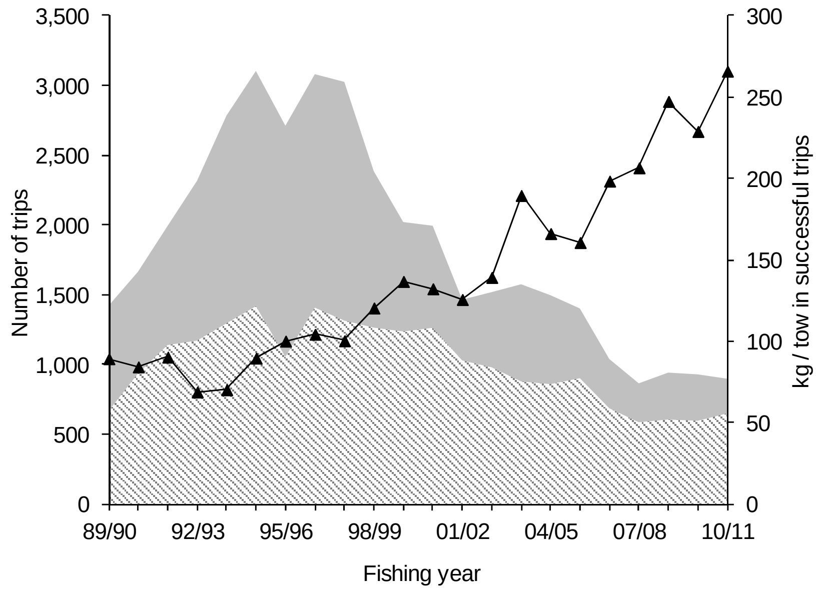


Figure H.3: Number of qualifying trips in TAR3_BT_MIX (dark area), the number of those trips that landed tarakihi (light area) and the simple catch rate (kg/tow) of tarakihi in successful trip-strata, by fishing year.

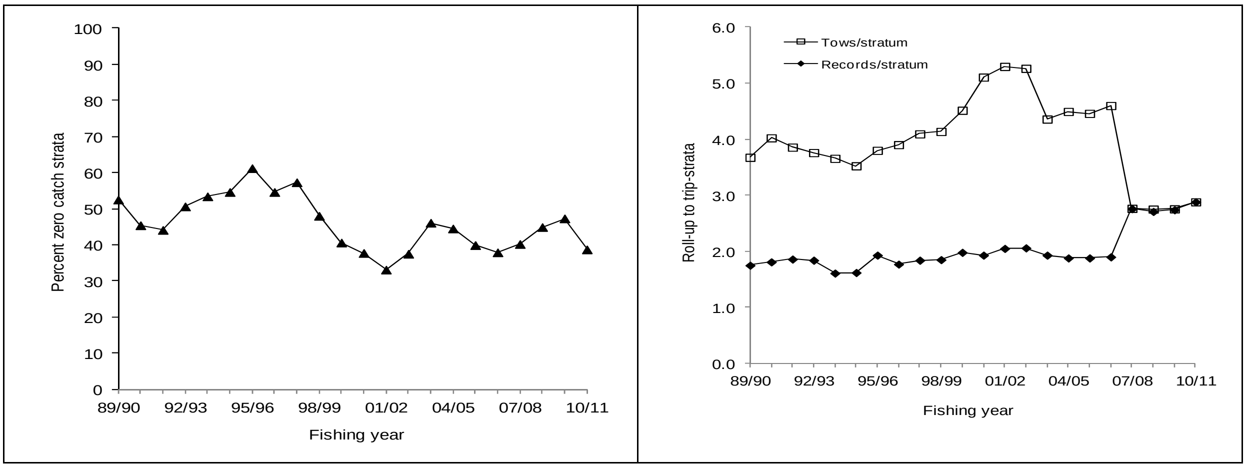


Figure H.4: The proportion of qualifying in TAR3_BT_MIX, that landed zero tarakihi (left), and the effect of amalgamation to trip-strata on the number of original records per trip-stratum and the number of tows per trip-stratum, by fishing year.

H.3.3 TAR3_SN_TAR: Kaikoura target tarakihi setnet

This fishery had virtually no trip-strata reporting zero tarakihi catch up to the 2008–09 fishing year, when inexplicably, there was a sudden appearance of zero-catch trip strata (Figure H.5). Otherwise, there has been little change in this fishery over the 22 years. The strong increase in proportion of zero trip-strata is apparent in the [left panel] of Figure H.14. This fishery had a long history of only recording a single trip-stratum per trip, presumably these being day trips ([right panel] Figure H.14). The average number of events per trip-stratum jumped to over 1.5 in the year the NCELR forms were introduced (2006–07) and have since increased to greater than 2 events per trip-stratum.

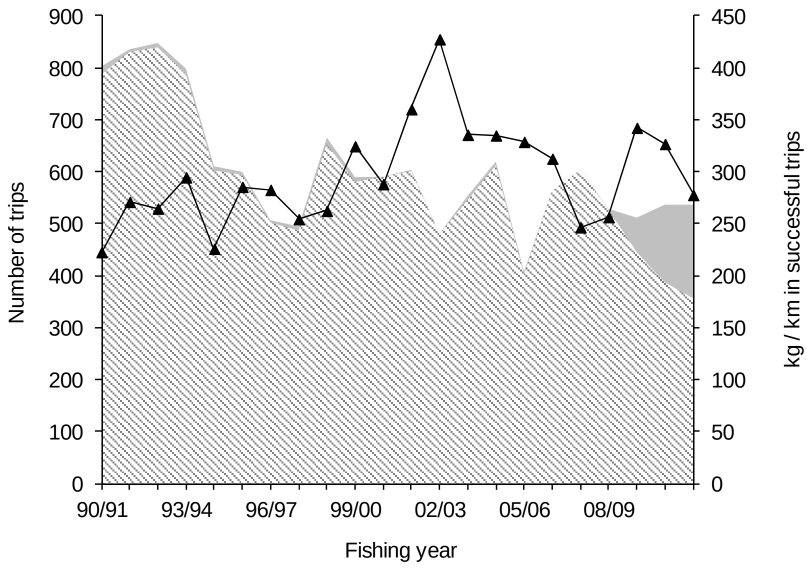


Figure H.5: Number of trips targeting tarakihi, in TAR3_SN_TAR (dark area), the number of those trips that landed tarakihi (light area) and the simple catch rate (kg/km) of tarakihi in successful trip-strata, by fishing year.

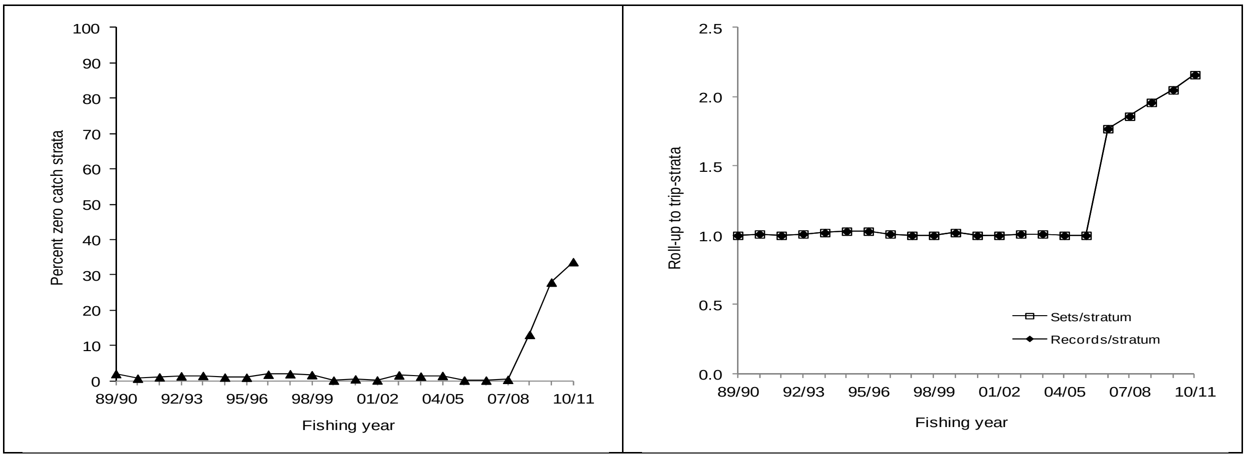


Figure H.6: The proportion of qualifying trips targeting tarakihi in TAR3_SN_TAR, that landed zero tarakihi (left), and the effect of amalgamation to trip-strata on the number of original records per trip-stratum and the number of sets per trip-stratum, by fishing year.

H.4 Standardised CPUE analysis

H.4.1 Core fleet definitions

The data sets used for the standardised CPUE analysis were restricted to those vessels that participated with some consistency in the defined fishery. Core vessels were selected by specifying two variables; the number of trips that determined a qualifying year, and the number of qualifying years that each vessel participated in the fishery. The effect of these two variables on the amount of landed tarakihi retained in the dataset and on the number of core vessels, and the length of participation by the core vessels in each fishery are depicted for each of the defined fisheries in Figure I.1 (TAR 2_BT_MIX), Figure I.2 (TAR 3_BT_MIX) and Figure I.3 (TAR 3_SN_TAR). The core fleet was selected by choosing variable values that resulted in the fewest vessels while maintaining the largest catch of tarakihi. The selection process usually reduced the number of vessels in the dataset by about 70% while reducing the amount of landed tarakihi by about 20%. The summary for the data sets with the core vessels is presented in Table I.1.

H.4.2 Model selection and trends in model year effects

The lognormal models selected for each of the above three fisheries are described in Table H.1 (TAR2_BT_MIX), Table H.2 (TAR3_BT_MIX), and Table H.3 (TAR3_SN_TAR). These tables include the explanatory variables that met the AIC criteria and are not necessarily a complete list of the variables that were offered. The variables that met the acceptance criteria based on a 1% improvement in R^2 are indicated with asterisks in the table, along with the amount of deviance they explained.

Following each table are step-influence plots that demonstrate the progressive effect on the annual indices of each explanatory variable as it enters the model, and compares the influence of each variable on observed catch (which the model adjusts for), in adjacent panels. These plots highlight the observation made in Bentley et al. (2011) that the variables that explain the most deviance are not necessarily the ones responsible for most of the difference between standardised and observed series of CPUE. The influence of an explanatory variable is a combination of its GLM coefficients and its distributional changes over years, and these are summarised in Coefficient-Distribution-Influence (CDI) plots (Bentley et al. 2011), given for each accepted explanatory variable presented in Table H.1, Table H.2, and Table H.3.

Diagnostic plots of the residuals from each lognormal model fit show a relatively poor fit to the distributional assumption for the TAR2_BT_MIX analysis (Figure I.4) and the TAR3_SN_TAR analysis (Figure I.9). However, the TAR3_BT_MIX analysis (Figure I.7) shows a much better fit to the lognormal distribution. Analyses testing alternative distributional assumptions (not reported here because these analyses were not used in the stock assessment) found that the Weibull distribution gave better fits to the data sets for the TAR2_BT_MIX and TAR3_SN_TAR data sets (see Appendix Section J.2.2 for a description of this method), but that the lognormal distributional assumption was the best (lowest AIC) for TAR3_BT_MIX data set. However, the resulting Weibull-based year indices were not greatly different from the lognormal-based indices.

Implied coefficient plots for each statistical area by year combination shows a likely area×year interaction effect for TAR2_BT_MIX analysis (Figure I.5) but not for the TAR 3_BT_MIX analysis (Figure I.8). Figure I.5 appears to show that the two statistical areas north of Hawkes Bay (Area 011 and Area 012) have different annual trends than the areas off the Wairarapa coast (Area 013 and Area 014, which have the greater catch levels; see Appendix D). Further investigation of these issues should be considered for the next iteration of these analyses. Month×area interaction effects were also investigated for the TAR2_BT_MIX and TAR3_BT_MIX analyses but were found to be unimportant. Finally, implied residual coefficients for targetspecies×year in the TAR2_BT_MIX analysis show that the two most important target species in terms of total catch (TAR and GUR, Figure I.6) show similar peak periods of good catches, but there are periods of lower TAR catch rates before and after the peak period when targeting GUR compared to TAR. The NINSWG concluded, on the basis of this evidence, that the addition of GUR as an explanatory factor improved the analysis because it covered a portion of the TAR depth distribution that was not sampled by the target TAR fishery.

H.4.2.1 Other models

Other models that were examined but were not used in the stock assessment and are therefore not presented here. These include binomial and combined models for the mixed target fisheries, and a lognormal model for the TAR2_BT_MIX fishery that offered a month×area interaction term to better account for the seasonal migration of tarakihi along the coast. The interaction term was accepted in the TAR2_BT_MIX analysis in preference to area and month (offered only as main effects), but did not produce discernibly different annual indices. For ease of interpretation and clearer diagnostics, the main effects models are presented here.

H.4.2.2 TAR2_BT_MIX: East coast, North Island mixed species bottom trawl

The TAR2_BT_MIX lognormal model (Table H.1) explained 60% of the variance in log catch, by standardising for the effect of changes in targeting, number of tows, and participation of vessels in the core fleet. Diagnostic residual plots are presented for the lognormal model in Figure I.4 and show a relatively poor fit of the data to the lognormal assumption with unexplained patterns in the residuals, and with a marked departure at the tail of the distribution associated with smaller observed values.

Table H.1: Order of acceptance of variables into the lognormal model of successful catches of tarakihi for core vessels (based on the vessel selection criteria of at least 10 trips in 5 or more fishing years) in the TAR2_BT_MIX fishery with the amount of explained deviance for each variable. Variables accepted into the model are marked with an *. Fishing year was forced as the first variable.

Term	DF	Deviance	Deviance explained (%)	AIC	Final
None	0	116 987	0.00	124 167	
fyear	22	116 038	0.81	123 969	*
target	27	80 271	31.38	113 130	*
poly(log(tows) 3)	30	57 491	50.86	103 310	*
vessel	97	46 626	60.14	97 277	*
area	102	45 473	61.13	96 550	
poly(log(duration) 3)	105	44 465	61.99	95 896	
month	116	44 191	62.23	95 736	

Residual implied coefficients show an earlier peak in Area 011 compared to Areas 012, 013 or 014 (Figure I.5). This implies some difference in the fishing year trends among the statistical areas. Area 011 is an important area with respect to landed catch, and this difference in trend may reduce the utility of this index series.

Shifts in the importance of bycatch (mainly red gurnard) relative to the target fishery are predicted to have accounted for greater catches of tarakihi in the early 1990s and a period of lower catches in the early 2000s; a pattern that is cyclical but that had a negative influence overall (Figure I.10). Adjusting for this influence lowers the initial points and creates the peak in the middle of the time series. The influence of tows on observed catches has also been cyclical but slightly negative overall and its inclusion into the lognormal model reduces some of the interannual variance, smoothing the trajectory without changing its shape (Figure I.11). Changes in the core fleet have also had a cyclical influence on observed catches that has had an increasing trend over the last ten years (Figure I.12). Its inclusion into the model further lifts the peak, drops some recent points, and generally smoothes the trajectory giving it a more credible shape. Shifts in all three explanatory variables have been cyclical in their influence on observed CPUE, but all suggest that there was some active and effective avoidance of tarakihi during the early 2000s when abundance was at a peak (Figure H.7).

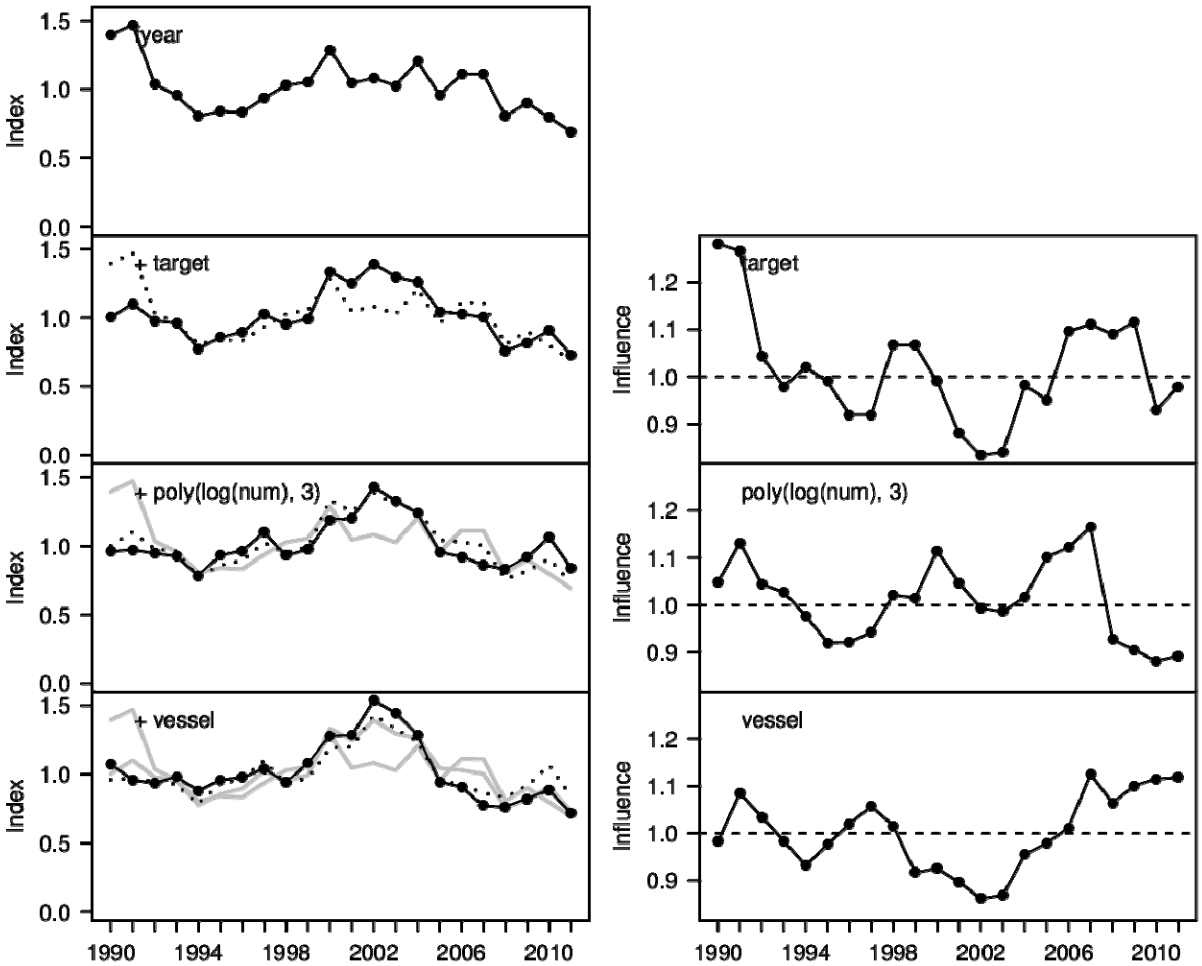


Figure H.7: Step and annual influence plot for TAR2_BT_MIX. (a) CPUE index at each step in the selection of variables. The index obtained in the previous step (if any) is shown by a dotted line and for steps before that by grey lines. (b) Annual influence on observed catches arising from a combination of its GLM coefficients and its distributional changes over years, for each explanatory variable in the final model.

The effect of standardisation on catch rate in successful trips was to create a broad peak over several years in the late 1990s and early 2000s that was not evident in the unstandardised series (Figure H.8). This indicates that factors within the control of fishers can be altered to reduce catches when abundance was high. This appears to have been caused by a shift towards shallower gurnard tows. After 2002–03, the opposite is apparent, with standardisation dropping the series to account for more effective targeting of tarakihi. The last half of the time series declines over a period of nine years, except for a shallow recovery in 2008–09 and 2009–10 which was reversed by a sharp drop in 2010–11, which is the lowest point in the series. The trajectory is well-determined with relatively small error bars around each point and there is good agreement with the previous series presented for this fishery (Jiang & Bentley 2008). That series was based on target tows only (Figure H.10) and was replicated for this study (Figure 22), producing a lower and broader peak than the series presented here.

A standardised binomial model showed a shallow increasing trend for this fishery, but very little effect on the overall trend when combined with the lognormal model (Figure H.9).

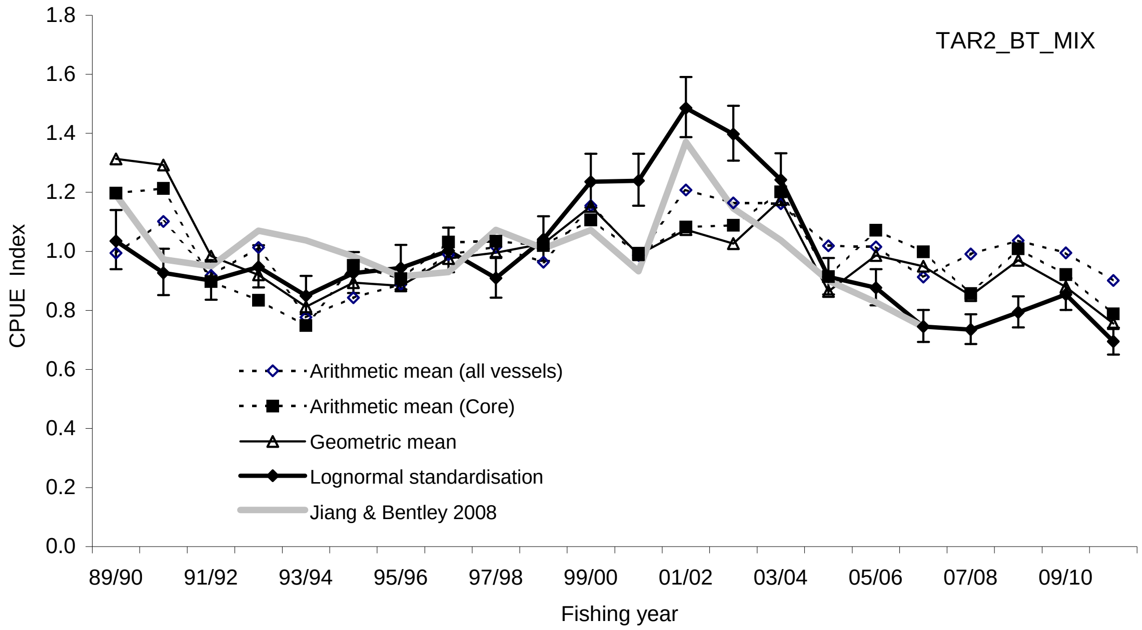


Figure H.8: The effect of standardisation on the raw CPUE of tarakihi in successful trips by core vessels in the TAR2_BT_MIX fishery. Broken lines are the raw CPUE (kg /tow) for all vessels and for the core fleet only, the solid line is the unstandardised CPUE (annual geometric mean), the bold line is the standardised CPUE canonical indices with ± 2 * SE error bars. Grey line is the previous lognormal series presented in 2008 for a similar fishery(target tows only). All series are relative to the geometric mean over the years in common.

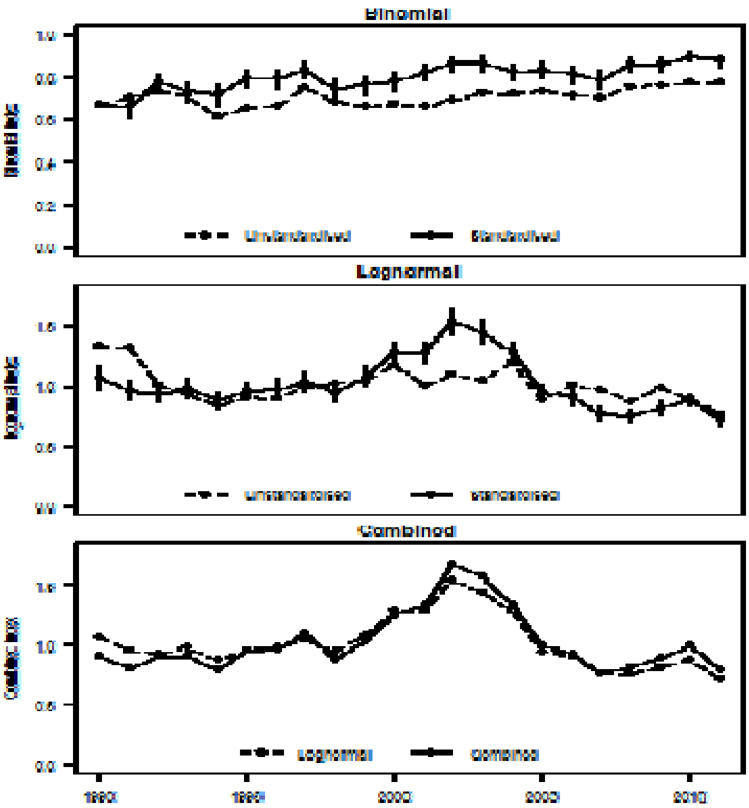


Figure H.9: The effect of standardisation on the raw CPUE of tarakihi by core vessels in the TAR2_BT_MIX fishery. Top: Binomial index of probability of capture. Middle: Lognormal index of magnitude of catch. broken line is the raw CPUE (kg / tow) the solid line is the standardised CPUE canonical indices with ± 2 * SE error bars. Bottom: The effect on the lognormal index of combining it with the Binomial index.

H.4.2.3 TAR3_BT_MIX: East coast, South Island mixed species bottom trawl

The TAR3_BT_MIX lognormal model (Table H.2) explained 40% of the variance in log catch, by standardising for the effect of changes in the core fleet, duration of fishing, targeting, as well as month and area fished. Diagnostic residual plots are presented for the lognormal model in Figure I.7 and show a good fit of the data to the assumed lognormal distribution. Residual implied coefficients show very similar year indices in each of the component statistical areas (Figure I.8).

Changes in the participation of the core vessels in this fishery are predicted to have steadily increased observed catches over the entire study period and when the model adjusts for this influence, an apparently increasing trajectory is changed to one that is flat overall (Figure I.13). The inclusion of duration into the model lifts some recent points in an adjustment for a shift towards lower total duration per stratum, but the inclusion of the remaining variables continue to move the standardised series downwards in recent years (Figure I.14). A shift away from red cod bycatch and towards more targeted tarakihi since the early 2000s increased catches (Figure I.15), and an increased emphasis since 2004–05 on the months of peak abundance of tarakihi (January to May), similarly increased catches (Figure I.16). Increased fishing in the less productive areas of 024 and 026 may have depressed observed catches somewhat since 2001–02 but the influence is small (Figure I.17) and the effect on the year effects was negligible (Figure H.10).

The effect of standardisation on catch rate in successful trips is dramatic; changing a trajectory that increases steadily over the first half of the time series, and steeply over the second half, to one that is flat overall, and which declines over four consecutive years from a peak in 1999–2000 to a new low level where it has been relatively stable for the most recent eight years (Figure H.11). This difference between the unstandardised and standardised CPUE demonstrates the high degree to which fishers are able to adjust their catch of tarakihi in this mixed species fishery and appear to have resulted in increased tarakihi catches due to more specific targeting despite flat or declining underlying abundance (Figure H.11).

Table H.2: Order of acceptance of variables into the lognormal model of successful catches of tarakihi for core vessels (based on the vessel selection criteria of at least 10 trips in 5 or more fishing years) in the TAR3_BT_MIX fishery with the amount of explained deviance for each variable. Variables accepted into the model are marked with an * . Fishing year was forced as the first variable.

Term	DF	Deviance	Deviance explained (%)	AIC	Final
None	0	146 463	0.00	116 027	
fyear	22	143 182	2.24	115 497	*
vessel	98	120 748	17.56	111 347	*
poly(log(duration), 3)	101	106 533	27.26	108 191	*
target	105	92 168	37.07	104 543	*
month	116	90 088	38.49	103 989	*
area	121	88 097	39.85	103 435	*
poly(log(num), 3)	124	88 036	39.89	103 423	

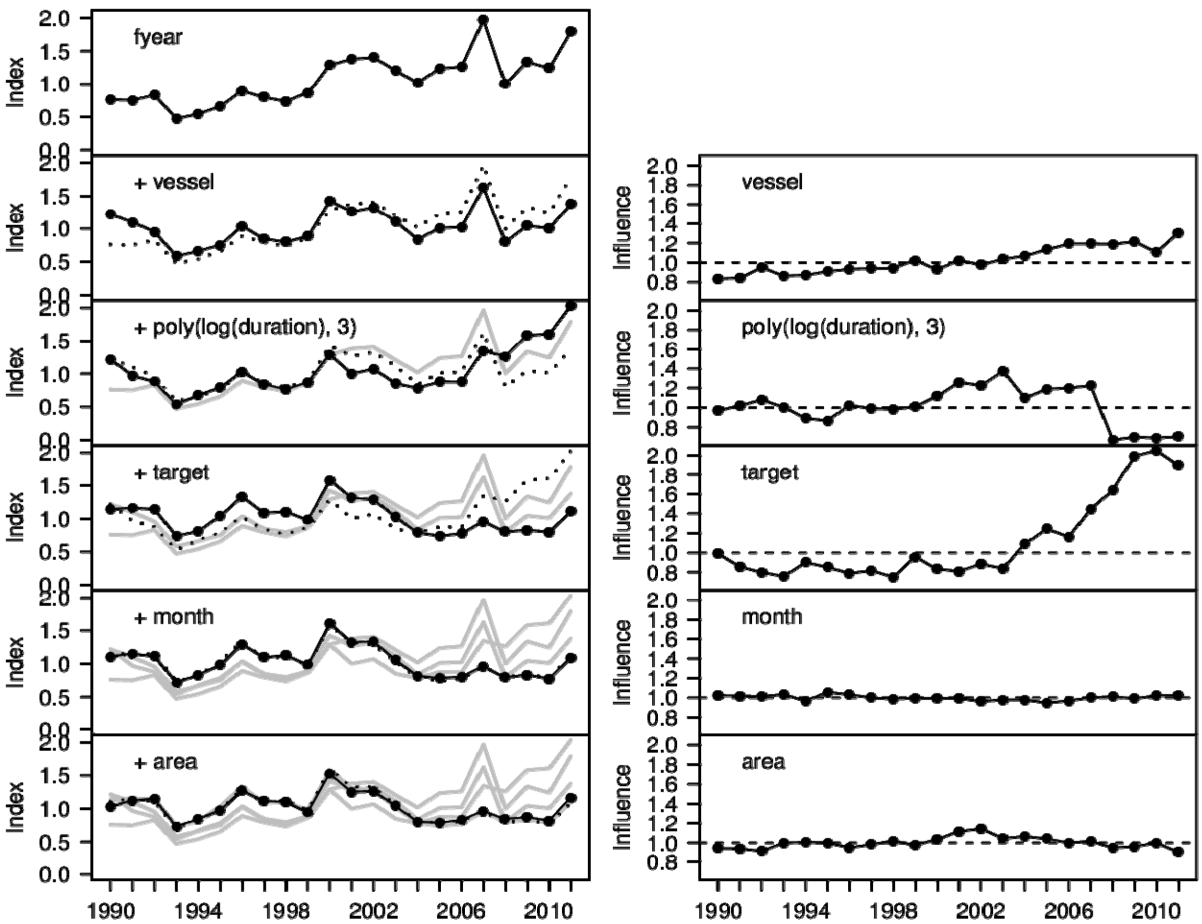


Figure H.10: Step and annual influence plot for TAR3_BT_MIX. (a) CPUE index at each step in the selection of variables. The index obtained in the previous step (if any) is shown by a dotted line and for steps before that by grey lines. (b) Annual influence on observed catches arising from a combination of its GLM coefficients and its distributional changes over years, for each explanatory variable in the final model.

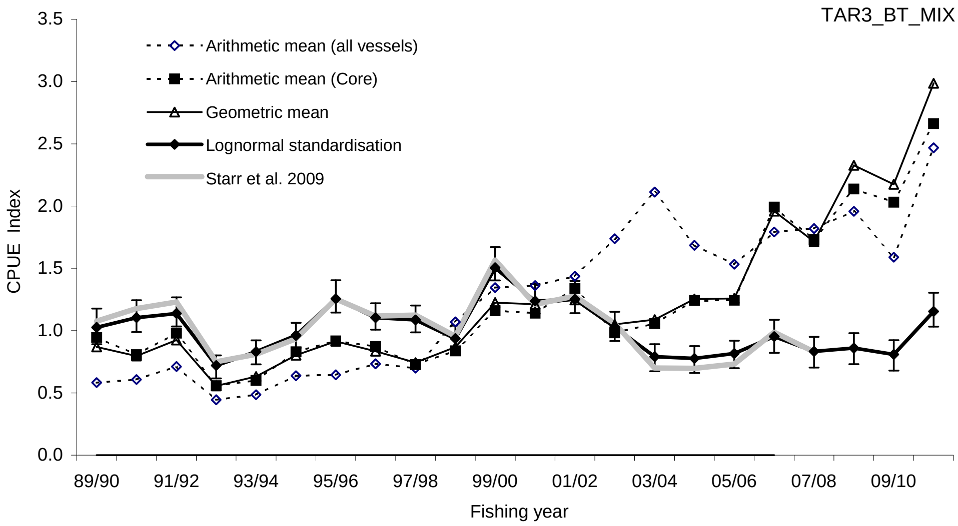


Figure H.11: The effect of standardisation on the raw CPUE of tarakihi in successful trips by core vessels in the TAR3_BT_MIX fishery. Broken lines are the raw CPUE (kg /tow) for all vessels and for the core fleet only, the solid line is the unstandardised CPUE (annual geometric mean), the bold line is the standardised CPUE canonical indices with ± 2 * SE error bars. Grey line is the previous lognormal series presented in 2009 for a similar fishery. All series are relative to the geometric mean over the years in common.

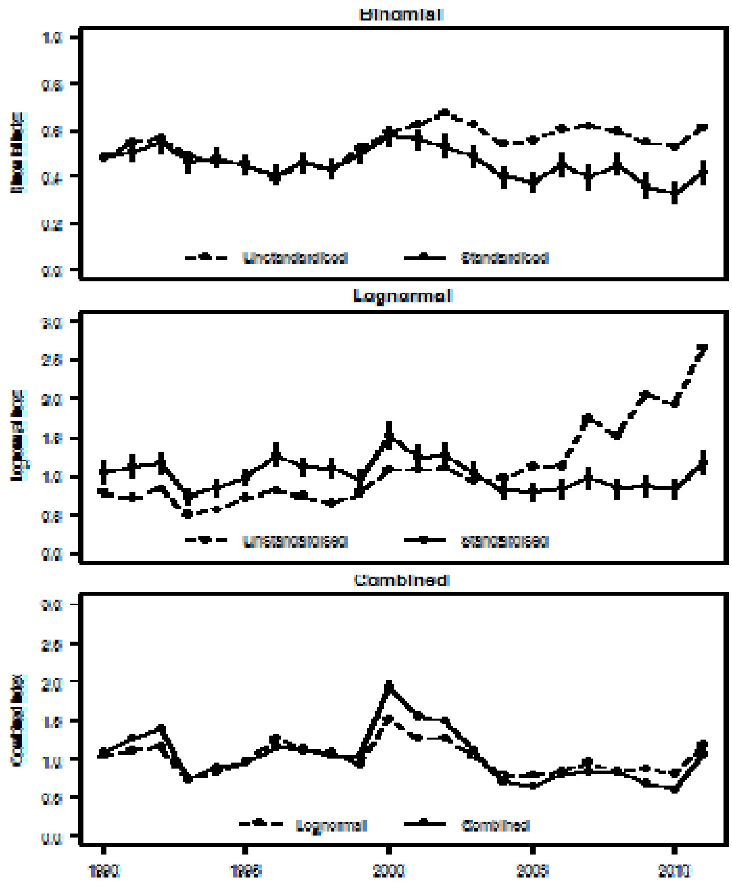


Figure H.12: The effect of standardisation on the raw CPUE of tarakihi by core vessels in the TAR3_BT_MIX fishery. Top: Binomial index of probability of capture. Middle: Lognormal index of magnitude of catch. broken line is the raw CPUE (kg / tow) the solid line is the standardised CPUE canonical indices with ± 2 * SE error bars. Bottom: The effect on the lognormal index of combining it with the Binomial index.

A standardised binomial model showed a stepped decrease from a peak near 2000, resembling closely the lognormal trend (Figure H.12). However, as for the TAR 2_BT_MIX CPUE series, there was very little effect on the overall trend when combined with the lognormal model (Figure H.12).

H.4.2.4 TAR3_SN_MIX: Kaikoura target tarakihi setnet

The TAR3_SN_TAR lognormal model (Table H.3) explained 45% of the variance in log catch, by standardising for the effect of changes in length of net set, and changes in the core fleet as well as to the seasonality of fishing. Although net length was the variable with the greatest explanatory power (23%), its influence on observed catches was neutral overall and its inclusion in the lognormal model did not markedly alter the trajectory of annual indices (Figure I.18). The influence of changes in the core fleet however was strongly positive and predicted to have increased catches of tarakihi over the study period (Figure I.19). The inclusion of vessel into the model lifted early points and lowered the peak in the early 2000s that is the main effect in the shift away from the unstandardised series. The influence of shifts in the seasonality of fishing was also positive overall (Figure I.20), and continued to move the standardised series away from the unstandardised by lifting early points, lowering the peak in the early 2000s and dropping more recent points **(**Figure H.13**).**

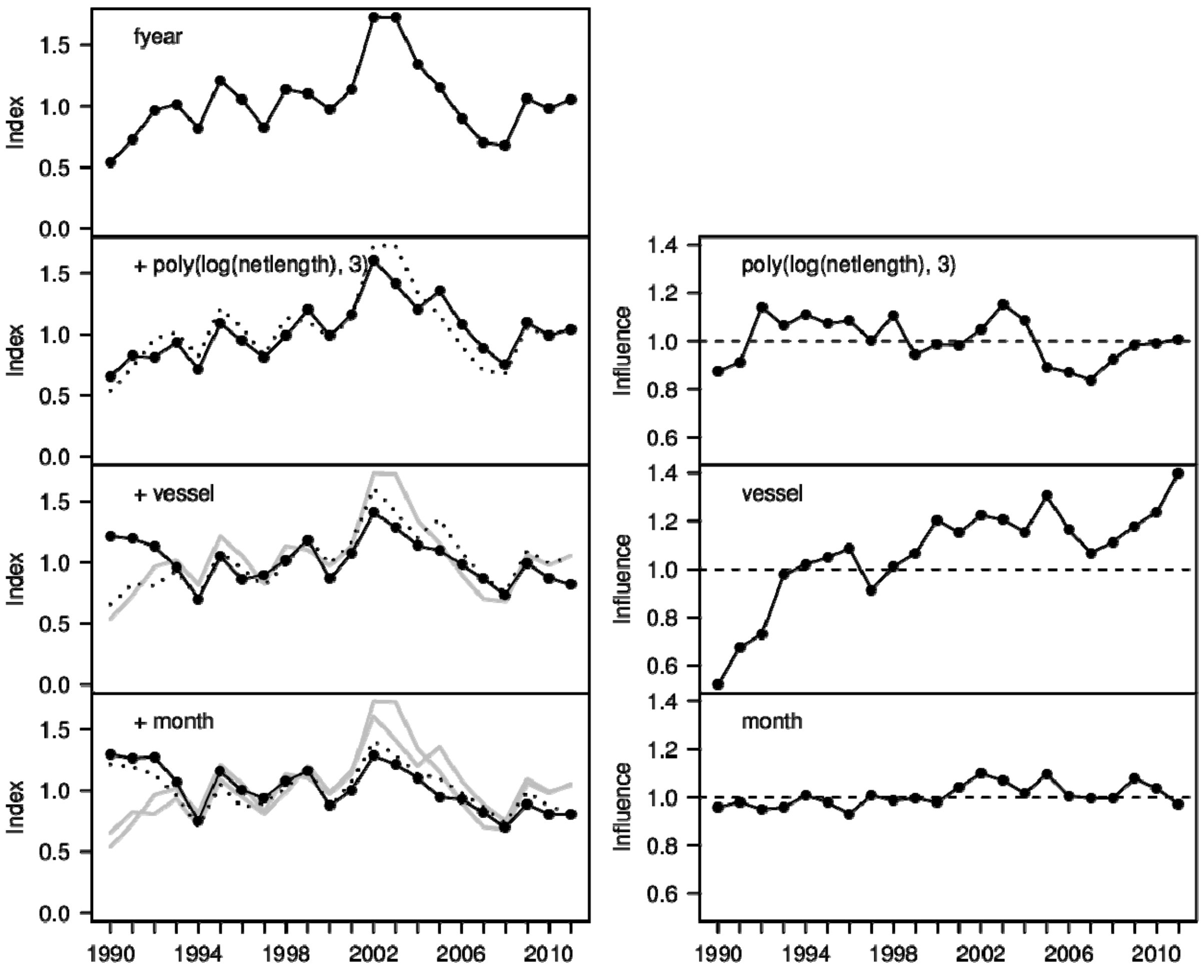


Figure H.13: Step and annual influence plot for TAR3_SN_TAR. (a) CPUE index at each step in the selection of variables. The index obtained in the previous step (if any) is shown by a dotted line and for steps before that by grey lines. (b) Annual influence on observed catches arising from a combination of its GLM coefficients and its distributional changes over years, for each explanatory variable in the final model.

Diagnostic residual plots are presented for the lognormal model in Figure I.9 and show a poor fit of the data to the lognormal assumption with considerable departure at the lower tail end of the residual distribution but with the remaining distribution reasonably well formed.

Table H.3: Order of acceptance of variables into the lognormal model of successful catches of tarakihi for core vessels (based on the vessel selection criteria of at least 10 trips in 3 or more fishing years) in the TAR3_SN_TAR fishery with the amount of explained deviance for each variable. Variables accepted into the model are marked with an * . Fishing year was forced as the first variable

Term	DF	Deviance	Deviance explained (%)	AIC	Final
None	0	20 161	0.00	42 080	
fyear	22	19 159	4.97	41 471	*
poly(log(netlength), 3)	25	14 526	27.95	37 941	*
vessel	40	11 988	40.54	35 519	*
month	50	11 047	45.21	34 494	*
poly(log(duration), 3)	53	10 985	45.51	34 428	

The effect of standardisation on catch rate in successful trips was considerable, and mainly flattened and smoothed the series, reducing the apparent peak in observed catches in the early 2000s, and thereby the steepness of the decline sustained over the following six consecutive years (Figure H.14). An apparent recovery after the low in 2007–08 is also reduced by standardisation. The differences between the standardised and unstandardised series indicates that despite this being a target fishery, fishers have been able to improve their targeting of the species, even while the underlying population has been apparently declining. The trajectory is reasonably well-determined with small error bars around each point and there is good agreement with the previous series presented for this fishery (Figure H.14).

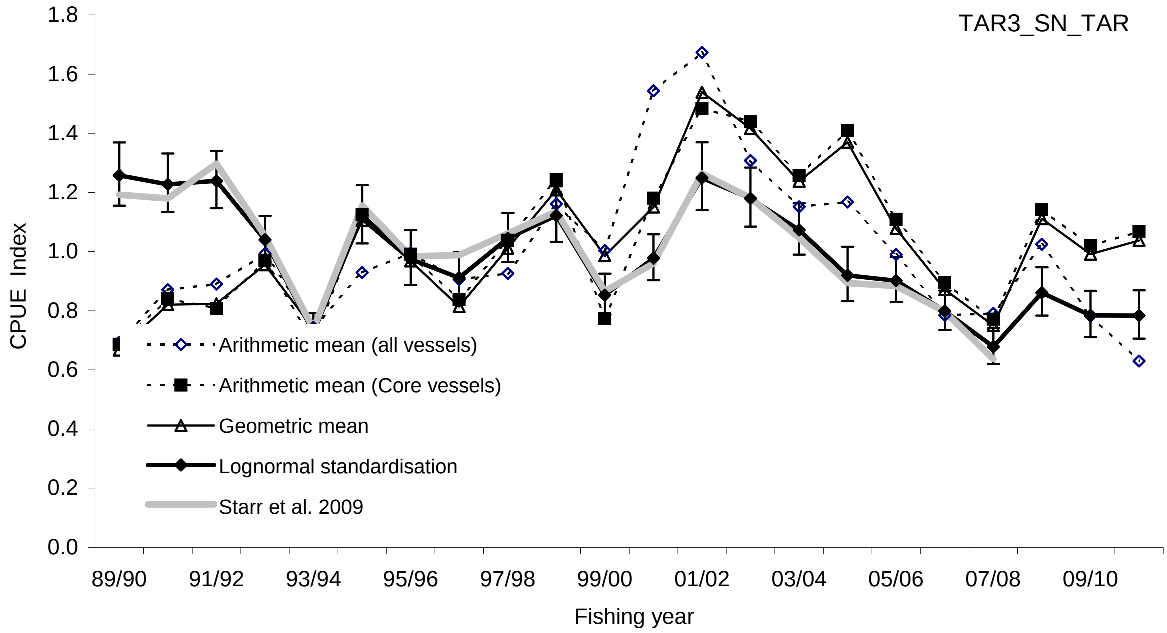


Figure H.14: The effect of standardisation on the raw CPUE of tarakihi in successful trips by core vessels in the TAR3_SN_TAR fishery. Broken lines are the raw CPUE (kg /km net) for all vessels and for the core fleet only, the solid line is the unstandardised CPUE (annual geometric mean), the bold line is the standardised CPUE canonical indices with ± 2 * SE error bars. Grey line is the previous lognormal series presented in 2009 for this fishery. All series are relative to the geometric mean over the years in common.

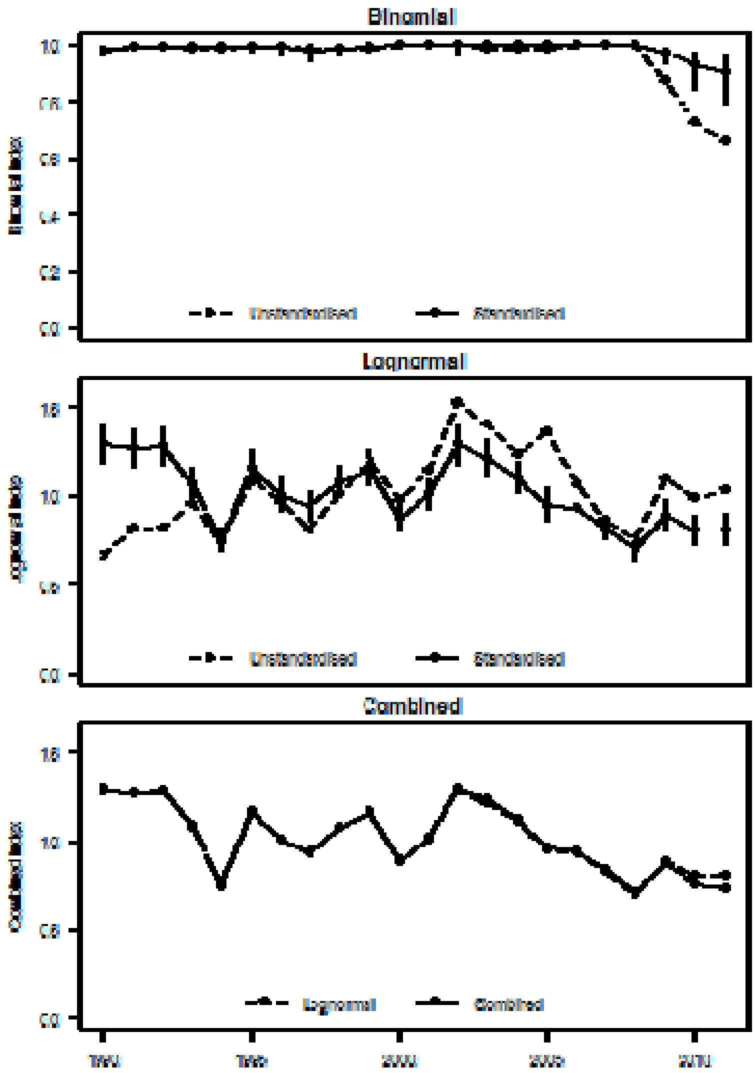


Figure H.15: The effect of standardisation on the raw CPUE of tarakihi by core vessels in the TAR3_SN_TAR fishery. Top: Binomial index of probability of capture. Middle: Lognormal index of magnitude of catch. broken line is the raw CPUE (kg / km) the solid line is the standardised CPUE canonical indices with ± 2 * SE error bars. Bottom: The effect on the lognormal index of combining it with the Binomial index.

A standardised binomial model showed no change over every year in the series except for the final three years, where there is a strong drop caused by the increasing proportion of zero trip strata in this fishery (Figure H.15). Surprisingly, as for the TAR 2_BT_MIX and TAR 3_BT_MIX CPUE series, this declining trend had very little overall effect on the trend when combined with the lognormal model (Figure H.15).

Appendix I. DETAILED DIAGNOSTICS FOR TARAKIHI (EAST COAST) CPUE STANDARDISATIONS

I.1 Core vessel selection

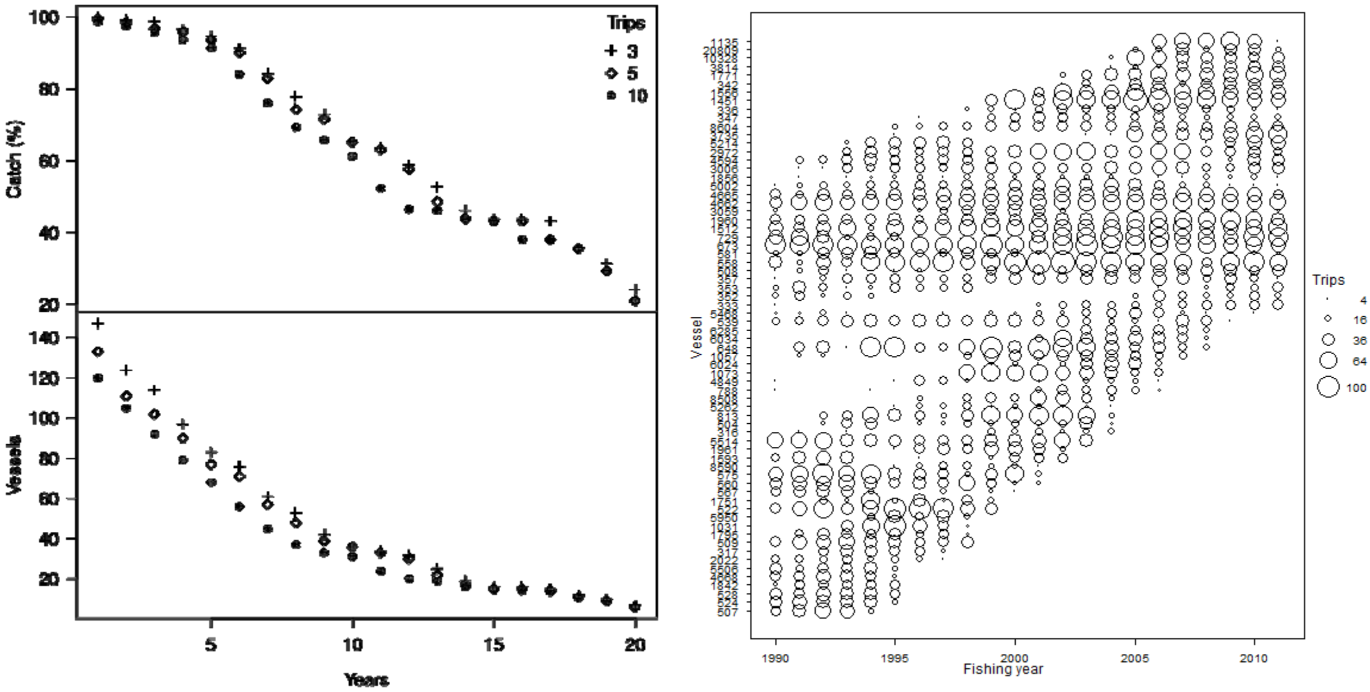


Figure I.1: The total landed tarakihi [top left] and the number of vessels [bottom left] retained in the TAR2_BT_MIX dataset depending on the minimum number of qualifying years used to define core vessels. The distribution of trips by fishing year for the selected core vessels (defined as 10 trips per year in 5 years) is shown on the right.

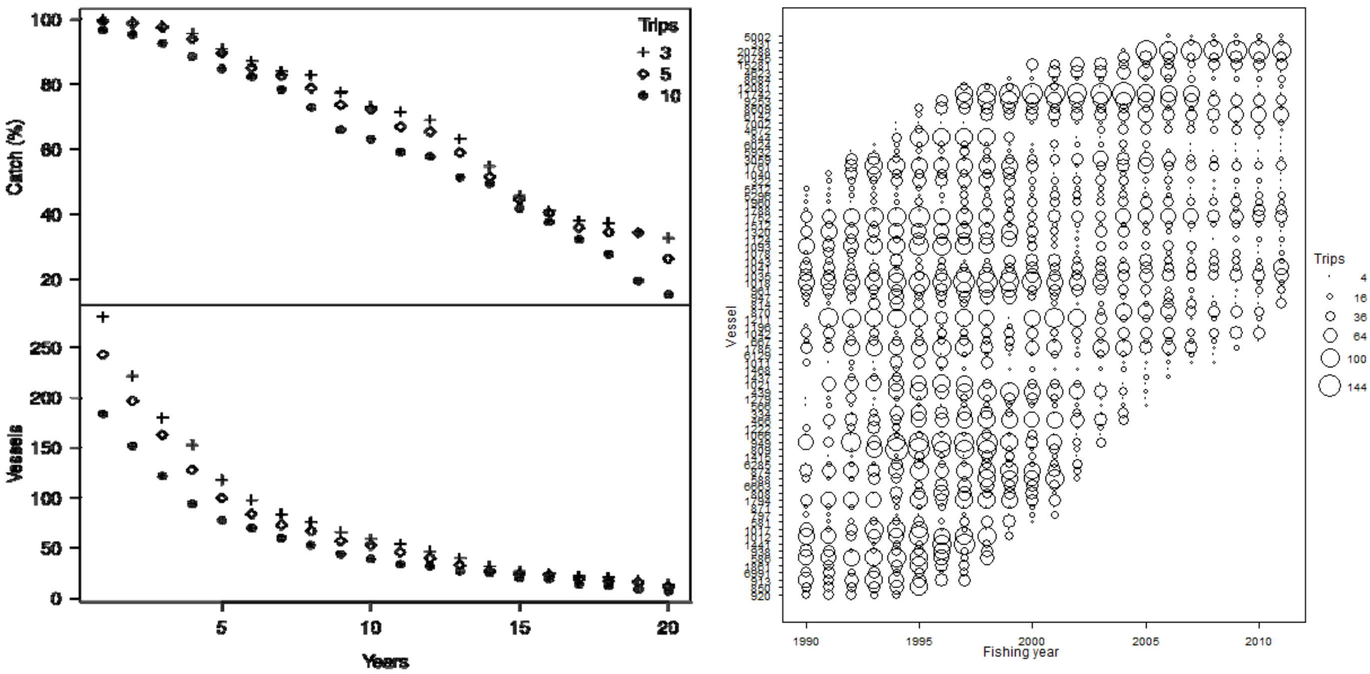


Figure I.2: The total landed tarakihi [top left] and the number of vessels [bottom left] retained in the TAR3_BT_MIX dataset depending on the minimum number of qualifying years used to define core vessels. The distribution of trips by fishing year for the selected core vessels (defined as 10 trips per year in 5 years) is shown on the right.

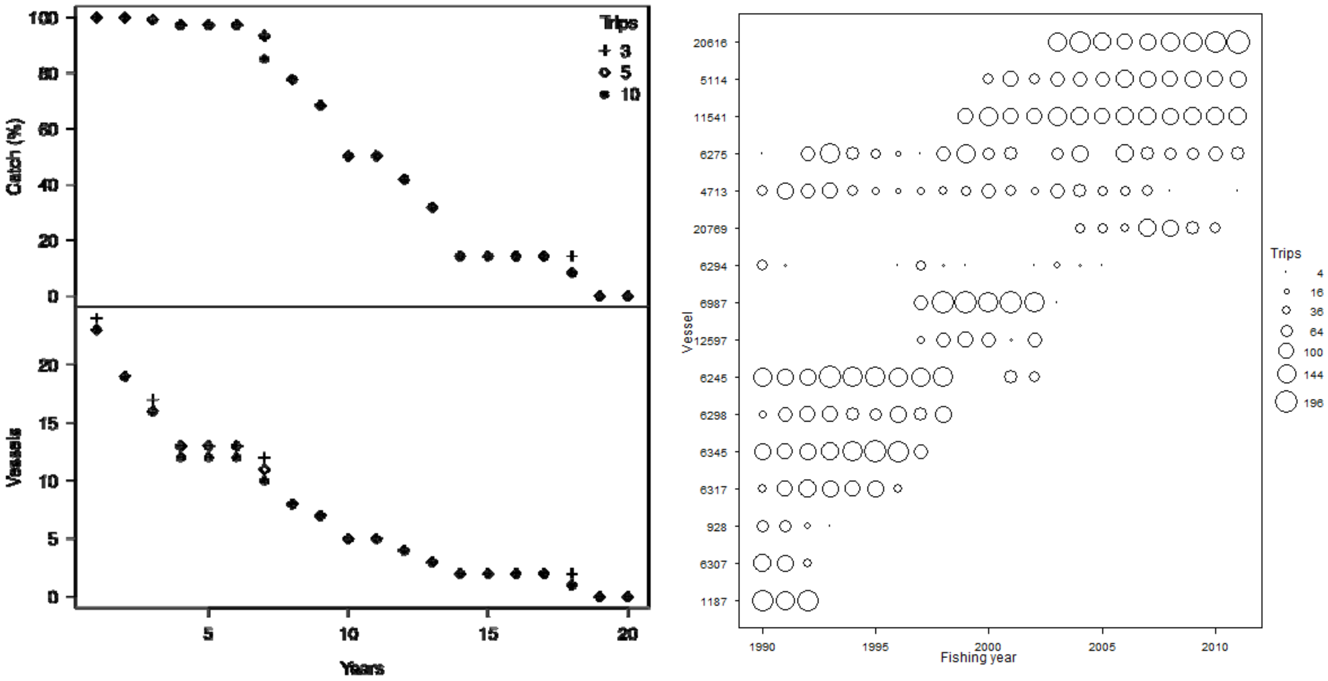


Figure I.3: The total landed tarakihi [top left] and the number of vessels [bottom left] retained in the TAR3_SN_TAR dataset, depending on the minimum number of qualifying years used to define core vessels. The distribution of trips by fishing year for the selected core vessels (defined as 10 trips per year in 3 years) is shown on the right.

I.2 Data summaries

Table I.1: Number of vessels, trips, trip strata, events, sum of catch, sum of tows (or net length) and sum of hours fishing for core vessels in the three CPUE analyses by fishing year.

	TAR 2_BT_MIX								TAR 3_BT_MIX								TAR 3_SN_TAR							
Fishing year	Vessel	Trips	Trip-strata	events	Catch	Tows	Hours	% zero	Vessel	Trips	Trip-strata	events	Catch	Tows	Hours	% zero	Vessel	Trips	Trip-strata	events	Catch	Net (km)	Hours	% zero
1990	33	876	1 086	1 881	942	4 508	16 901	33.0	41	1 421	1 640	2 872	315	6 028	19 977	52.5	10	803	803	805	189	861	22 140	2.0
1991	35	1 071	1 408	2 723	1 409	6 455	24 258	29.7	49	1 666	1 911	3 461	420	7 689	25 498	45.4	9	836	836	847	287	1 063	22 006	0.7
1992	38	1 422	1 807	3 425	1 327	7 630	29 939	27.2	56	1 993	2 331	4 338	540	8 992	32 431	44.1	9	848	848	852	352	1 348	21 370	1.1
1993	42	1 319	1 782	3 230	1 395	7 588	31 070	28.8	55	2 317	2 655	4 883	386	9 985	36 062	50.6	7	799	799	806	337	1 154	19 511	1.4
1994	40	1 511	2 025	3 730	1 136	7 632	31 170	39.2	62	2 785	3 033	4 881	430	11 091	36 189	53.4	6	611	611	622	198	888	15 070	1.5
1995	42	1 400	1 871	3 321	1 133	6 587	26 675	34.7	61	3 105	3 349	5 432	566	11 804	39 599	54.6	6	600	600	618	259	911	14 852	1.0
1996	41	1 187	1 596	3 362	1 040	5 902	22 425	33.6	60	2 713	2 930	5 643	579	11 136	35 652	61.2	7	507	507	522	209	745	12 417	1.0
1997	38	1 134	1 637	3 381	1 098	6 226	23 178	25.7	62	3 082	3 348	5 920	761	13 064	40 449	54.6	8	495	495	498	180	718	11 654	1.8
1998	39	1 234	1 682	3 458	1 225	6 785	24 697	32.2	59	3 027	3 326	6 135	735	13 619	40 824	57.3	7	666	666	669	259	1 000	15 485	2.0
1999	40	1 423	1 915	3 872	1 339	7 636	28 183	33.6	56	2 387	2 596	4 793	806	10 740	32 699	48.0	6	590	590	591	240	750	13 812	1.7
2000	37	1 337	1 837	3 829	1 541	7 890	29 906	32.2	55	2 022	2 247	4 446	988	10 145	31 038	40.6	6	591	591	600	243	845	14 692	0.2
2001	41	1 477	2 021	4 137	1 437	8 089	29 594	33.7	55	1 995	2 187	4 211	1 085	11 169	36 269	37.7	7	604	604	604	309	863	14 680	0.5
2002	39	1 551	2 126	4 364	1 561	8 278	29 906	30.9	50	1 465	1 674	3 439	824	8 868	28 267	33.1	7	481	481	481	348	816	10 829	0.2
2003	38	1 521	2 179	4 454	1 587	8 589	32 055	27.9	45	1 519	1 766	3 635	916	9 296	31 713	37.5	7	554	554	558	308	932	13 480	1.6
2004	38	1 367	1 987	4 177	1 546	7 951	28 971	28.6	45	1 575	1 848	3 571	933	8 055	27 454	46.1	7	620	620	626	299	904	15 036	1.3
2005	35	1 450	2 089	4 580	1 553	9 047	33 546	26.6	44	1 497	1 794	3 371	864	8 061	28 180	44.5	6	408	408	409	154	474	9 284	1.5
2006	39	1 426	2 030	4 493	1 738	9 150	32 909	29.1	41	1 402	1 677	3 152	855	7 478	26 650	39.9	6	564	564	565	212	679	16 327	0.2
2007	33	1 299	1 885	4 704	1 540	8 808	31 040	30.0	39	1 039	1 297	2 469	844	5 965	22 042	37.9	6	604	604	1 075	176	714	29 500	0.2
2008	35	1 105	1 971	7 817	1 495	7 859	27 705	24.6	35	864	1 475	4 078	563	4 078	14 733	40.2	6	529	529	982	178	695	29 287	0.4
2009	32	1 170	2 174	8 396	1 700	8 397	29 574	24.2	37	941	1 634	4 428	708	4 496	16 524	44.9	5	512	512	1 001	200	703	29 349	13.1
2010	33	1 252	2 379	9 173	1 698	9 173	32 365	22.4	40	929	1 720	4 721	661	4 742	17 326	47.3	5	537	537	1 103	178	748	32 368	27.9
2011	32	1 088	2 178	8 514	1 486	8 514	29 320	23.0	38	898	1 680	4 841	889	4 841	17 561	38.7	5	537	537	1 159	144	765	33 460	33.7

I.3 Diagnostic plots

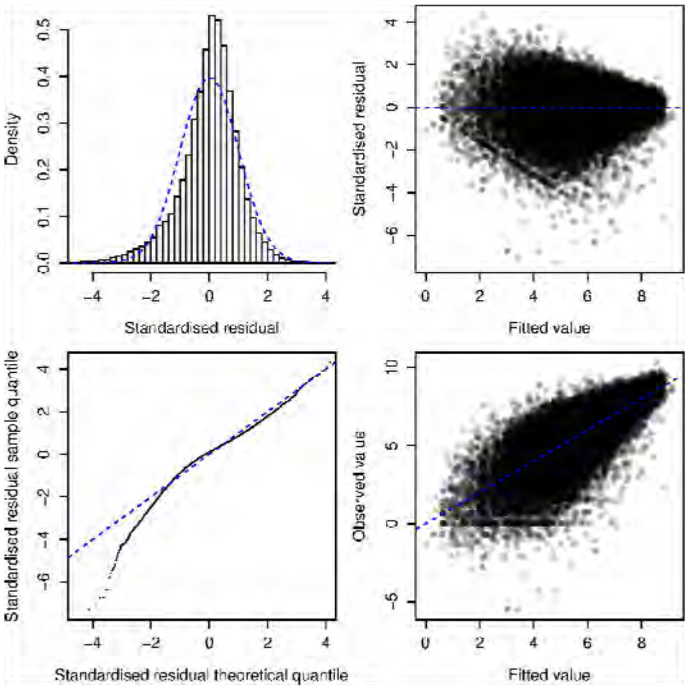


Figure I.4: Plots of the fit of the standardised CPUE model to successful catches of tarakihi in the TAR2_BT_MIX fishery. [Upper left] histogram of the standardised residuals compared to a lognormal distribution (SDSR: standard deviation of standardised residuals. MASR: median of absolute standardised residuals); [Upper right] Standardised residuals plotted against the predicted model catch per trip; [Lower left] Q-Q plot of the standardised residuals; [Lower right] Observed catch per record plotted against the predicted catch per record.

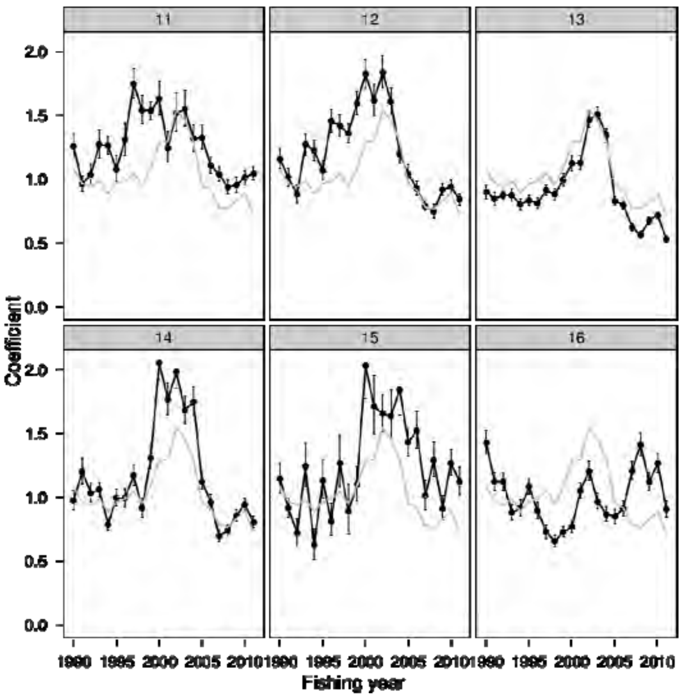


Figure I.5: Residual implied coefficients for each area in each fishing year for the TAR2_BT_MIX CPUE analysis. Implied coefficients are calculated as the sum of the fishing year coefficient plus the mean of the residuals in each fishing year in each area. The error bars indicate one standard error of residuals. The grey line indicates the model's overall fishing year coefficients.

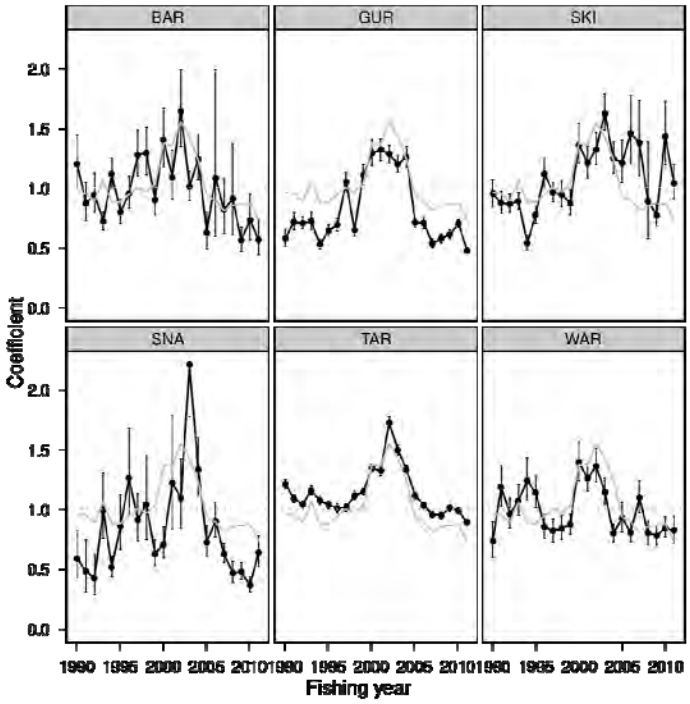


Figure I.6: Residual implied coefficients for each target species in each fishing year for the TAR2_BT_MIX CPUE analysis. Implied coefficients are calculated as the sum of the fishing year coefficient plus the mean of the residuals in each fishing year for each target species. The error bars indicate one standard error of residuals. The grey line indicates the model's overall fishing year coefficients.

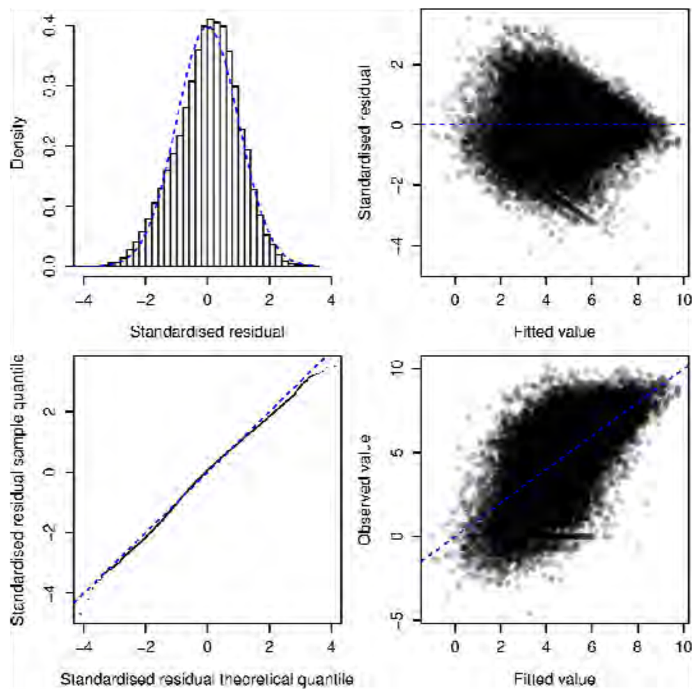


Figure I.7: Plots of the fit of the standardised CPUE model to successful catches of tarakihi in the TAR3_BT_MIX fishery. [Upper left] histogram of the standardised residuals compared to a lognormal distribution (SDSR: standard deviation of standardised residuals. MASR: median of absolute standardised residuals); [Upper right] Standardised residuals plotted against the predicted model catch per trip; [Lower left] Q-Q plot of the standardised residuals; [Lower right] Observed catch per record plotted against the predicted catch per record.

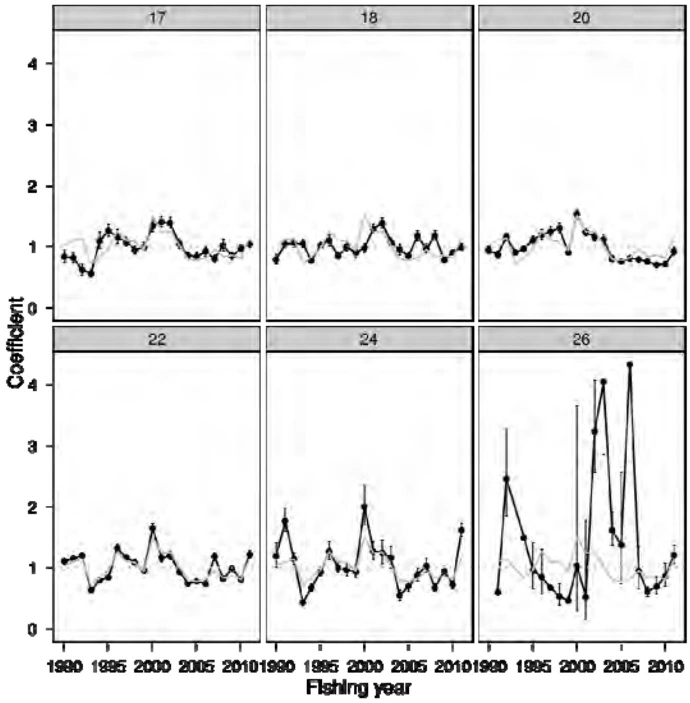


Figure I.8: Residual implied coefficients for each area in each fishing year for the TAR3_BT_MIX CPUE analysis. Implied coefficients are calculated as the sum of the fishing year coefficient plus the mean of the residuals in each fishing year in each area. The error bars indicate one standard error of residuals. The grey line indicates the model's overall fishing year coefficients.

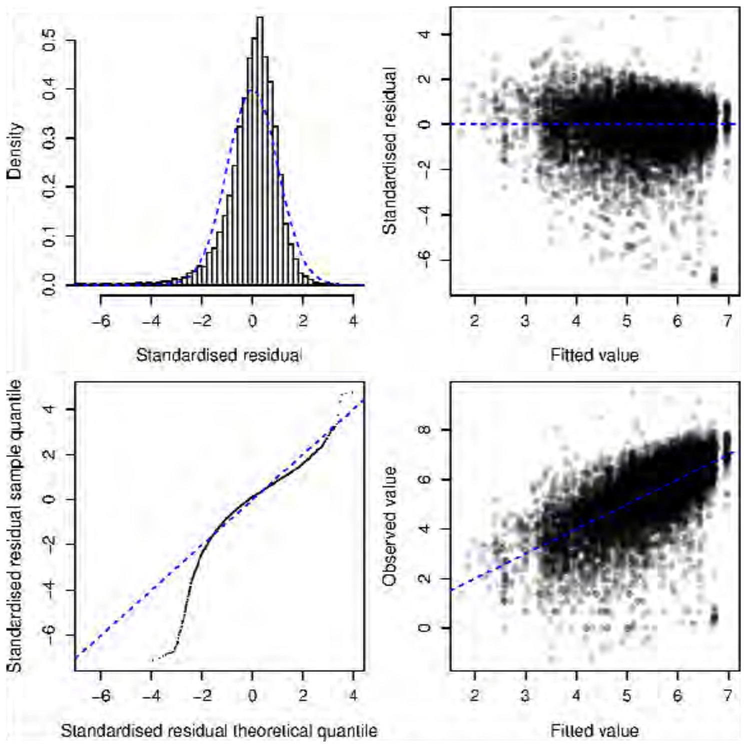


Figure I.9: Plots of the fit of the standardised CPUE model to successful catches of tarakihi in the TAR3_SN_MIX fishery. [Upper left] histogram of the standardised residuals compared to a lognormal distribution (SDSR: standard deviation of standardised residuals. MASR: median of absolute standardised residuals); [Upper right] Standardised residuals plotted against the predicted model catch per trip; [Lower left] Q-Q plot of the standardised residuals; [Lower right] Observed catch per record plotted against the predicted catch per record.

I.4 Model coefficients

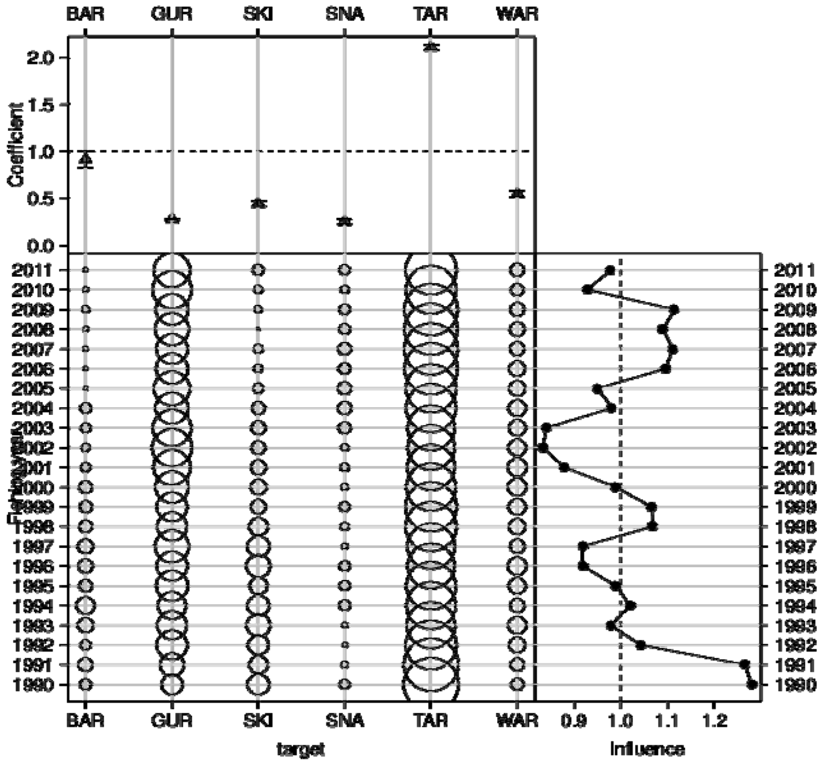


Figure I.10: Effect of target **in the lognormal model for the TAR2_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

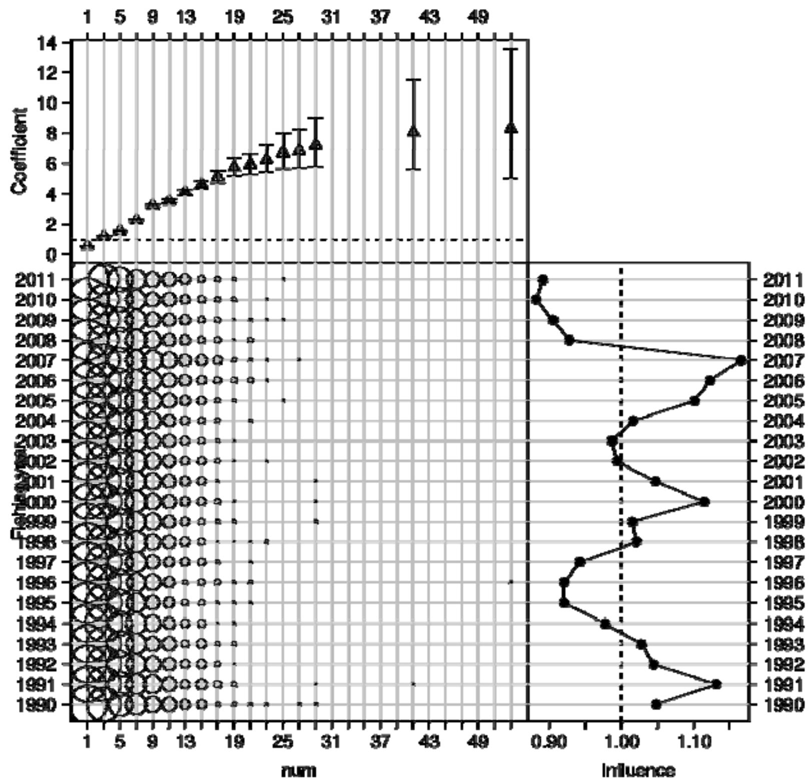


Figure I.11: Effect of number of tows **in the lognormal model for the TAR2_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

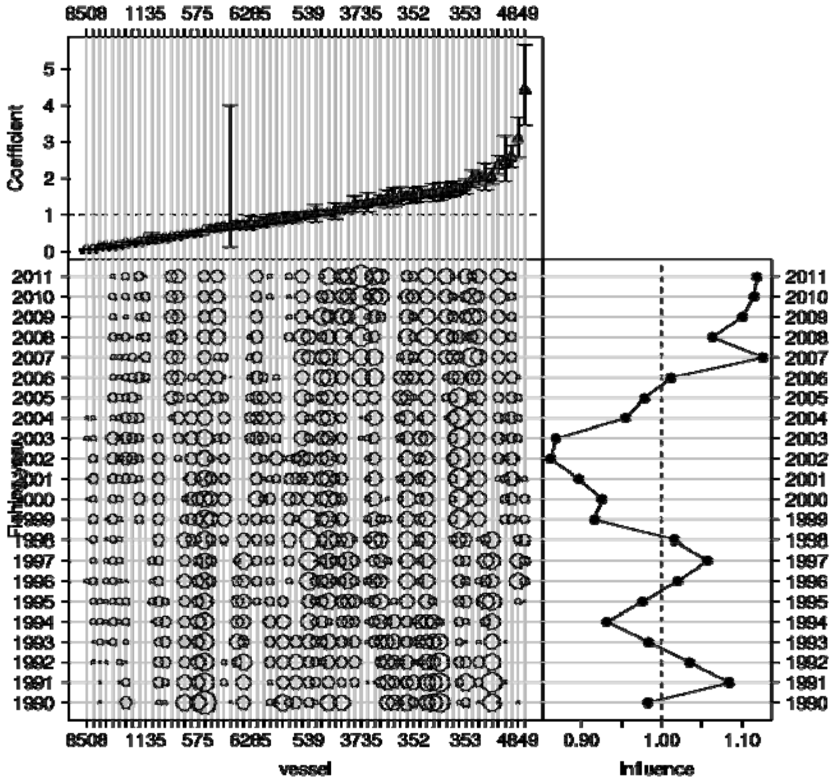


Figure I.12: Effect of vessel **in the lognormal model for the TAR2_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

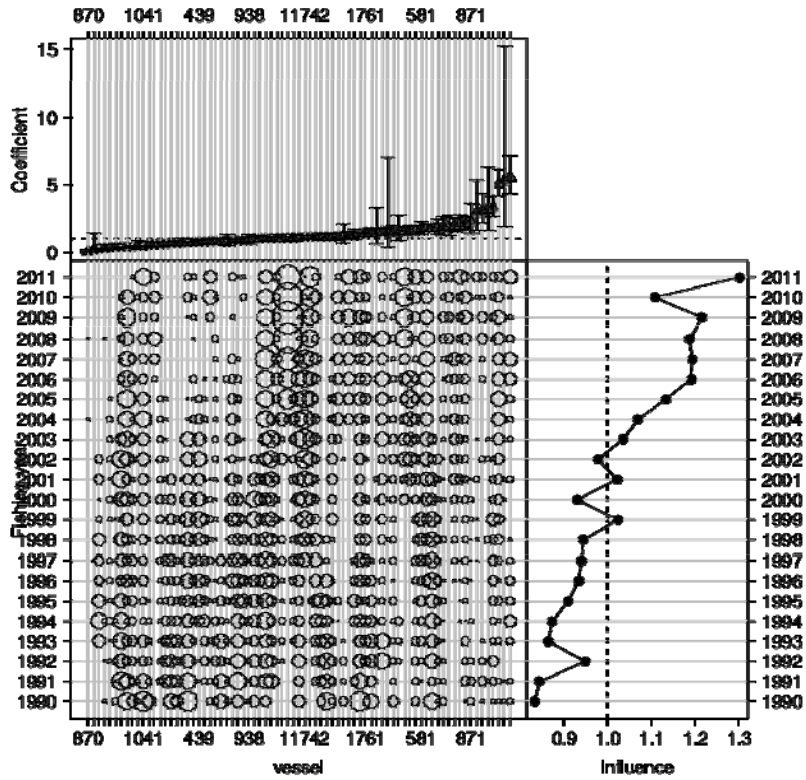


Figure I.13: Effect of vessel **in the lognormal model for the TAR3_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

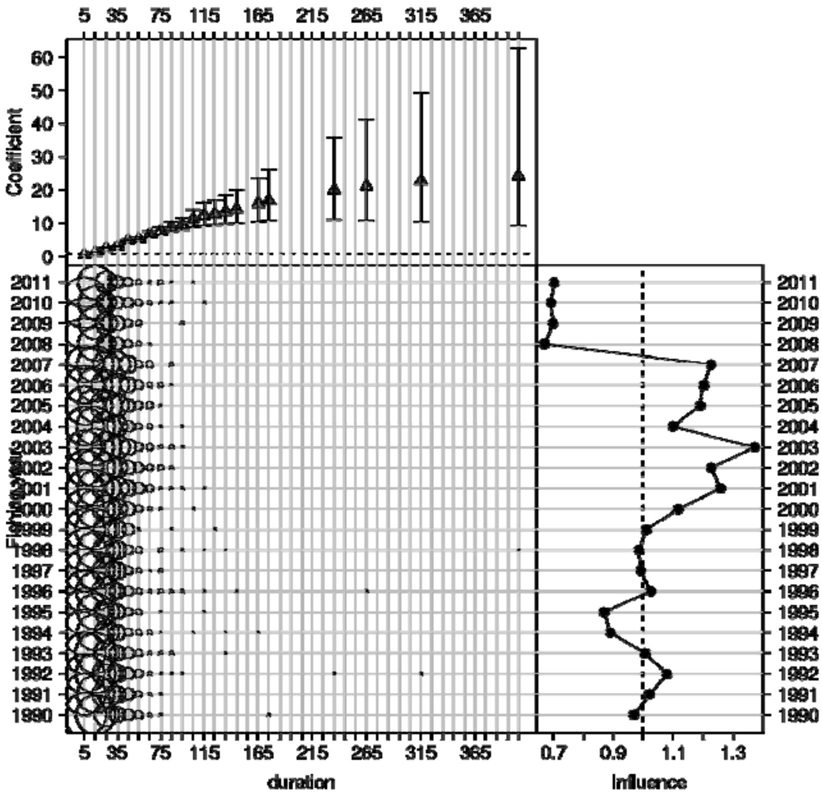


Figure I.14: Effect of duration **in the lognormal model for the TAR3_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

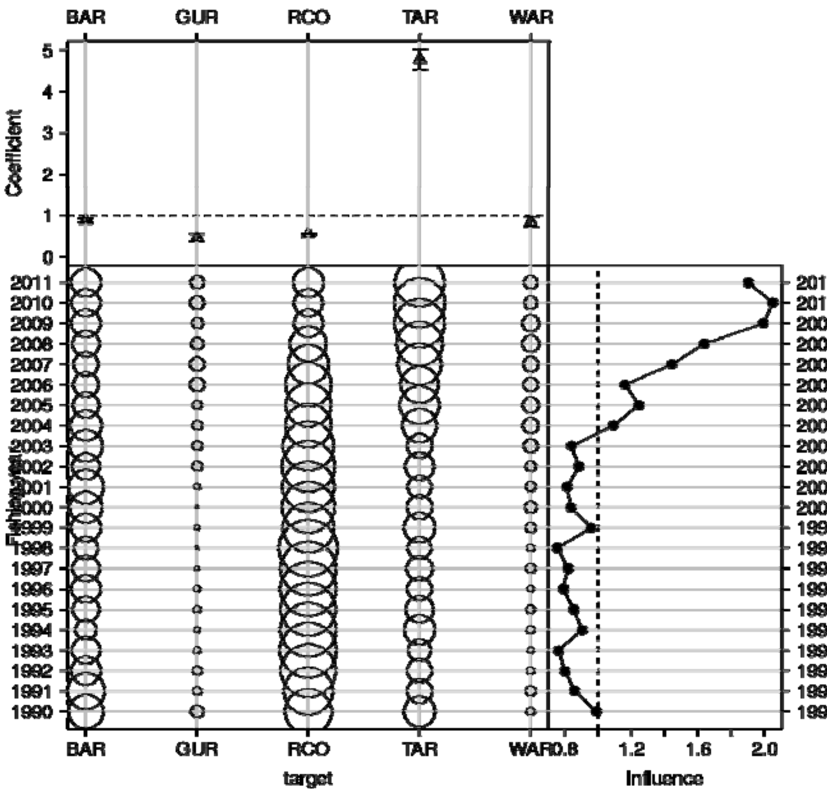


Figure I.15: Effect of target **in the lognormal model for the TAR3_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

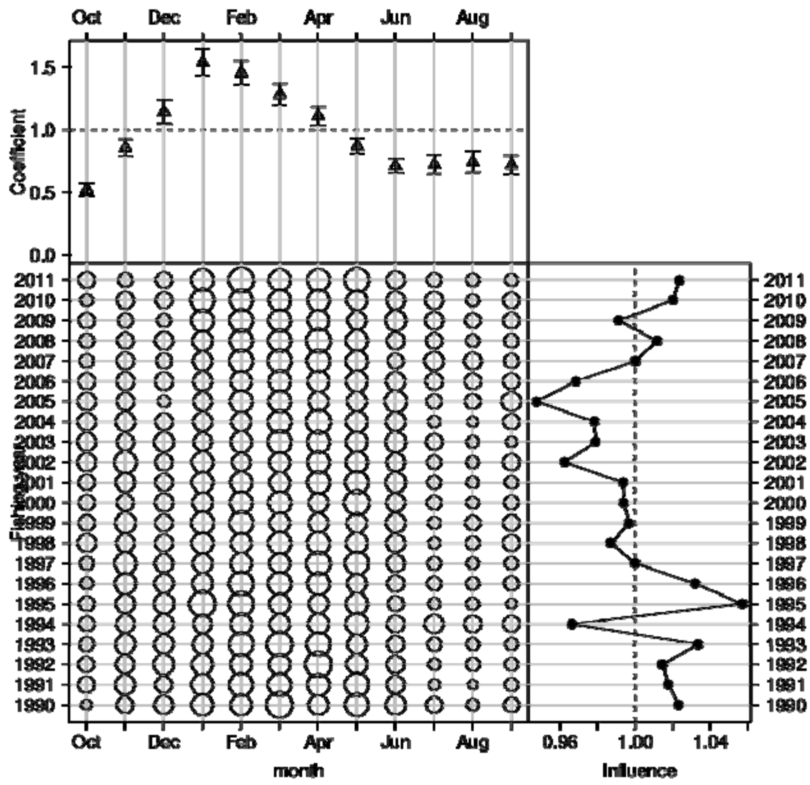


Figure I.16: Effect of month **in the lognormal model for the TAR3_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

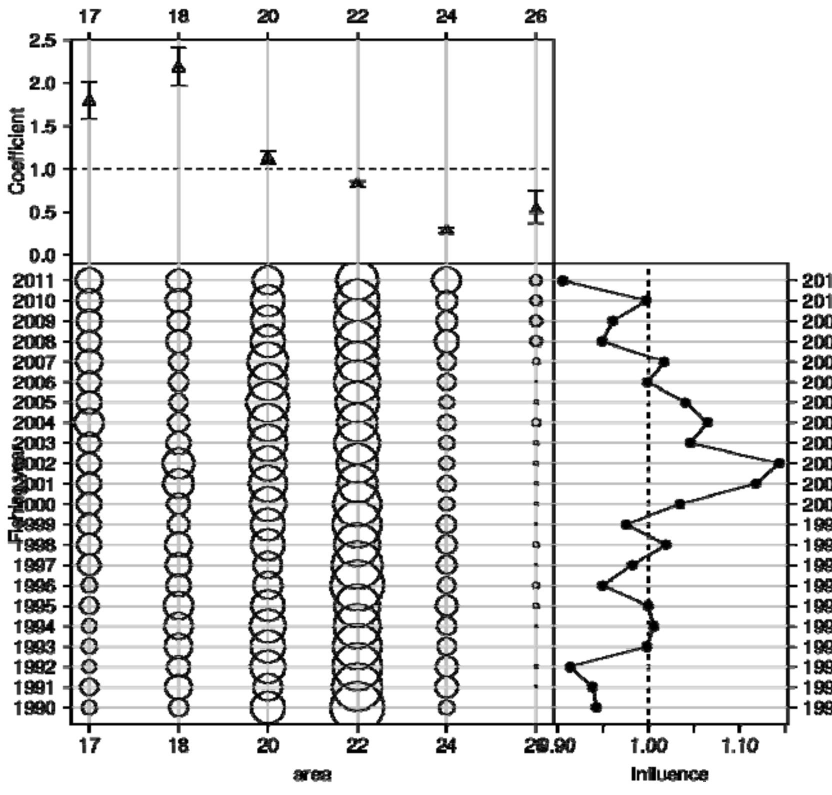


Figure I.17: Effect of area **in the lognormal model for the TAR3_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

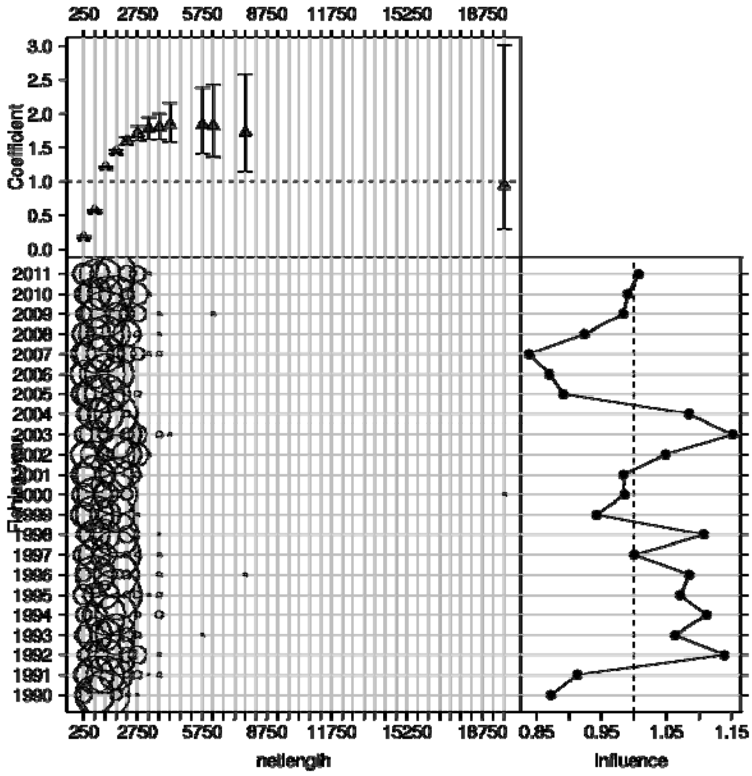


Figure I.18: Effect of netlength **in the lognormal model for the TAR3_SN_TAR fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

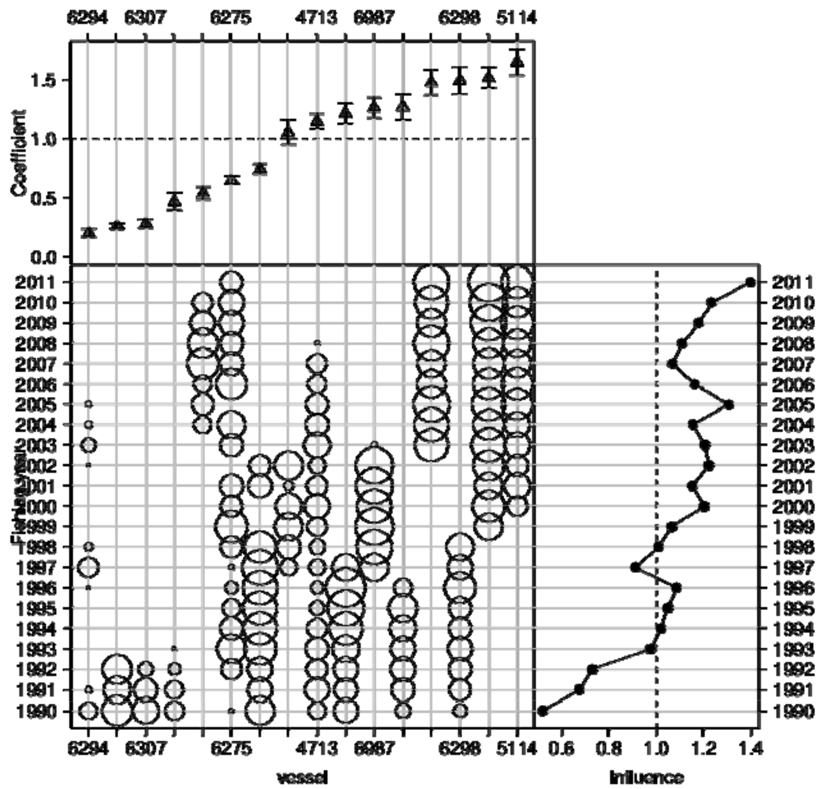


Figure I.19: Effect of vessel **in the lognormal model for the TAR3_SN_TAR fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

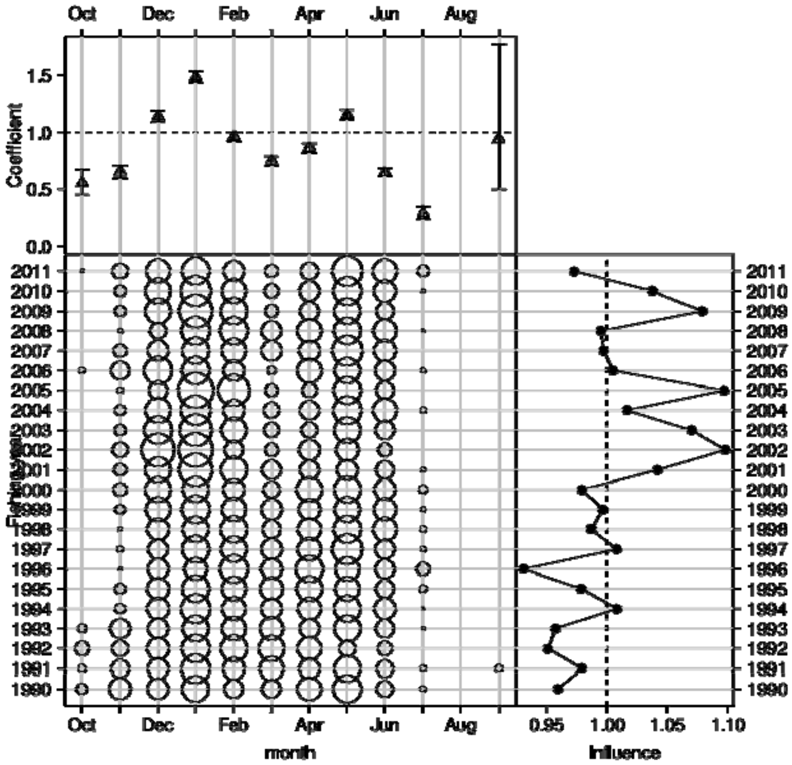


Figure I.20: Effect of month **in the lognormal model for the TAR3_SN_TAR fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

I.5 CPUE indices

Table I.2: Arithmetic indices for the total and core data sets, geometric and lognormal standardised indices and associated standard error for the core data set by fishing year for each of the three CPUE models.

	TAR 2_BT_MIX					TAR 3_BT_MIX					TAR 3_SN_TAR				
Fishing	All	Core				All	Core				All	Core			
Year	Arithmetic	Arithmetic	Geometric	Standardised	SE	Arithmetic	Arithmetic	Geometric	Standardised	SE	Arithmetic	Arithmetic	Geometric	Standardised	SE
1990	0.924	0.997	1.340	1.071	0.0473	0.582	0.531	0.769	1.037	0.0684	0.725	0.715	0.663	1.294	0.0416
1991	1.004	1.105	1.319	0.959	0.0412	0.546	0.554	0.703	1.117	0.0591	0.907	0.899	0.816	1.264	0.0395
1992	0.832	0.921	1.004	0.933	0.0363	0.652	0.649	0.817	1.150	0.0533	0.907	0.918	0.819	1.276	0.0381
1993	0.915	1.016	0.939	0.980	0.0369	0.394	0.405	0.492	0.728	0.0531	1.026	1.024	0.950	1.070	0.0366
1994	0.732	0.779	0.829	0.879	0.0370	0.465	0.442	0.558	0.839	0.0517	0.737	0.766	0.734	0.748	0.0416
1995	0.899	0.846	0.912	0.958	0.0366	0.575	0.581	0.710	0.971	0.0503	0.967	0.959	1.099	1.154	0.0429
1996	0.928	0.891	0.901	0.977	0.0388	0.599	0.588	0.809	1.268	0.0560	1.038	1.026	0.962	1.004	0.0466
1997	1.032	0.993	0.996	1.037	0.0368	0.693	0.668	0.738	1.116	0.0490	0.946	0.935	0.809	0.938	0.0447
1998	1.061	1.019	1.016	0.941	0.0372	0.649	0.637	0.657	1.097	0.0508	0.967	0.956	1.005	1.075	0.0391
1999	0.997	0.967	1.047	1.077	0.0353	0.978	0.976	0.768	0.947	0.0517	1.214	1.197	1.202	1.155	0.0412
2000	1.103	1.159	1.176	1.279	0.0360	1.186	1.226	1.083	1.521	0.0516	0.937	1.035	0.980	0.878	0.0401
2001	1.026	0.990	1.009	1.283	0.0346	1.189	1.240	1.071	1.250	0.0516	1.611	1.592	1.143	1.006	0.0390
2002	1.234	1.212	1.095	1.537	0.0334	1.510	1.310	1.102	1.263	0.0562	1.663	1.726	1.529	1.286	0.0450
2003	1.210	1.168	1.047	1.446	0.0325	1.646	1.585	0.927	1.038	0.0565	1.348	1.349	1.408	1.214	0.0415
2004	1.169	1.166	1.199	1.285	0.0342	1.821	1.926	0.962	0.799	0.0594	1.188	1.187	1.230	1.104	0.0396
2005	1.072	1.023	0.882	0.946	0.0329	1.516	1.536	1.108	0.785	0.0596	1.221	1.204	1.361	0.947	0.0490
2006	1.085	1.019	1.006	0.907	0.0339	1.387	1.397	1.113	0.825	0.0592	1.035	1.021	1.071	0.929	0.0412
2007	0.937	0.916	0.969	0.772	0.0353	1.556	1.633	1.732	0.962	0.0662	0.820	0.809	0.866	0.822	0.0410
2008	0.989	0.994	0.867	0.760	0.0335	1.674	1.659	1.516	0.841	0.0655	0.827	0.816	0.745	0.698	0.0440
2009	1.061	1.040	0.990	0.821	0.0322	1.656	1.784	2.057	0.868	0.0655	1.071	1.057	1.104	0.887	0.0465
2010	1.036	0.998	0.897	0.884	0.0308	1.464	1.448	1.922	0.817	0.0657	0.819	0.808	0.986	0.808	0.0491
2011	0.908	0.905	0.770	0.719	0.0321	2.054	2.249	2.639	1.166	0.0615	0.659	0.650	1.031	0.806	0.0512

Appendix J. CPUE ANALYSES FOR WCNI, EAST NORTHLAND AND BAY OF PLENTY BOTTOM TRAWL FISHERIES

J.1 General overview

This appendix describes three fisheries that were updated and examined for this project, which had been previously accepted as standardised CPUE series by the NINSWG (Kendrick 2009), but were not used in the stock assessment (Langley & Starr 2012). Two major trawl fisheries off East Northland and in the Bay of Plenty were investigated: the Bay of Plenty series was nearly identical to the East coast North Island series and the NINSWG agreed that it would not add information to the stock assessment model, while the East Northland series appeared to be inconsistent with the series from the main portion of the biological stock. Consequently, neither series was used as input to the stock assessment model. The west coast of Northland was not considered to be a candidate series as these tarakihi were not thought to belong to the same biological stock as on the east coast.

The marked shift away from the unstandardised as a result of the standardisation procedure in each of the three fisheries demonstrates that there have been changes over time in these fisheries which affect the expected catch rate. Some of these shifts are likely to be due to active choices made by the fleet participants to affect the catch of tarakihi. For the Bay of Plenty bottom trawl fishery, there was evidence of active and effective avoidance of tarakihi during a peak of abundance in the early 2000s, and for the west coast North Island bottom trawl fishery, the increasing unstandardised catch rates of tarakihi appear to be the result of increased targeting without a corresponding increase in the underlying abundance.

J.2 Methods

J.2.1 Data Preparation

Data were prepared as described in Section 2.3.3 and Appendix Section H.2.1. The same potential data variables were available from each trip in these data sets, including estimated and landed catch of tarakihi, the number of tows, total duration of fishing, fishing year, statistical area, target species, month of landing, and a unique vessel identifier. Data might not represent an entire fishing trip; just those portions of it that qualified, but the amount of landed catch assigned to the part of the trip that was kept would be proportional to the total landed catch for the trip based on the estimated catches which apportion the landings to each trip stratum. Trips were not dropped because they targeted more than one species or fished in more than one statistical area.

J.2.2 Analytical methods for standardisation

The analytical methods used for standardisation are described in Appendix Section H.2.2, with one important addition. Updated analytical software, not available at the time the analyses described in Appendix H were performed, was used to process these series. This software allowed the exploration of alternative distributional assumptions for the standardisation models. This was done in two steps when fitting to the successful (positive) catch records. First, alternative regressions based on five statistical distributional assumptions (lognormal, log-logistic, inverse Gaussian, gamma and Weibull) predicted catch based on a dataset with a reduced set of six explanatory variables (year, month, area, vessel, target species and the log of number tows). The distribution which resulted in the model with the lowest negative log-likelihood was then selected for use in the final model. The second step involved repeating the regression using the selected distribution: regressing log(catch) against the full set of explanatory variables in a stepwise procedure, selecting variables one at a time until the improvement in the model R^2 was less than 0.01. The order of the variables in the selection process was based on the variable with the lowest AIC, so that the degrees of freedom were minimised. Datasets were again restricted to core fleets of vessels, defined by their activity in the fishery, thus selecting only the most active vessels without unduly constraining the amount of catch and effort available for analysis.

A binomial model which predicted success or failure of tarakihi catch was fitted to the total dataset, including records that reported a zero catch of tarakihi and a lognormal model was fitted to positive catches. These two models were combined into a single set of indices using the method of Vignaux (1994) (Eq. H.4) but these analyses were not strongly informative and are not presented in detail (See Appendix K.6 for plots of the resultant annual effects).

J.2.3 Fishery definitions for CPUE analysis

Tarakihi is an important bycatch of most inshore bottom trawl fisheries along the east coast of both islands and there are also well defined target fisheries, however the choice of which target fisheries to include was intended to be inclusive rather than selective, so as to be compatible with previously accepted series and also to be less sensitive to any trends in reporting of target species that these fisheries are subject to, because of the shift from daily to tow-by-tow reporting.

The inclusion of statistical areas in the defined fisheries is also largely based on previous studies but their relevance is evaluated with the help of residual implied coefficients plotted for each year in each area that are included in Appendix K.4. Only catches from the inshore statistical areas were kept, and the small amounts taken in adjacent offshore areas were dropped.

BoP_BT_MIX – Bay of Plenty mixed species bottom trawl – The Fishery is defined from bottom single trawl fishing events which fished in statistical areas 008–010, and targeted TAR, SNA, TRE, BAR, SKI, JDO, or GUR. This definition potentially allows the use of total effort in the analysis of catch rates, however only the analysis of positive catches is presented in detail.

EN_BT_MIX – East Northland mixed species bottom trawl – The Fishery is defined from bottom single trawl fishing events which fished in statistical areas 002–007, and targeted TAR, SNA, TRE, BAR, JDO, or GUR. This definition potentially allows the use of total effort in the analysis of catch rates, however only the analysis of positive catches is presented in detail.

WCNI_BT_MIX– West coast North Island mixed species bottom trawl -- The Fishery is defined from bottom single trawl fishing events which fished in statistical areas 041, 042, 045–048, and targeted TAR, SNA, or TRE. This definition potentially allows the use of total effort in the analysis of catch rates, however only the analysis of positive catches is presented in detail.

J.3 Unstandardised CPUE

J.3.1 BoP_BT_MIX Mixed target Bottom trawl in TAR 1

Effort in this fishery has cycled several times with peaks in the early 1990s and again in the early 2000s (Figure J.1). Tarakihi is caught in most trips in this fishery, with that proportion increasing, especially in the most recent few years. Nominal catch rates have varied similarly to effort and are currently near the highest level of the study period. At trip stratum level success rate shows an increasing trend during the 1990s and improved stability at about 70% since then (Figure J.2 [left panel]). The effect of improved reporting on TCEPR forms is evident in the roll-up of data to trip-stratum from the mid 1990s (Figure J.2 [right panel]).

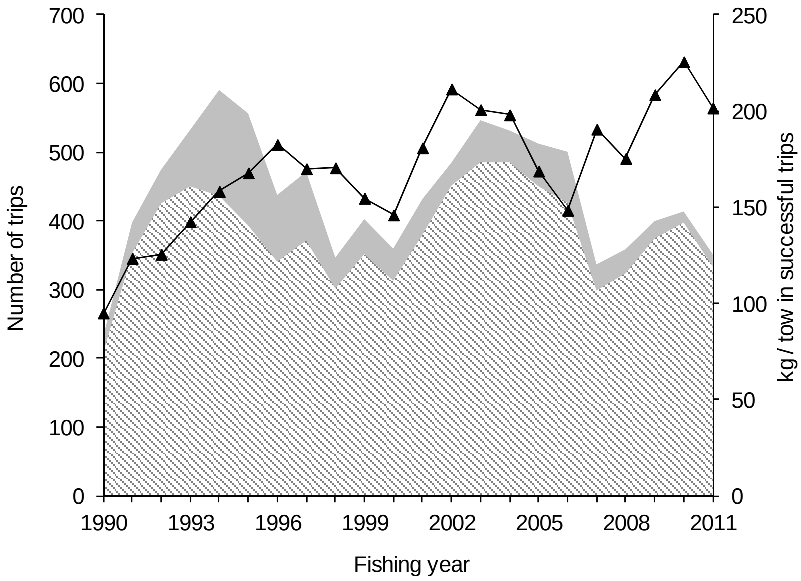


Figure J.1: Number of qualifying trips in BoP_BT_MIX (dark area), the number of those trips that landed tarakihi (light area) and the simple catch rate (kg/tow) of tarakihi in successful trip-strata, by fishing year.

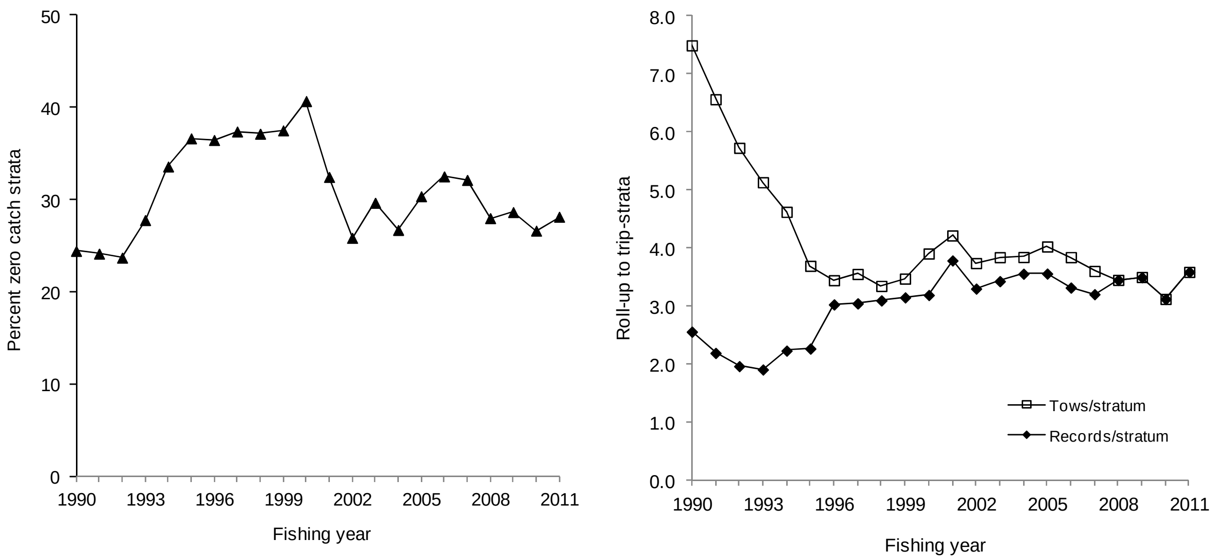


Figure J.2: The proportion of qualifying trips in BoP_BT_MIX, that landed zero tarakihi (left), and the effect of amalgamation to trip-strata on the number of original records per trip-stratum and the number of tows per trip-stratum, by fishing year.

J.3.2 EN_BT_MIX Mixed target Bottom trawl in TAR 1

The number of qualifying trips in this fishery declined by about 50% from its peak in the early 1990s, but the number of trips reporting tarakihi catches did not decline proportionately. The nominal catch rate in successful trips shows some structure with a steady decline from the mid 1990s to a low point in 2002–03, but higher and more variable rates since then (Figure J.3). The proportion of zero catches of tarakihi at trip-stratum level decreased during the first half of the time series contradictory to the declining catch rate and has been more stable at about 60% in the last half of the series (Figure J.4 [left panel]). The effect of improved reporting on the TCEPR form is evident from the mid 1990s in the roll-up of data to trip-stratum (Figure J.4 [right panel]).

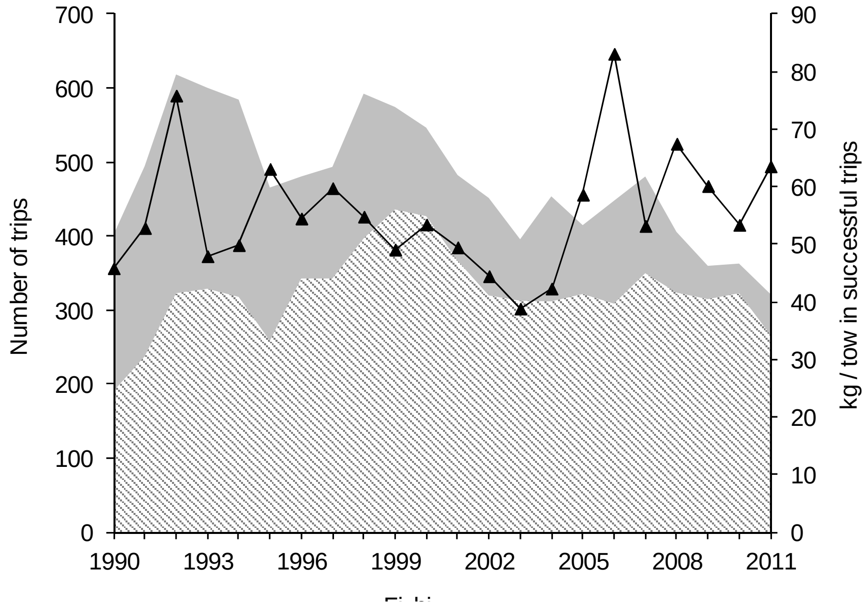
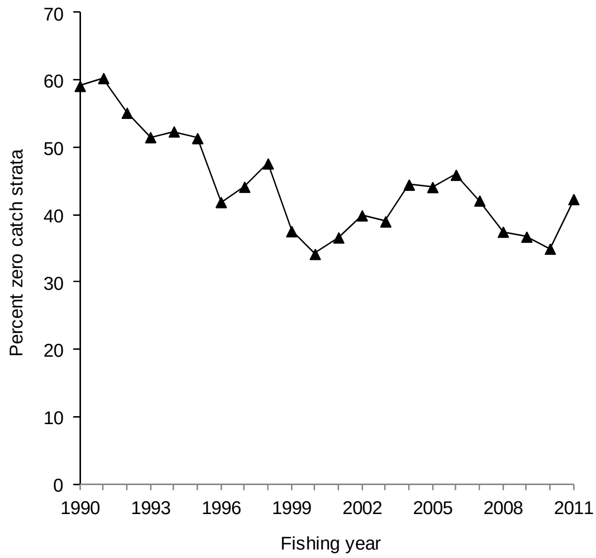


Figure J.3: Number of qualifying trips in EN_BT_MIX (dark area), the number of those trips that landed tarakihi (light area) and the simple catch rate (kg/tow) of tarakihi in successful trip-strata, by fishing year.



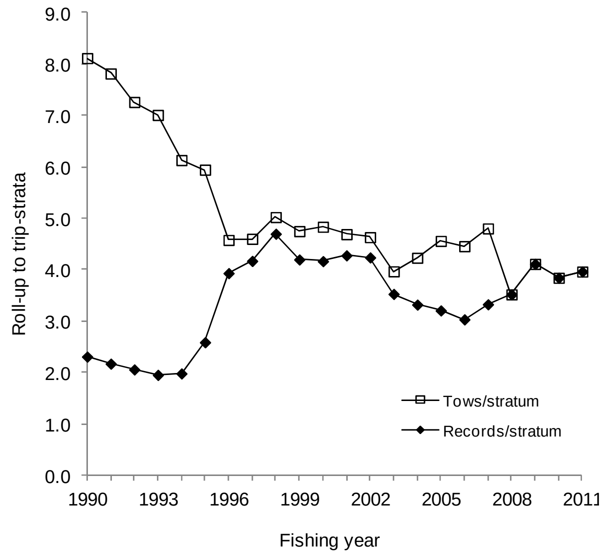


Figure J.4: The proportion of qualifying trips in EN_BT_MIX, that landed zero tarakihi (left), and the effect of amalgamation to trip-strata on the number of original records per trip-stratum and the number of tows per trip-stratum, by fishing year.

J.3.3 WCNI_BT_MIX Mixed target Bottom trawl in TAR 1

There has been a large change in this fishery, with a long-term declining trend in the number of reporting trips and a strong increasing trend in nominal catch per tow in those trips (Figure J.5). The proportion of trips reporting no catch of tarakihi has declined to almost zero, and at analysis (trip-strata) resolution the trend is a also evident, declining steadily from 60% to 40% over the study period (Figure J.6 [left panel]). The effect of improved reporting on the TCEPR form can be seen in the roll-up of data to trip-stratum (Figure J.6 [right panel]).

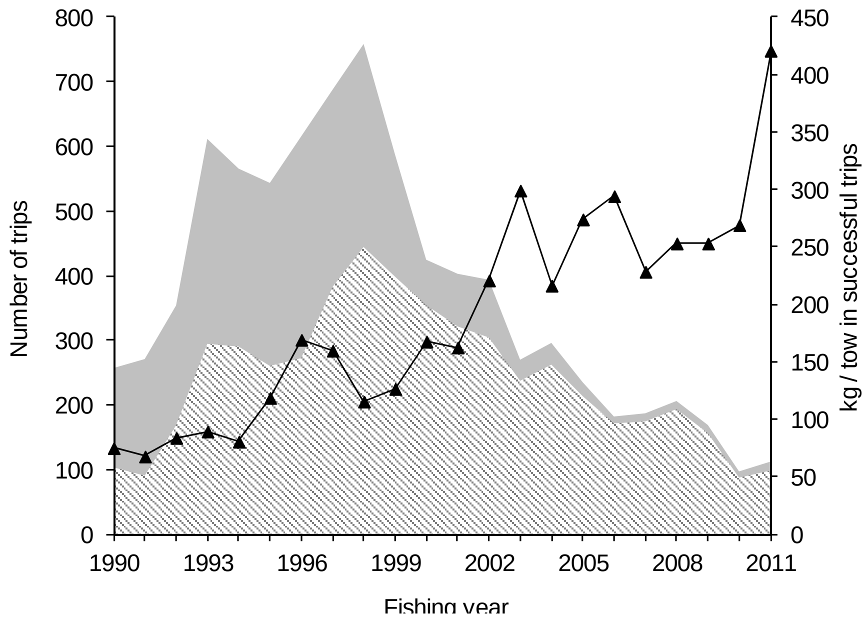


Figure J.5: Number of qualifying trips in WCSI_BT_MIX (dark area), the number of those trips that landed tarakihi (light area) and the simple catch rate (kg/tow) of tarakihi in successful trip-strata, by fishing year.

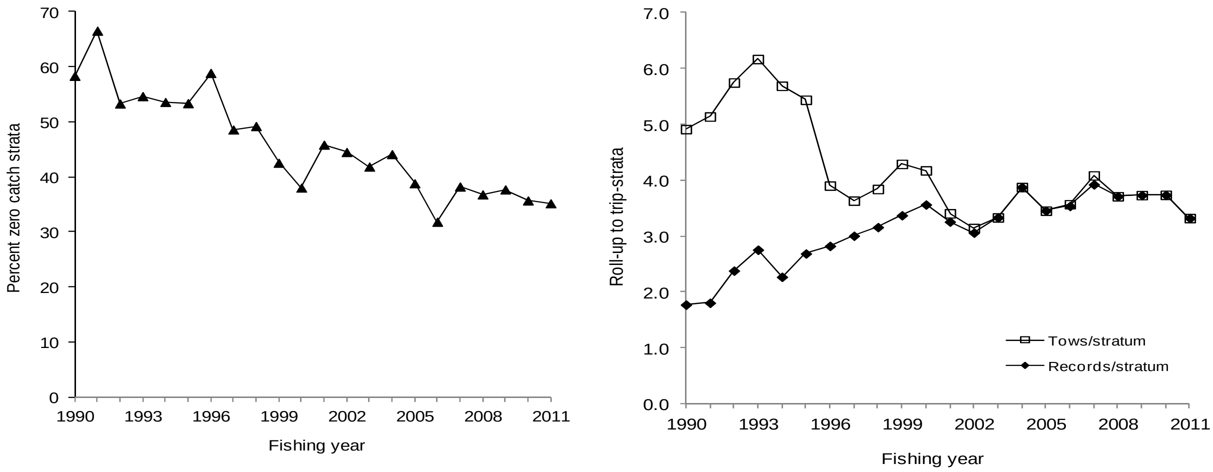


Figure J.6: The proportion of qualifying trips in WCSI_BT_MIX, that landed zero tarakihi (left), and the effect of amalgamation to trip-strata on the number of original records per trip-stratum and the number of tows per trip-stratum, by fishing year.

J.4 Standardised CPUE analysis

J.4.1 Core fleet definitions

The data sets used for the standardised CPUE analysis were restricted to those vessels that participated with some consistency in the defined fishery. Core vessels were selected by specifying two variables; the number of trips that determined a qualifying year, and the number of qualifying years that each vessel participated in the fishery. The effect of these two variables on the amount of landed tarakihi retained in the dataset and on the number of core vessels, and the length of participation by the core vessels in each fishery are depicted for the BoP_BT_MIX fishery (Figure K.1), EN_BT_MIX fishery (Figure K.2), WCNI_BT_MIX fishery (Figure K.3). The core fleet was selected by choosing variable values that resulted in the fewest vessels while maintaining the largest catch of tarakihi. The selection process usually reduced the number of vessels in the dataset by about 70% while reducing the amount of landed tarakihi by about 20%. All three fisheries selected the core vessel fleet on the basis of a minimum of 10 trips for each of five years. The summary for the data sets with the core vessels is presented in Table K.1.

J.4.2 Model selection, diagnostics and trends in model year effects

The final models selected for standardising positive catches in each fishery are described in Table J.1 (BoP_BT_MIX), Table J.2 (EN_BT_MIX) and Table J.3 (WCNI_BT_MIX). These tables include those explanatory variables that met the AIC criteria and each is not necessarily a complete list of the variables that were offered[1]. The variables that met the acceptance criteria based on a 1% improvement in R^2 are indicated with asterisks in the table, along with the amount of deviance they explained.

Following each table are step-influence plots that demonstrate the progressive effect on the annual indices of each explanatory variable as it enters the model, and shows the influence of each variable on the annual coefficients in adjacent panels. These plots highlight the observation made in Bentley et al. (2011) that the variables that explain the most deviance are not necessarily the ones responsible for most of the difference between standardised and observed series of CPUE.

Diagnostic plots of the residuals from each final model fit are given from Figure K.4 to Figure K.15 and include implied coefficient plots for each statistical area and target species by year. These allow the comparison of the annual trends among statistical area and target species categories in each analysis, effectively serving as a proxy for an interaction analysis.

The influence of an explanatory variable is a combination of the coefficients and its distributional changes over years, and are plotted as Coefficient-Distribution-Influence (CDI) plots (Bentley et al. (2011) for each accepted explanatory variable (see Figure K.16 to Figure K.29).

J.4.2.1 BoP_BT_MIX – TAR 1 Mixed species bottom trawl

The Weibull error distribution produced the best fit to the data set among the five distributions investigated for this model (Figure K.4). Fishing year was forced as the first variable in the model of positive catches and explained less than 1% of the variance in annual catch (Table J.1). Target species entered the model next explaining almost 30% of the annual variance and lifting a peak in the early 2000s noticeably (Figure J.7). Duration of fishing explained a further 12% of variance and continued to lift the peak in the early 2000s as well as dropping indices in the initial five years of the series, flattening the declining trend in the unstandardised series. Vessel was also accepted into the model explaining an additional 8% of variance and lowering indices in the most recent five years (Figure J.7). Area and month also entered the model with significant explanatory power but indiscernible influence on observed catches.

Diagnostic residual plots are presented for the final Weibull model in Figure K.5 and show a good fit of the data to the error assumption with some unexplained pattern in the residuals, particularly departures at the tail of the distribution associated with smaller observed values.

Shifts in the importance of constituent bycatch fisheries, particularly the decline in catch from gemfish tows and a subsequent increase in the importance of trevally bycatch are predicted to have accounted for greater catches of tarakihi in the 1990s compared with the 2000s, but the main influence is seen in 2000–01 when a noticeable shift away from targeting snapper and tarakihi is predicted to have accounted for a drop in catches of tarakihi (Figure K.16). Adjusting for this influence lifts the peak in the early 2000s. The influence of duration on observed catches largely accounts for the shift in reporting from CELR to TCEPR forms in the mid 1990s but there was also a trend towards shorter tows from 2001–02 to 2004–05 that is predicted to have reduced catches (Figure K.17). Changes in the

[1] Variables which make no improvement in the AIC are ignored by the software.

distribution of vessels in the core fleet mainly affected catches after 2005–06, with a positive influence on observed catches due to some of the poorer performing vessels departing the fishery (Figure K.18). The largest catches are taken in area 010, but most of the activity in each year occurs in area 009. Fishing in area 008 is variable from year to year and the model accounts for those shifts that are without overall trend or influence (Figure K.19). Likewise there is a well determined seasonal pattern to catches of tarakihi but consistent year-round effort means that the influence of month is slight, with little effect on the annual indices (Figure K.20).

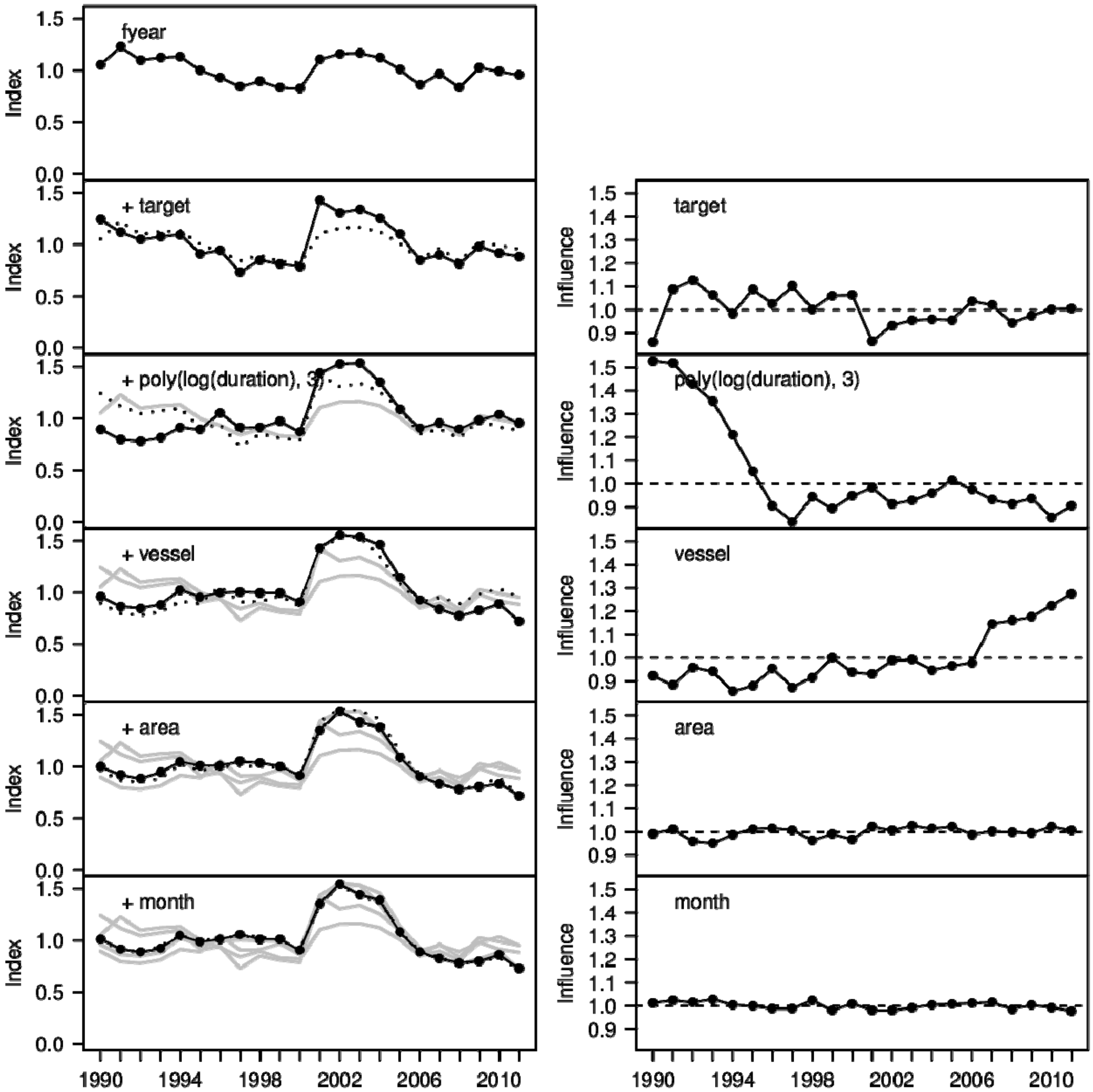


Figure J.7: Step and annual influence plot for BoP_BT_MIX. (a) CPUE index at each step in the selection of variables. The index obtained in the previous step (if any) is shown by a dotted line and for steps before that by grey lines. (b) Annual influence on observed catches arising from a combination of its GLM coefficients and its distributional changes over years, for each explanatory variable in the final model.

The effect of standardisation on catch rate in successful trips was to flatten the first half of the series (the contradictory trends in observed catch per tow and catch per stratum are an artefact of a systematic switch from reporting on CELRs to TCEPRs and were explored in earlier studies), increase the magnitude of the hump in the early 2000s (suggesting that there was some active and effective avoidance of tarakihi when abundance of tarakihi was at a peak), and lift the most recent five indices, suggesting that better targeting of tarakihi has somewhat masked the continuing decline in abundance after 2005–06 (Figure J.8). The trajectory is well-determined with relatively small error bars around each point and trends that are sustained over consecutive years. There is reasonable agreement with the previous series presented for this fishery (Kendrick 2009), although the series was based on TCEPR format data only (Figure J.8).

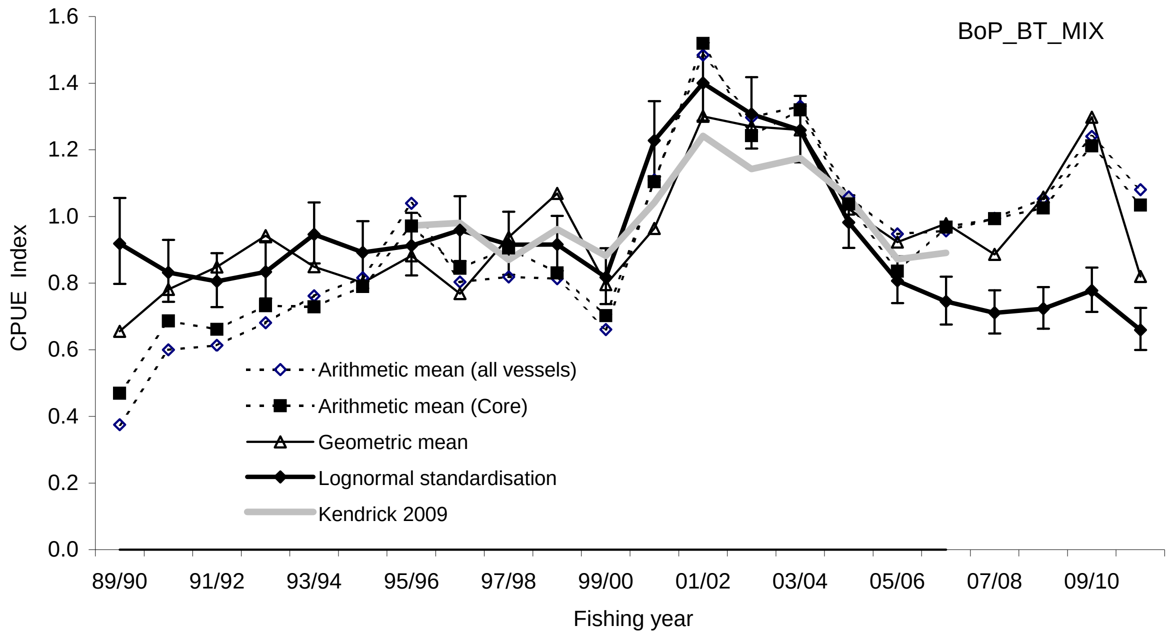


Figure J.8: The effect of standardisation on the raw CPUE of tarakihi in successful trips by core vessels in the BoP_BT_MIX fishery. Broken lines are the raw CPUE (kg /tow) for all vessels and for the core fleet only, the solid line is the unstandardised CPUE (annual geometric mean), the bold line is the standardised CPUE canonical indices with ± 2 * SE error bars. Grey line is the lognormal series presented in 2009 for a similar fishery(target tows only). All series are relative to the geometric mean over the years in common.

Table J.1: Order of acceptance of variables into the Weibull model of successful catches of tarakihi for core vessels (based on the vessel selection criteria of at least 10 trips in 5 or more fishing years) in the BoP_BT_MIX fishery with the amount of explained deviance for each variable. Variables accepted into the model are marked with an *. Fishing year was forced as the first variable.

Term	DF	Log likelihood	AIC	Nagelkerke pseudo-R2 (%)	Final
fyear	23	-104 935	209 916	0.61	*
target	29	-102 427	204 913	30.32	*
poly(log(duration), 3)	32	-101 003	202 070	43.04	*
vessel	165	-99 924	200 178	51.12	*
area	167	-99 700	199 734	52.64	*
month	178	-99 488	199 332	54.04	*
poly(log(num), 3)	181	-99 435	199 232	54.38	

A binomial model of the probability of capture produced annual indices that are almost flat except for a slight peak in the early 2000s which is similar to that seen in the standardised catch rates (Figure K.30).

J.4.2.2 EN_BT_MIX – TAR1 Mixed species bottom trawl

The Weibull error distribution produced the best fit to the data set among the five distributions investigated for this model (Figure K.8). Fishing year was forced as the first variable in the model of positive catches and explained less than 2% of the variance in annual catch (Table J.2). Target species entered the model next, explaining more than 31% of the annual variance and lifting a peak in 1999–00, but removing one of similar magnitude in 2005–06 (Figure J.9). Duration of fishing explained a further 11% of variance lowering indices in the initial four years of the series thereby flattening the declining trend in the unstandardised series. Area entered the model but its influence was largely constrained to the first half of the time series. Vessel was also accepted into the model explaining an additional 6% of variance and lowering indices in the most recent six years. Month entered the model but with indiscernible influence on observed catches (Figure J.9).

Diagnostic residual plots are presented for the final Weibull model in Figure K.9 and show a reasonable fit by most of the data to the error assumption, although with some unexplained pattern in the residuals, and a departure from the distribution at the tails of the distribution.

Catches of tarakihi are more than threefold greater when targeted than when a bycatch of the other associated species, and although there has been a steady increase in bycatch from trevally tows and some patchiness to the contribution from the gurnard fishery, the model has largely adjusted for the sporadic nature of targeting of tarakihi itself (Figure K.21). Overall, its influence has been almost neutral, with several one-year spikes and a period of negative influence in the early 2000s when there was a noticeable shift away from targeting tarakihi. The influence of duration on observed catches largely adjusts for the shift in reporting of effort from CELR to TCEPR forms in the mid 1990s and is an artefact of the roll-up of data to effort-strata (Figure K.22). Catches are greater but also more variable in area 002 and lowest in area 006, however most of the activity in each year occurs in areas 003 and 005 (Figure K.23). The main influence on catches of shifts among areas is attributed to the first year and the influence has otherwise been neutral to slightly negative with little effect on annual indices. Changes in the distribution of high catch rate vessels in the core fleet have mainly affected catches since 2005–06, with a positive influence on observed catches as some of the poorer performing vessels departed the fishery (Figure K.24). There is a well determined seasonal pattern to catches of tarakihi but consistent year-round effort means that the influence of month has been slight, with little effect on the annual indices (Figure K.25).

Table J.2: Order of acceptance of variables into the Weibull model of successful catches of tarakihi for core vessels (based on the vessel selection criteria of at least 10 trips in 5 or more fishing years) in the EN_BT_MIX fishery with the amount of explained deviance for each variable. Variables accepted into the model are marked with an * . Fishing year was forced as the first variable.

Term	DF	Log likelihood	AIC	Nagelkerke pseudo-R2 (%)	Final
fyear	23	-71 647	143 340	1.57	*
target	28	-69 396	138 848	32.99	*
poly(log(duration) 3)	31	-68 357	136 776	43.88	*
area	36	-67 548	135 167	51.13	*
vessel	204	-66 741	133 891	57.42	*
month	215	-66 331	133 093	60.30	*
poly(log(num) 3)	218	-66 325	133 086	60.34	

The effect of standardisation on catch rate in successful trips is largely to smooth the series and to widen the peak in the middle of the series, describing a steady decline from that peak that is not so evident in the unstandardised series (Figure J.10). It changes a trajectory from one that appears cyclical, to one that declines except for a hump shaped recovery between the early 1990s and the early 2000s. The trajectory is well-determined with relatively small error bars around each point and trends that are sustained over consecutive years. There is reasonable agreement with the previous series presented for this fishery (Kendrick 2009), although that series was based on TCEPR format data only, and produced a lower peak than the series presented here (Figure J.10).

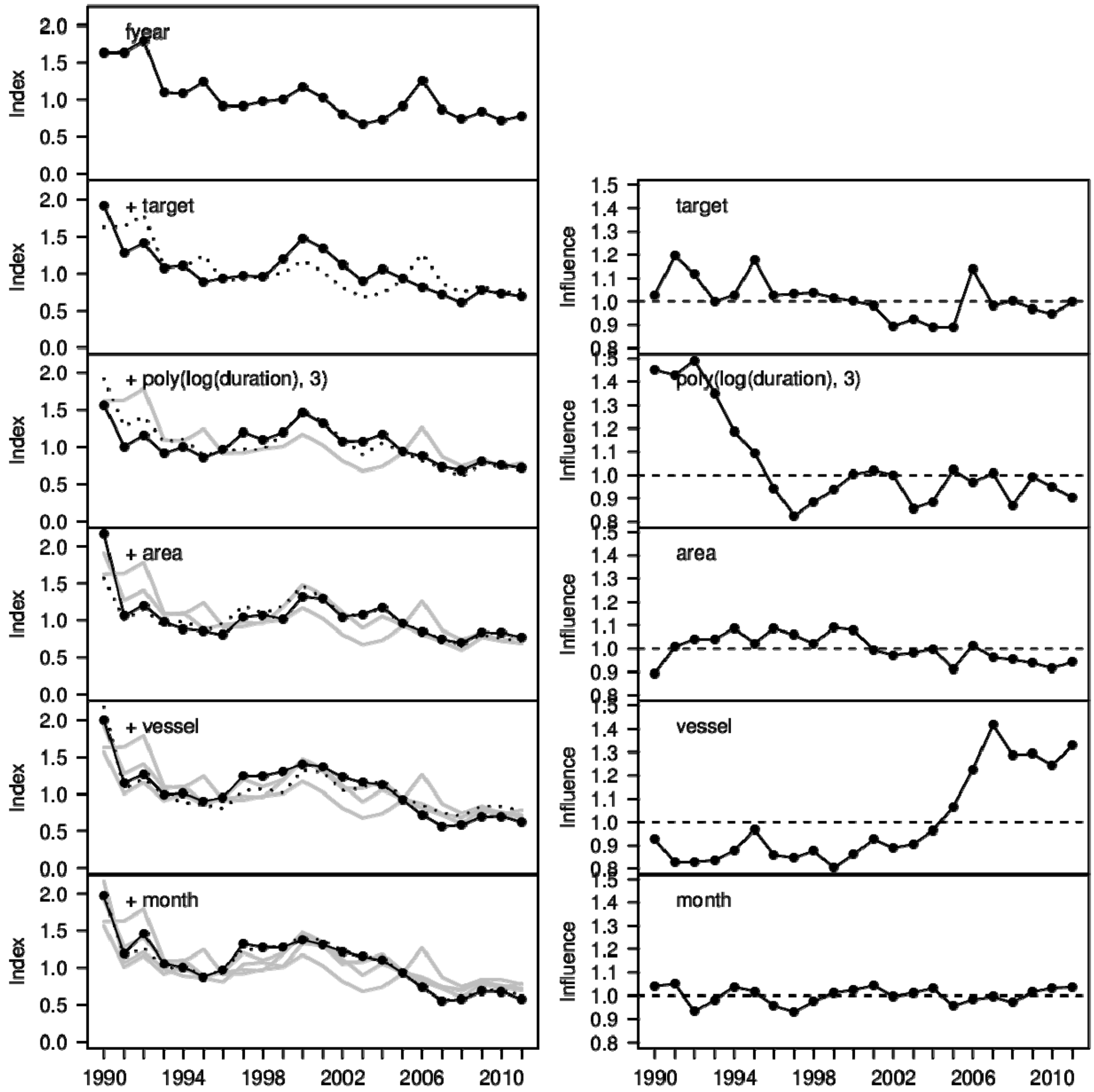


Figure J.9: Step and annual influence plot for EN_BT_MIX. (a) CPUE index at each step in the selection of variables. The index obtained in the previous step (if any) is shown by a dotted line and for steps before that by grey lines. (b) Annual influence on observed catches arising from a combination of its GLM coefficients and its distributional changes over years, for each explanatory variable in the final model.

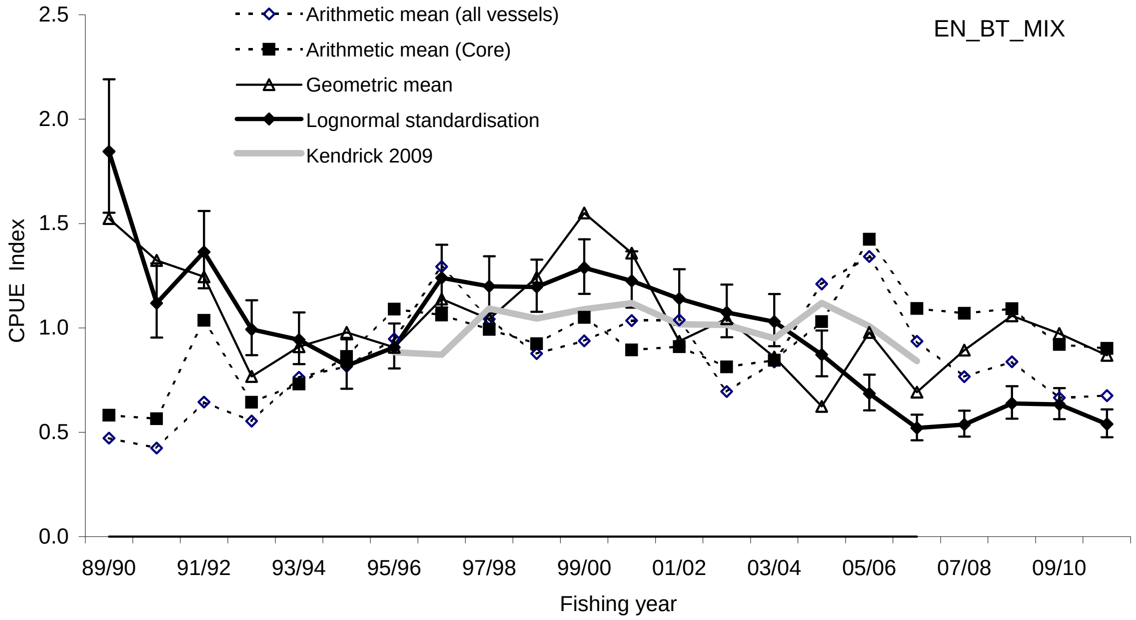


Figure J.10: The effect of standardisation on the raw CPUE of tarakihi in successful trips by core vessels in the EN_BT_MIX fishery. Broken lines are the raw CPUE (kg /tow) for all vessels and for the core fleet only, the solid line is the unstandardised CPUE (annual geometric mean), the bold line is the standardised CPUE canonical indices with ± 2 * SE error bars. Grey line is the previous lognormal series presented in 2009 for a similar fishery. All series are relative to the geometric mean over the years in common.

A binomial model of the probability of capture produced annual indices that steadily increase over the study period, and when combined with indices from a lognormal model, the effect is to accentuate the cyclical patterns in abundance (Figure K.31).

Table J.3: Order of acceptance of variables into the lognormal model of successful catches of tarakihi for core vessels (based on the vessel selection criteria of at least 10 trips in 3 or more fishing years) in the WCNI_BT_MIX fishery with the amount of explained deviance for each variable. Variables accepted into the model are marked with an * . Fishing year was forced as the first variable.

Term	DF	Log likelihood	AIC	Nagelkerke pseudo-R2 (%)	Final
fyear	23	-60 008	120 062	2.43	*
target	25	-58 395	116 839	33.77	*
poly(log(duration) 3)	28	-57 664	115 384	44.43	*
area	33	-57 226	114 518	49.98	*
vessel	146	-56 847	113 985	54.33	*
month	157	-56 525	113 364	57.72	*
poly(log(num) 3)	160	-56 474	113 269	58.24	

J.4.2.3 WCNI_BT_MIX – TAR 1 Mixed target bottom trawl

The Weibull error distribution produced the best fit to the data set among the five distributions investigated for this model (Figure K.12). Fishing year was forced as the first variable in the model of positive catches and explained less than 3% of the variance in annual catch (Table J.3). Target species entered the model next explaining almost 32% of the annual variance; lifting earlier indices and lowering those in the last half of the series, and dramatically changing the overall trajectory from one that increases to one that is flat overall with a low period in the late 1990s and early 2000s (Figure J.11). Duration of fishing explained a further 10% of variance, mainly accounting for the effect of the switch in reporting in the mid 1990s. Area entered the model explaining a further 5% of variance but with neutral influence on the overall trajectory. Vessel had less explanatory power but a positive influence on catches from the late 1990s to the mid 2000s. The model accounted for improvements in the core fleet by further lowering the indices in the late 2000s. Month was also accepted into the model with significant explanatory power but indiscernible influence on observed catches rates (Figure J.11).

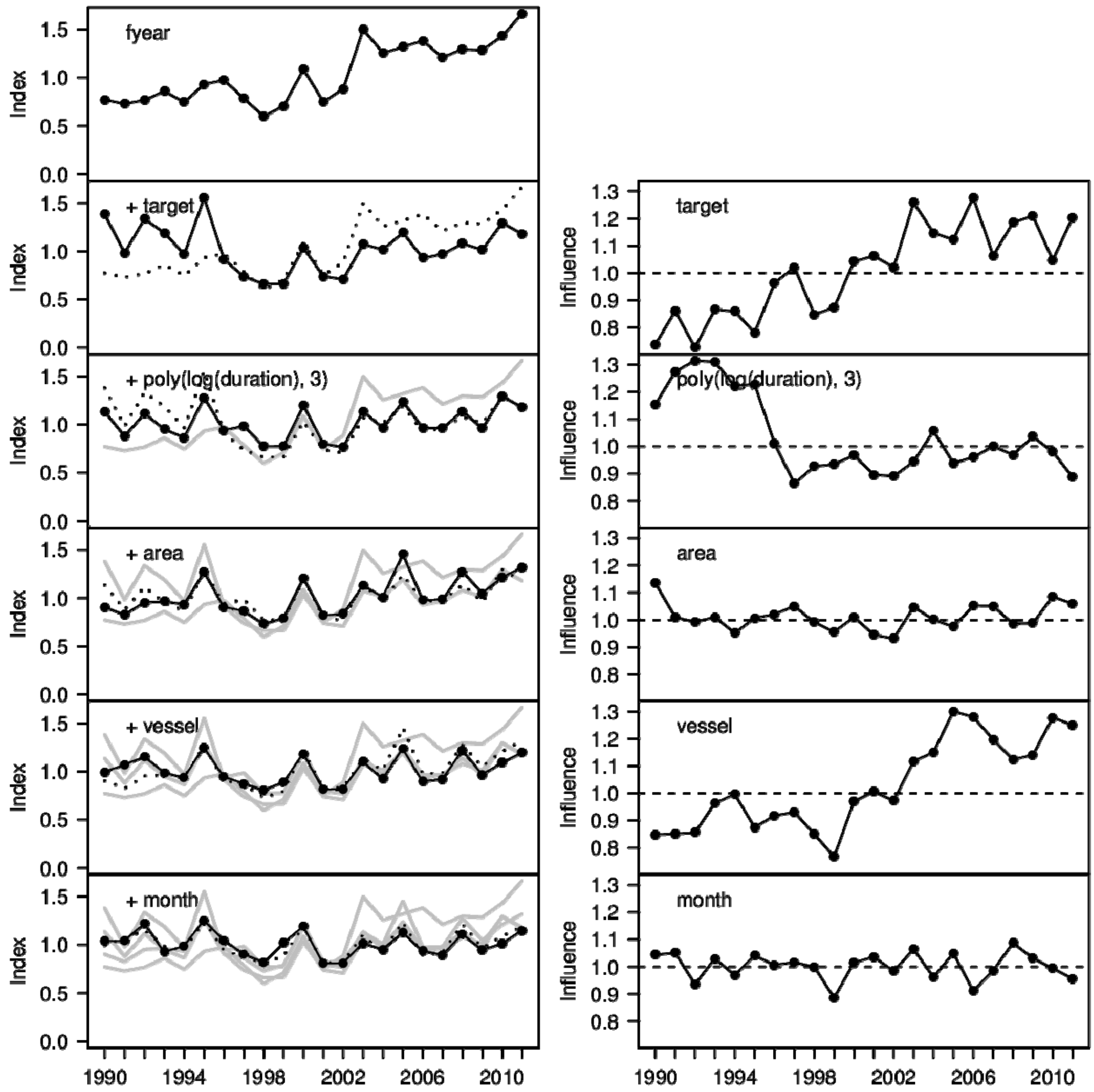


Figure J.11: Step and annual influence plot for WCNI_BT_MIX. (a) CPUE index at each step in the selection of variables. The index obtained in the previous step (if any) is shown by a dotted line and for steps before that by grey lines. (b) Annual influence on observed catches arising from a combination of its GLM coefficients and its distributional changes over years, for each explanatory variable in the final model.

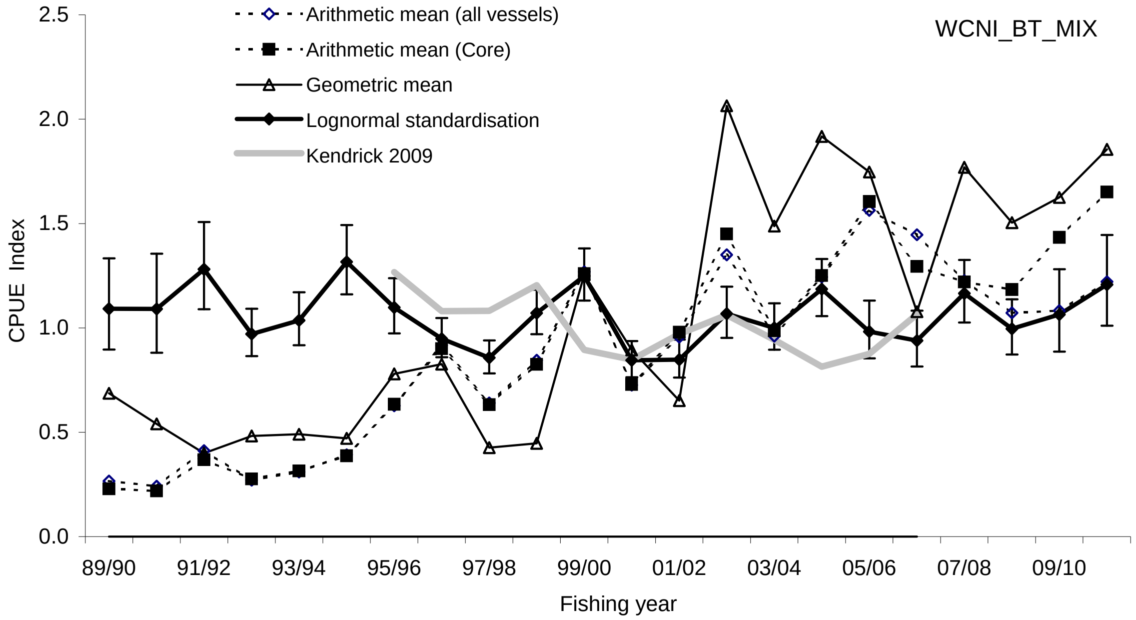


Figure J.12: The effect of standardisation on the raw CPUE of tarakihi in successful trips by core vessels in the WCNI_BT_MIX fishery. Broken lines are the raw CPUE (kg /km net) for all vessels and for the core fleet only, the solid line is the unstandardised CPUE (annual geometric mean), the bold line is the standardised CPUE canonical indices with ± 2 * SE error bars. Grey line is the previous lognormal series presented in 2009 for this fishery. All series are relative to the geometric mean over the years in common.

Diagnostic residual plots are presented for the final Weibull model in Figure K.13 and show a good fit of the data to the error assumption with some unexplained pattern in the residuals, particularly a departure at the tail of the distribution associated with smaller observed values.

A steady shift away from targeting of snapper towards more targeting of tarakihi predicted increased catches of tarakihi over the study period (Figure K.26). The coefficients for the target species categories are well determined with tight error bars and estimate a six-fold difference in catch rates between targeting tarakihi and catching tarakihi as a bycatch in the snapper or trevally fisheries. Consequently, the strong increase in unstandardised catch rates can be attributed to this shift in fishing behaviour (Figure J.11). The negative influence on catch rates of changes in fishing duration were confined to the two years in the mid 1990s when much of the fleet switched from reporting on CELRs to reporting on TCEPRs (Figure K.27). The highest catch rates are from area 047, but fishing in the other areas has been reasonably consistent over the study period with no systematic shifts driving any trend in catch rates (Figure K.28). Changes in the distribution of high catch rate vessels in the core fleet conversely have catch rates rising steadily during the 2000s, along with a strong drop in the number of qualifying vessels remaining in the fishery in the last half of the 2000s (Figure K.29).

The effect of standardisation on catch rate in successful trips was to change a strong increasing trend in observed catch rate to one that is flat, varying around around the mean and with the most recent index just above the mean for the series (Figure J.12). The agreement of this series with the previous series presented for this fishery (Kendrick 2009) is poor, possibly because that series was based only on data obtained from TCEPR forms, with that series also showing no trend but with asynchronous peaks and troughs compared to the currently estimated series (Figure J.12).

A binomial model of the probability of capture produced annual indices that are almost flat except for a slight peak in the late 1990s, providing little contrast or support for the trend in catch rate estimated by the series based on positive catches (Figure K.32).

Appendix K. DETAILED DIAGNOSTICS FOR ADDITIONAL TARAKIHI CPUE STANDARDISATIONS

K.1 Core vessel selection

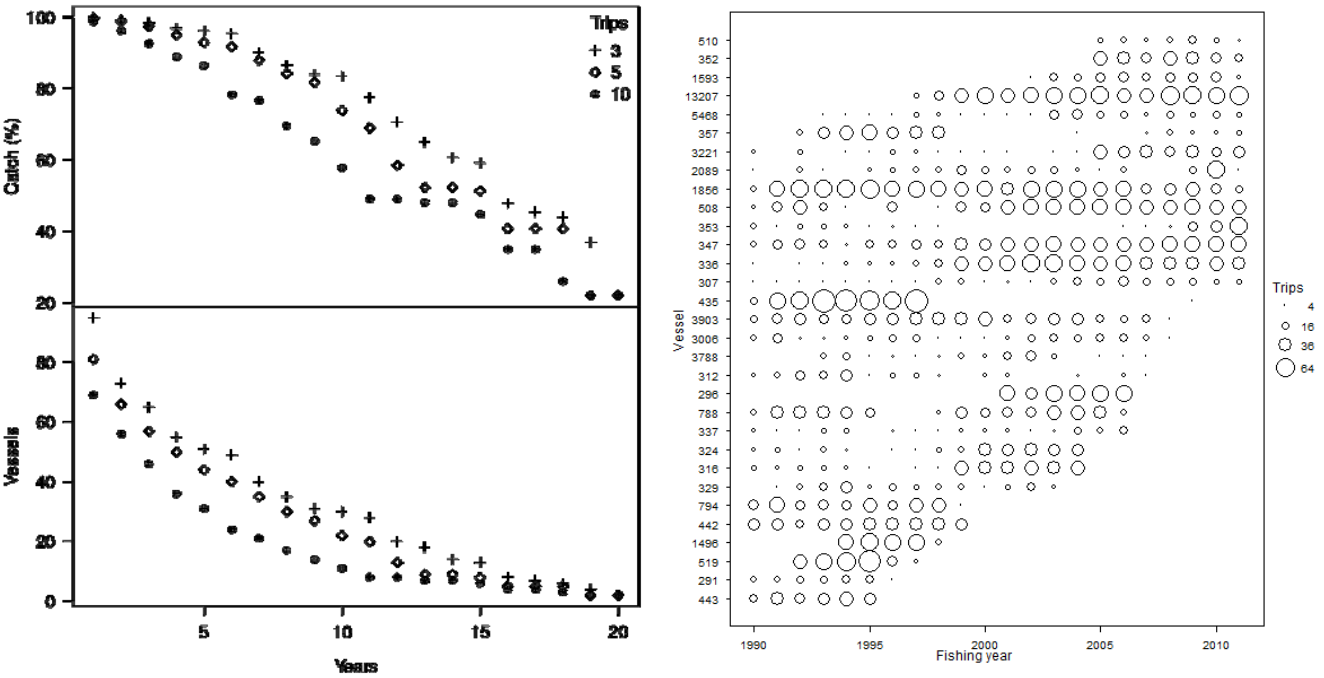


Figure K.1: The total landed tarakihi [top left panel] and the number of vessels [bottom left panel] retained in the BoP_BT_MIX dataset as a function of the minimum number of qualifying years used to define core vessels. [right panel]: the number of records for each vessel in each fishing year for the selected core vessels (based on at least 10 trips in 5 or more fishing years).

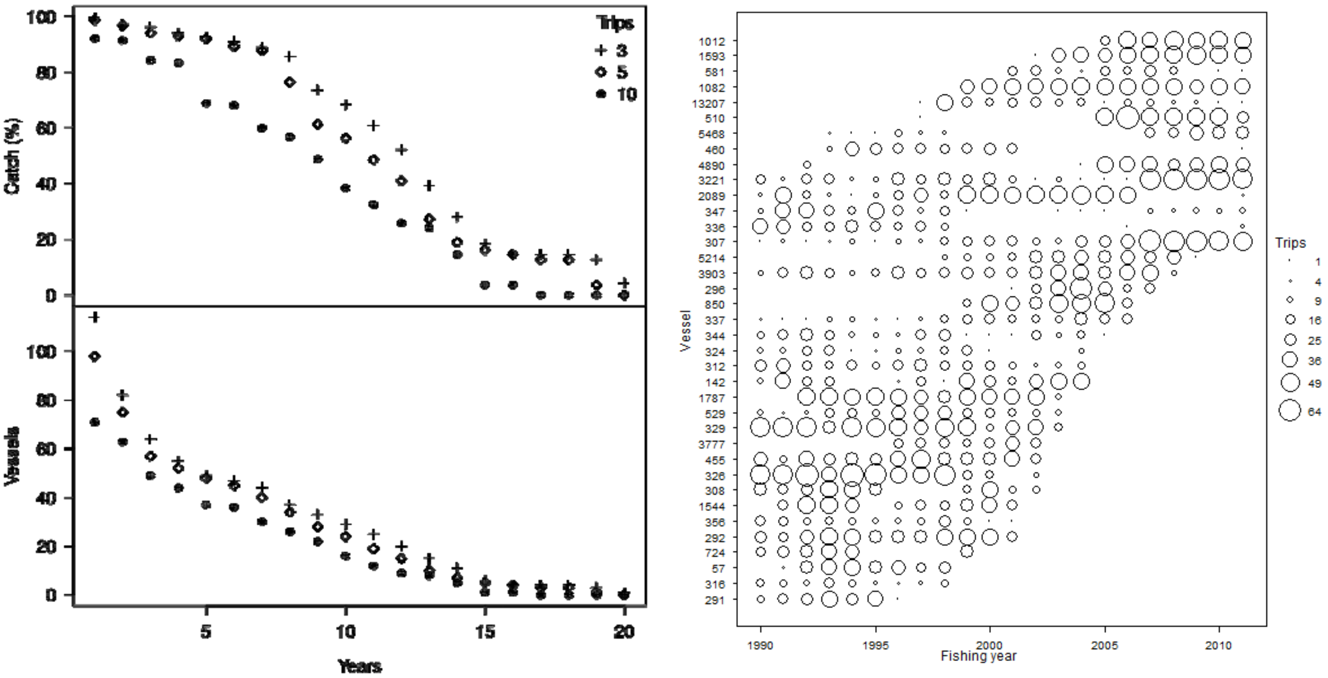


Figure K.2: The total landed tarakihi [top left panel] and the number of vessels [bottom left panel] retained in the EN_BT_MIX dataset as a function of the minimum number of qualifying years used to define core vessels. [right panel]: the number of records for each vessel in each fishing year for the selected core vessels (based on a minimum of 10 trips in 5 or more fishing years).

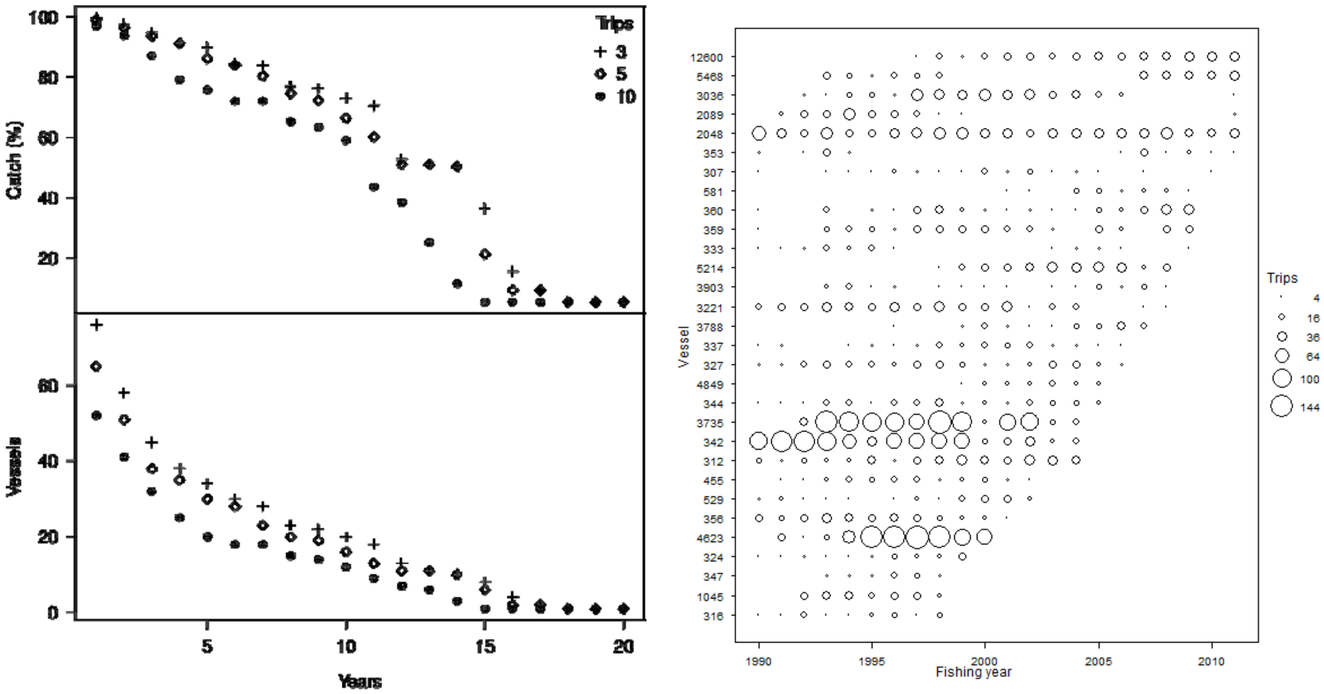


Figure K.3: The total landed tarakihi [top left panel] and the number of vessels [bottom left panel] retained in the WCNI_BT_MIX dataset as a function of the minimum number of qualifying years used to define core vessels. [right panel]: the number of records for each vessel in each fishing year for the selected core vessels (based on at least 10 trips in 5 or more fishing years.

K.2 Data summaries

Table K.1: Number of vessels, trips, trip strata, events, sum of catch, sum of tows (or net length) and sum of hours fishing for core vessels in the three CPUE analyses by fishing year.

	BoP_BT_MIX								EN_BT_MIX								WCNI_BT_MIX							
Fishing year	Vessel	Trips	Trip-strata	events	Catch	Tows	Hours	% zero	Vessel	Trips	Trip-strata	Events	Catch		Hours	% zero	Vessel	Trips	Trip-strata	events	Catch	Tows	Hours	% zero
1990	20	230	272	922	211.9	2 699	7 853	24.4	21	402	575	1 328	97	4 668	11 204	59.1	16	257	317	562	66	1 558	4 411	58.4
1991	18	398	443	1 282	396.9	3 835	12 334	24.1	23	495	718	1 560	126	5 613	13 588	60.3	15	271	335	605	60	1 722	4 895	66.6
1992	23	475	544	1 403	430.7	4 086	14 090	23.7	25	619	932	1 919	226	6 770	18 264	55.2	18	354	450	1 072	129	2 587	7 447	53.3
1993	24	533	572	1 512	467.4	4 068	14 708	27.8	26	601	887	1 732	144	6 219	16 028	51.5	24	612	922	2 541	274	5 688	16 212	54.7
1994	25	591	601	2 023	519.9	4 187	13 709	33.6	25	585	909	1 802	136	5 576	14 183	52.4	24	566	830	1 885	202	4 723	13 245	53.6
1995	23	557	567	2 032	431.5	3 309	10 529	36.7	23	466	726	1 880	134	4 317	10 139	51.4	23	544	785	2 110	280	4 270	12 394	53.4
1996	23	438	519	2 476	378.4	2 817	8 604	36.5	25	481	924	3 635	150	4 231	10 505	41.9	25	616	985	2 782	306	3 845	12 103	58.9
1997	23	472	551	2 683	349.1	3 129	8 289	37.4	26	494	974	4 064	161	4 482	9 435	44.2	23	688	1 144	3 439	358	4 158	12 736	48.6
1998	23	347	511	2 520	340	2 724	8 540	37.2	26	593	1 149	5 400	174	5 773	12 024	47.6	25	759	1 294	4 089	333	4 973	14 959	49.2
1999	19	403	663	3 344	398.9	3 688	11 026	37.5	26	575	1 158	4 864	189	5 502	13 499	37.6	23	588	1 034	3 488	371	4 438	12 508	42.6
2000	18	360	526	2 832	326.8	3 467	9 906	40.7	24	547	1 112	4 633	210	5 378	14 051	34.2	21	425	899	3 205	415	3 754	12 253	38.0
2001	19	432	643	3 607	544.4	4 017	11 356	32.5	24	483	991	4 241	166	4 650	12 549	36.6	21	403	986	3 213	303	3 360	11 592	45.8
2002	18	485	803	3 578	667.6	4 055	11 975	25.9	22	452	897	3 803	123	4 157	10 945	39.9	19	394	892	2 731	376	2 805	9 989	44.5
2003	19	547	830	4 050	701.4	4 538	13 527	29.7	19	396	887	3 130	97	3 520	8 182	39.0	18	270	719	2 397	453	2 397	8 922	41.9
2004	19	532	919	4 465	757.6	4 824	14 933	26.7	18	454	949	3 153	109	4 017	9 029	44.5	18	296	800	3 102	417	3 102	11 351	44.1
2005	18	513	894	4 575	662.3	5 175	15 953	30.4	17	415	866	2 777	155	3 949	9 607	44.1	15	235	703	2 429	431	2 429	9 067	38.8
2006	20	501	747	3 678	471.8	4 258	12 685	32.5	16	448	958	2 907	212	4 271	11 421	45.9	13	182	421	1 490	319	1 503	5 375	31.8
2007	17	337	589	2 784	442.4	3 131	9 504	32.1	14	481	1 050	3 494	183	5 043	12 249	42.1	11	187	442	1 735	266	1 806	6 123	38.2
2008	15	359	674	3 233	446.6	3 233	10 365	28.0	13	406	1 105	3 890	177	3 890	11 243	37.5	10	206	557	2 068	333	2 068	7 320	36.8
2009	15	400	757	3 714	622.6	3 717	11 948	28.7	11	360	999	4 109	175	4 109	11 508	36.7	8	169	541	2 020	347	2 020	7 426	37.7
2010	14	414	832	3 544	640.8	3 544	11 730	26.6	11	363	1 053	4 047	161	4 047	11 261	35.0	5	97	252	942	175	942	3 246	35.7
2011	14	352	669	3 344	530	3 344	10 256	28.1	14	322	990	3 925	162	3 925	9 973	42.3	6	112	270	897	255	897	3 129	35.2

K.3 Diagnostic plots

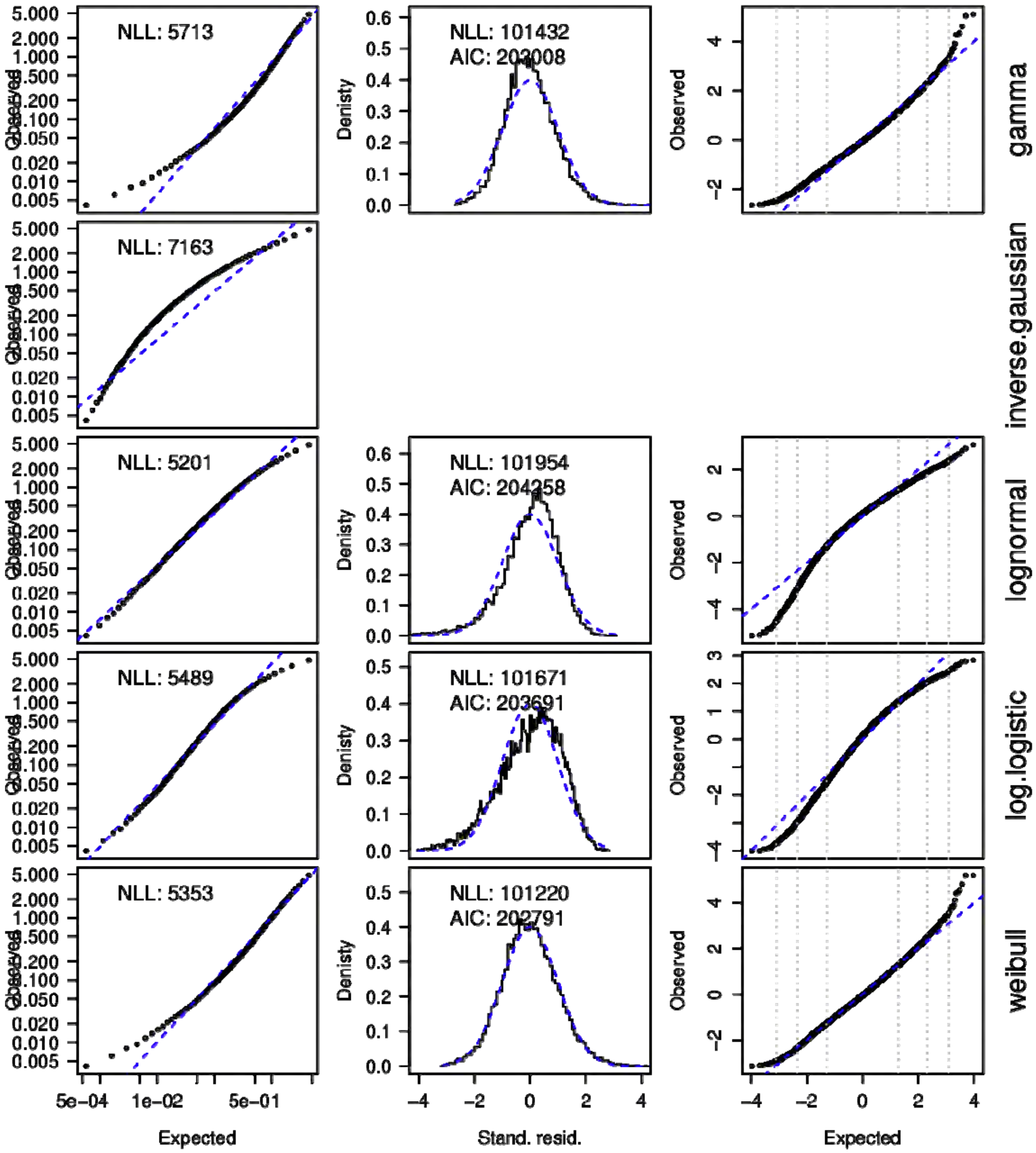


Figure K.4: Diagnostics for alternative distributional assumptions for catch in the BoP_BT_MIX fishery. Left: quantile-quantile plot of observed catches (centred (by mean) and scaled (by standard deviation) in log space) versus maximum likelihood fit of distribution (missing panel indicates that the fit failed to converge); Middle: standardised residuals from a generalised linear model fitted using the formula catch ~ fyear + month + area + vessel + target and the distribution (missing panel indicates that the model failed to converge); Right: quantile-quantile plot of model standardised residuals against standard normal (vertical lines represent 0.1%, 1% and 10% percentiles). NLL = negative log-likelihood; AIC = Akaike information criterion.

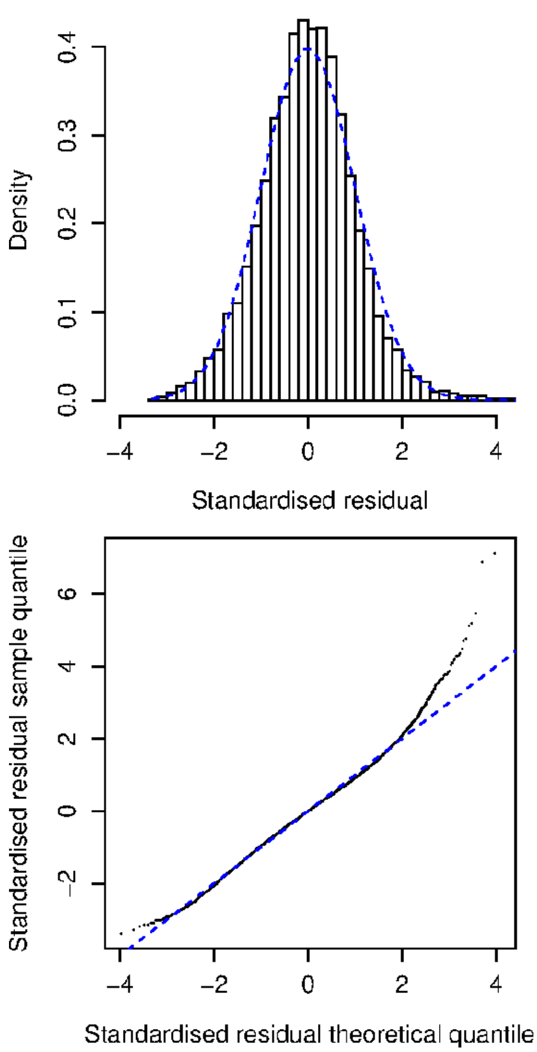


Figure K.5: Plots of the fit of the standardised CPUE model to successful catches of tarakihi in the BoP_BT_MIX fishery. [Upper left] histogram of the standardised residuals compared to a lognormal distribution (SDSR: standard deviation of standardised residuals. MASR: median of absolute standardised residuals); [Upper right] Standardised residuals plotted against the predicted model catch per trip; [Lower left] Q-Q plot of the standardised residuals; [Lower right] Observed catch per record plotted against the predicted catch per record.

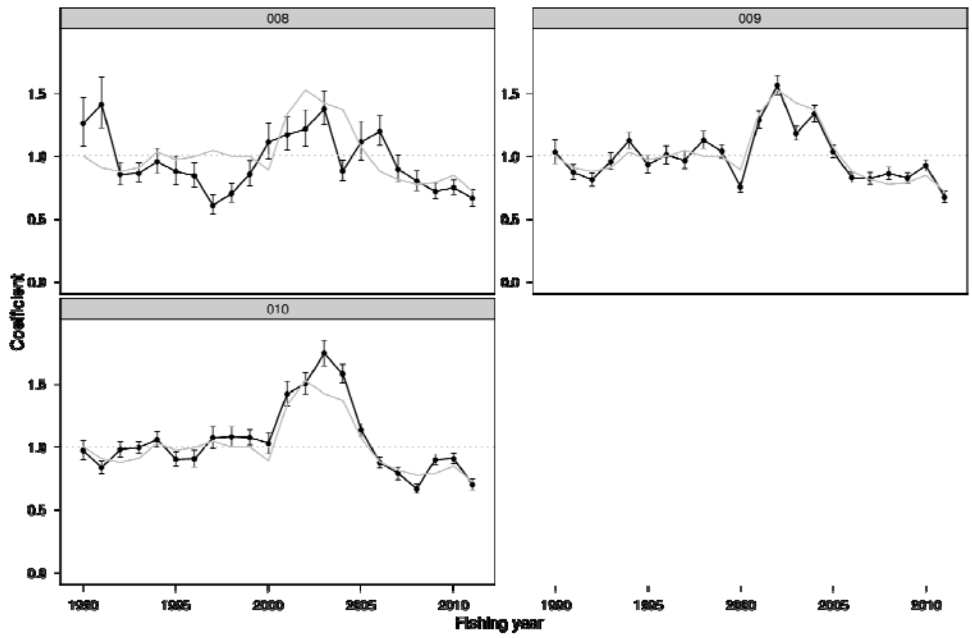


Figure K.6: Residual implied coefficients for each area in each fishing year in the BoP_BT_MIX fishery. Implied coefficients are calculated as the sum of the fishing year coefficient plus the mean of the residuals in each fishing year in each area. The error bars indicate one standard error of residuals. The grey line indicates the model's overall fishing year coefficients.

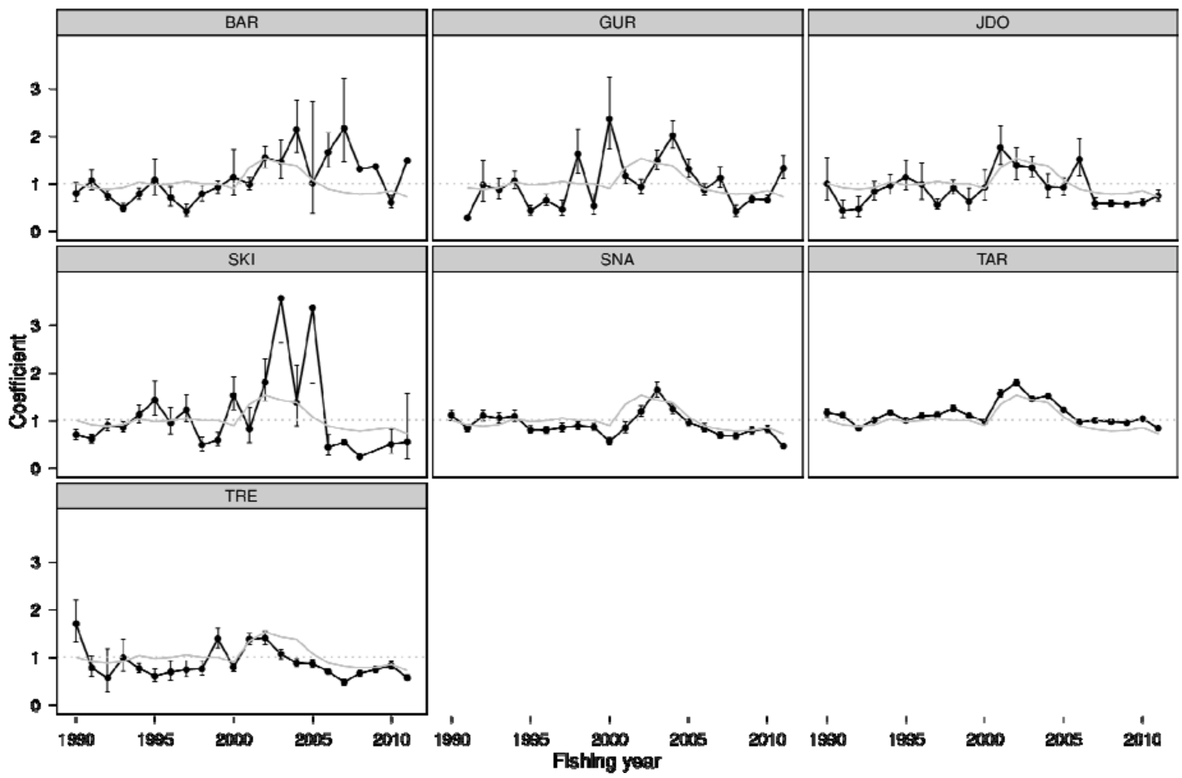


Figure K.7: Residual implied coefficients for each target species in each fishing year in the BoP_BT_MIX fishery. Implied coefficients are calculated as the sum of the fishing year coefficient plus the mean of the residuals in each fishing year for each target. The error bars indicate one standard error of residuals. The grey line indicates the model's overall fishing year coefficients.

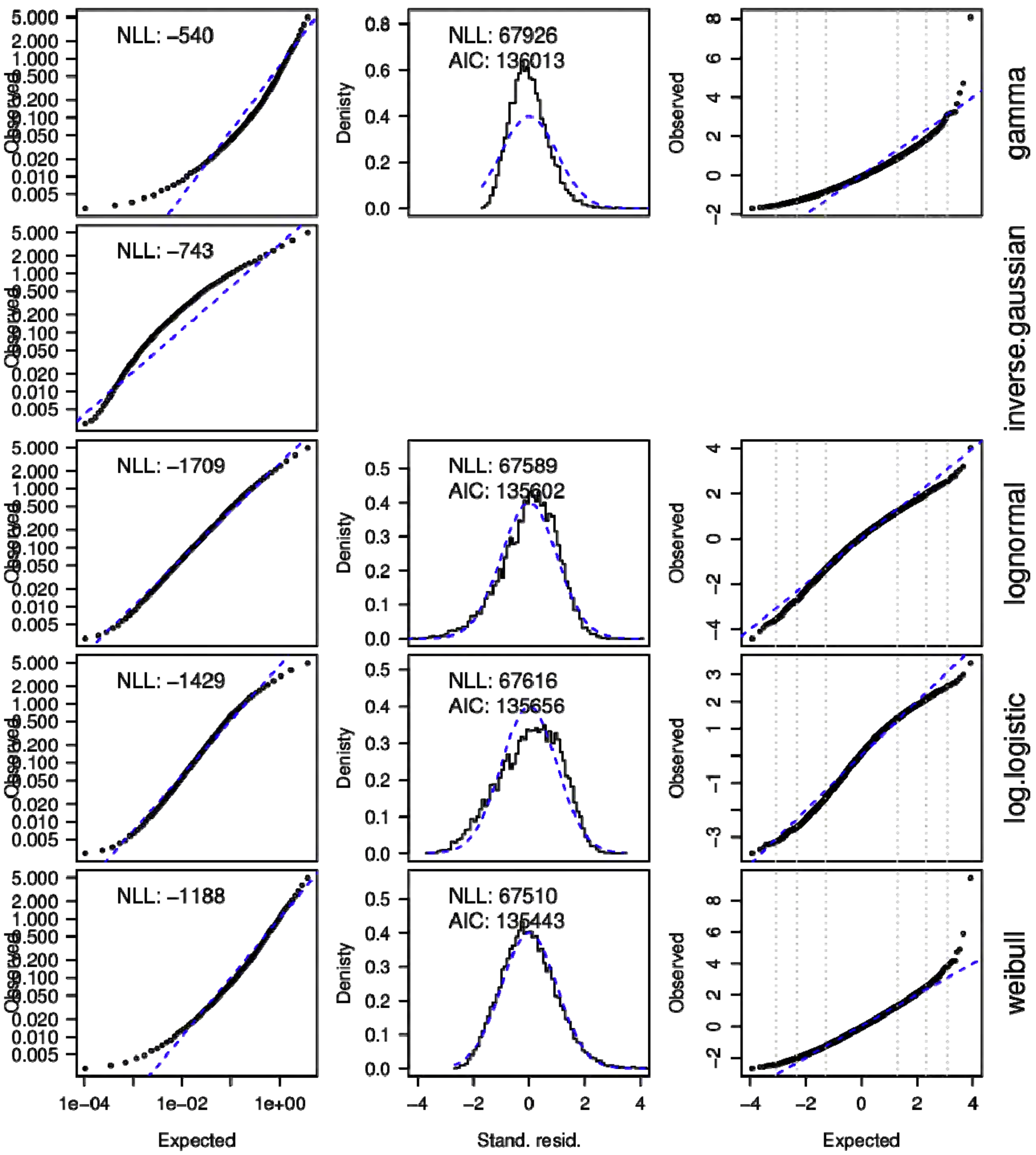


Figure K.8: Diagnostics for alternative distributional assumptions for catch in the EN_BT_MIX fishery. Left: quantile-quantile plot of observed catches (centred (by mean) and scaled (by standard deviation) in log space) versus maximum likelihood fit of distribution (missing panel indicates that the fit failed to converge); Middle: standardised residuals from a generalised linear model fitted using the formula catch ~ fyear + month + area + vessel + target and the distribution (missing panel indicates that the model failed to converge); Right: quantile-quantile plot of model standardised residuals against standard normal (vertical lines represent 0.1%, 1% and 10% percentiles). NLL = negative log-likelihood; AIC = Akaike information criterion.

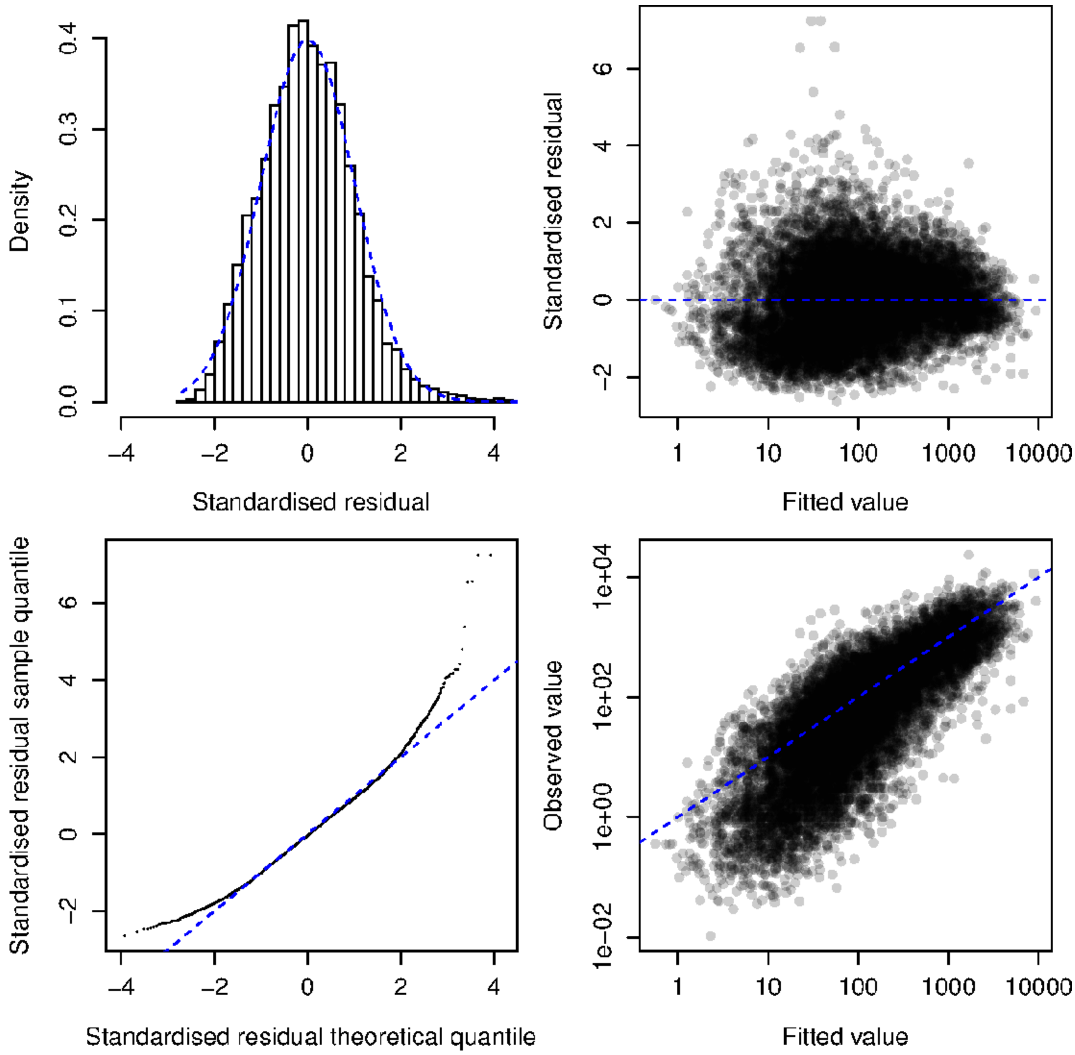


Figure K.9: Plots of the fit of the standardised CPUE model to successful catches of tarakihi in the EN_BT_MIX fishery. [Upper left] histogram of the standardised residuals compared to a lognormal distribution (SDSR: standard deviation of standardised residuals. MASR: median of absolute standardised residuals); [Upper right] Standardised residuals plotted against the predicted model catch per trip; [Lower left] Q-Q plot of the standardised residuals; [Lower right] Observed catch per record plotted against the predicted catch per record.

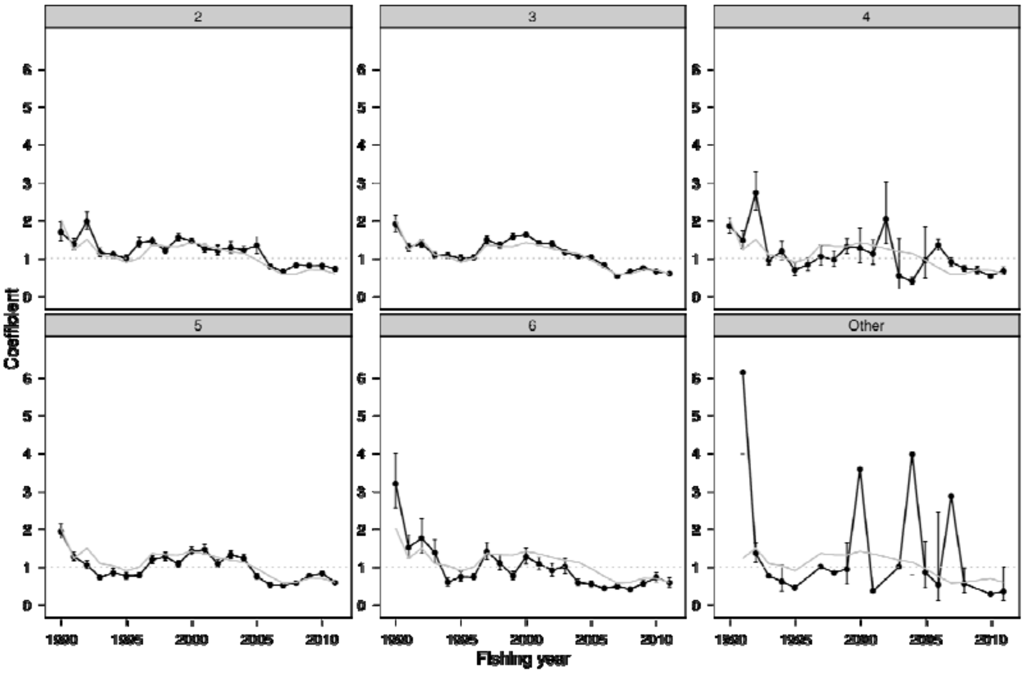


Figure K.10: Residual implied coefficients for each area in each fishing year in the EN_BT_MIX fishery. Implied coefficients are calculated as the sum of the fishing year coefficient plus the mean of the residuals in each fishing year in each area. The error bars indicate one standard error of residuals. The grey line indicates the model's overall fishing year coefficients.

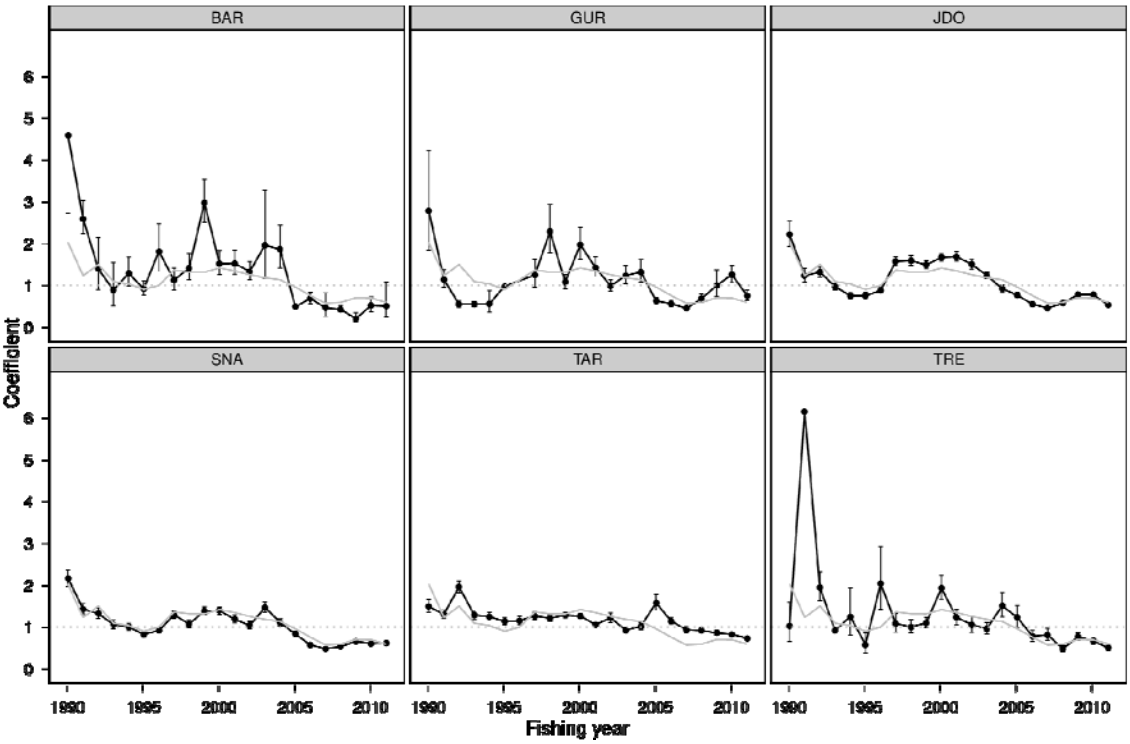


Figure K.11: Residual implied coefficients for each target species in each fishing year in the EN_BT_MIX fishery. Implied coefficients are calculated as the sum of the fishing year coefficient plus the mean of the residuals in each fishing year for each target. The error bars indicate one standard error of residuals. The grey line indicates the model's overall fishing year coefficients.

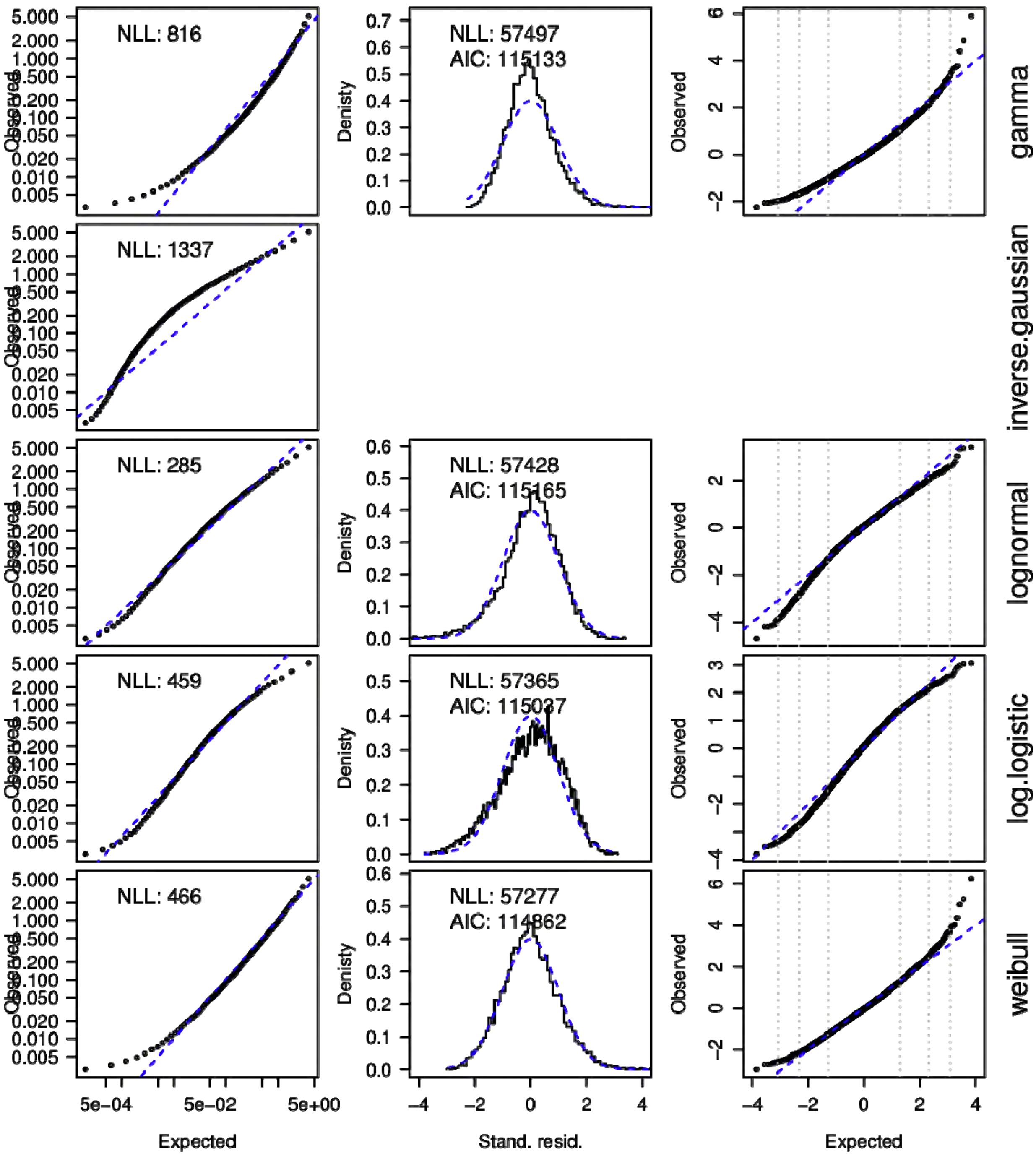


Figure K.12: Diagnostics for alternative distributional assumptions for catch in the WCNI_BT_MIX fishery. Left: quantile-quantile plot of observed catches (centred (by mean) and scaled (by standard deviation) in log space) versus maximum likelihood fit of distribution (missing panel indicates that the fit failed to converge); Middle: standardised residuals from a generalised linear model fitted using the formula catch ~ fyear + month + area + vessel + target and the distribution (missing panel indicates that the model failed to converge); Right: quantile-quantile plot of model standardised residuals against standard normal (vertical lines represent 0.1%, 1% and 10% percentiles). NLL = negative log-likelihood; AIC = Akaike information criterion.

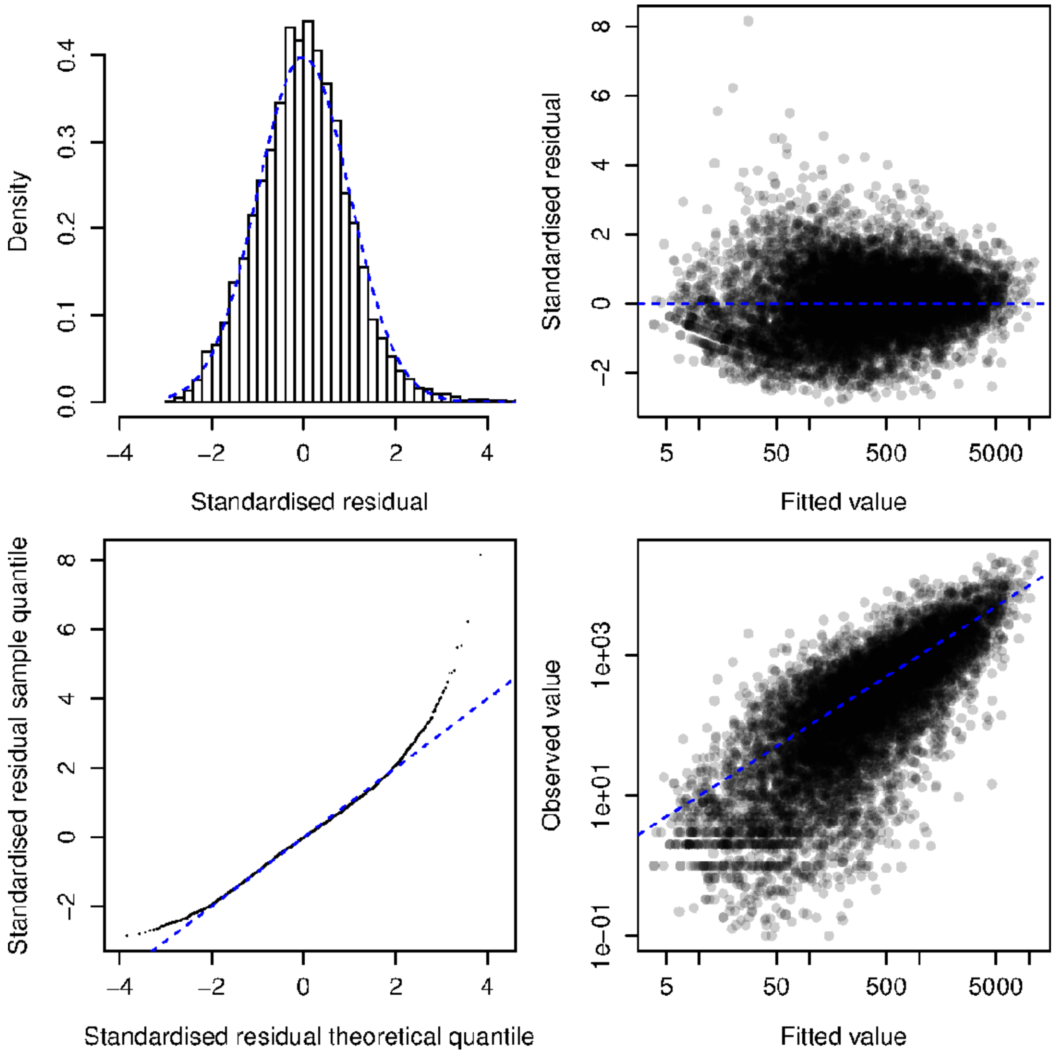


Figure K.13: Plots of the fit of the standardised CPUE model to successful catches of tarakihi in the WCNI_BT_MIX fishery. [Upper left] histogram of the standardised residuals compared to a lognormal distribution (SDSR: standard deviation of standardised residuals. MASR: median of absolute standardised residuals); [Upper right] Standardised residuals plotted against the predicted model catch per trip; [Lower left] Q-Q plot of the standardised residuals; [Lower right] Observed catch per record plotted against the predicted catch per record.

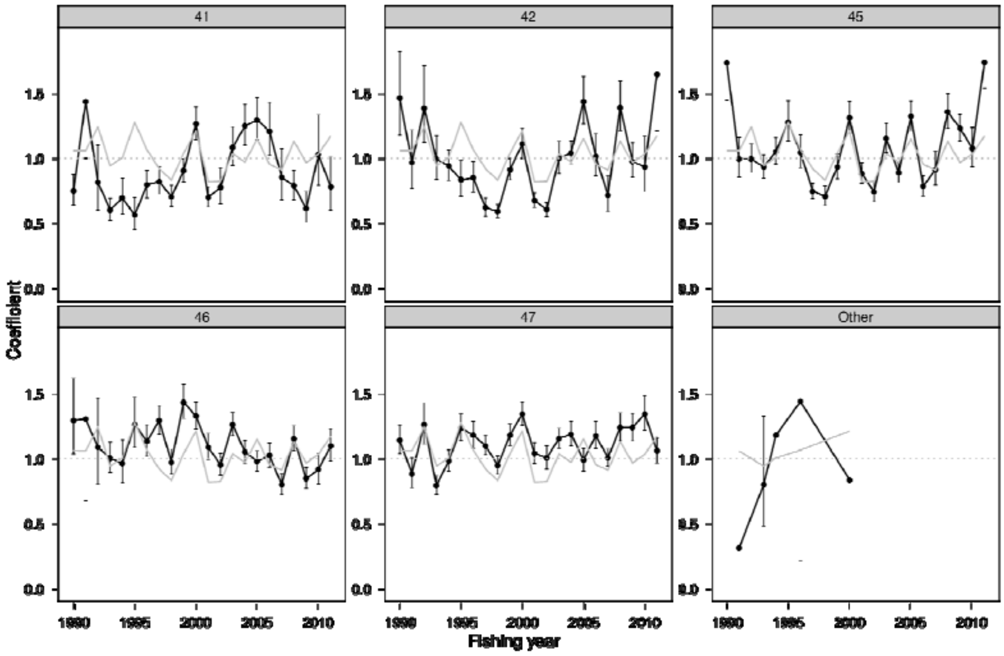


Figure K.14: Residual implied coefficients for each area in each fishing year in the WCNI_BT_MIX fishery. Implied coefficients are calculated as the sum of the fishing year coefficient plus the mean of the residuals in each fishing year in each area. The error bars indicate one standard error of residuals. The grey line indicates the model's overall fishing year coefficients.

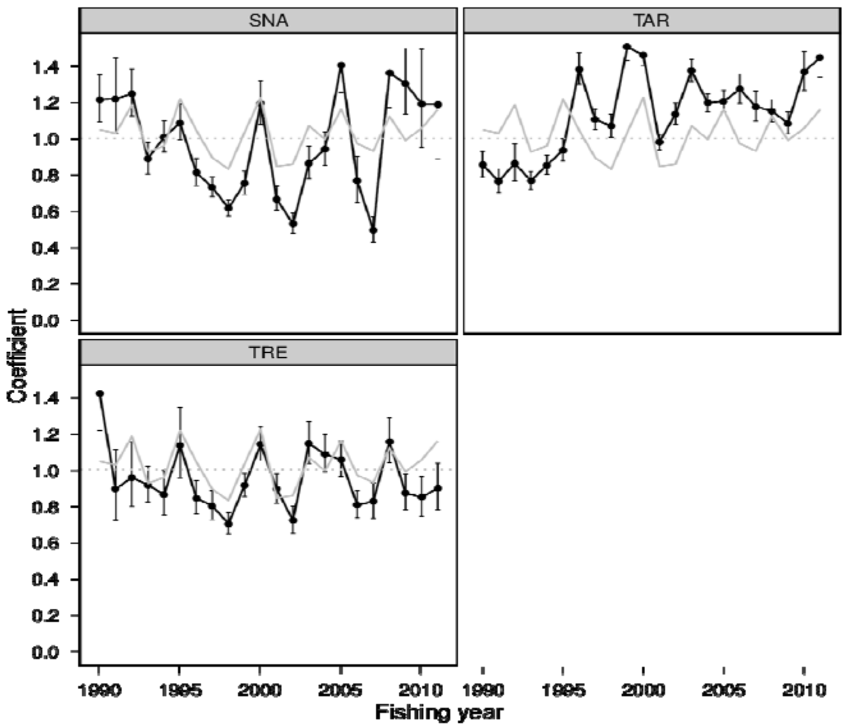


Figure K.15: Residual implied coefficients for each target species in each fishing year in the WCNI_BT_MIX fishery. Implied coefficients are calculated as the sum of the fishing year coefficient plus the mean of the residuals in each fishing year for each target. The error bars indicate one standard error of residuals. The grey line indicates the model's overall fishing year coefficients.

K.4 Model coefficients

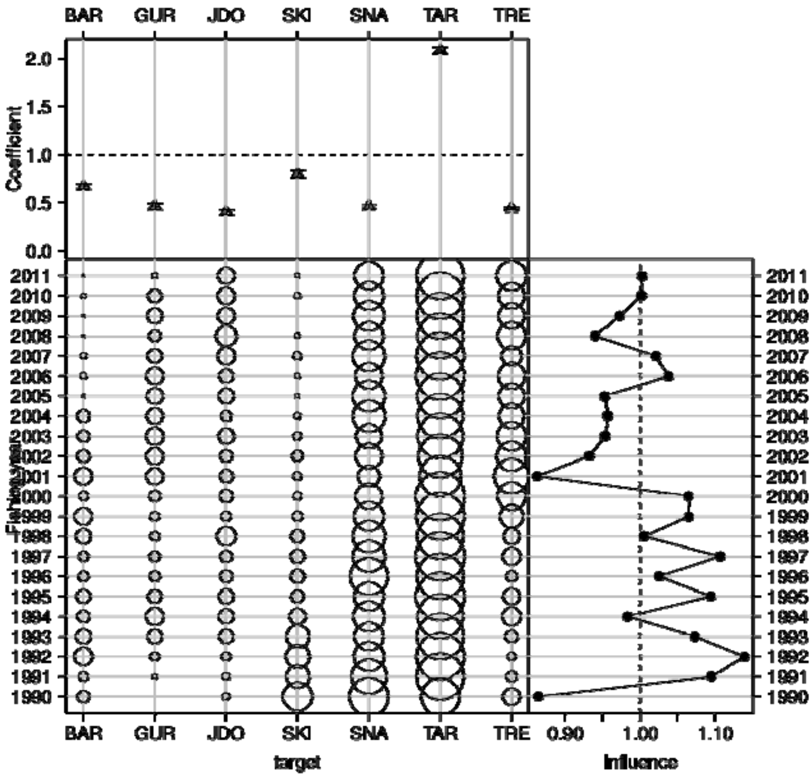


Figure K.16: Effect of target **in the Weibull model for the BoP_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

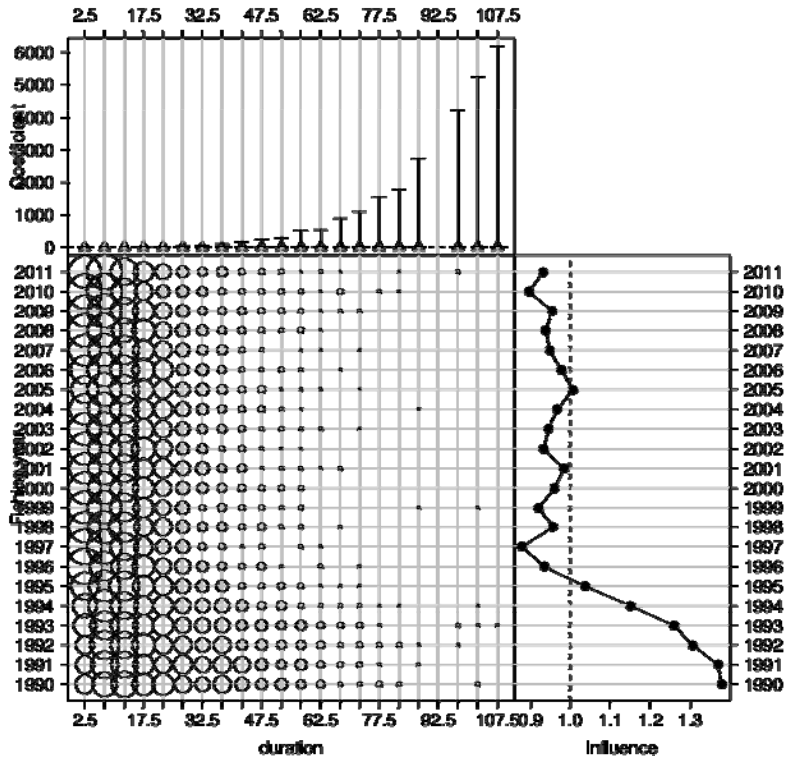


Figure K.17: Effect of duration **in the Weibull model for the BoP_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

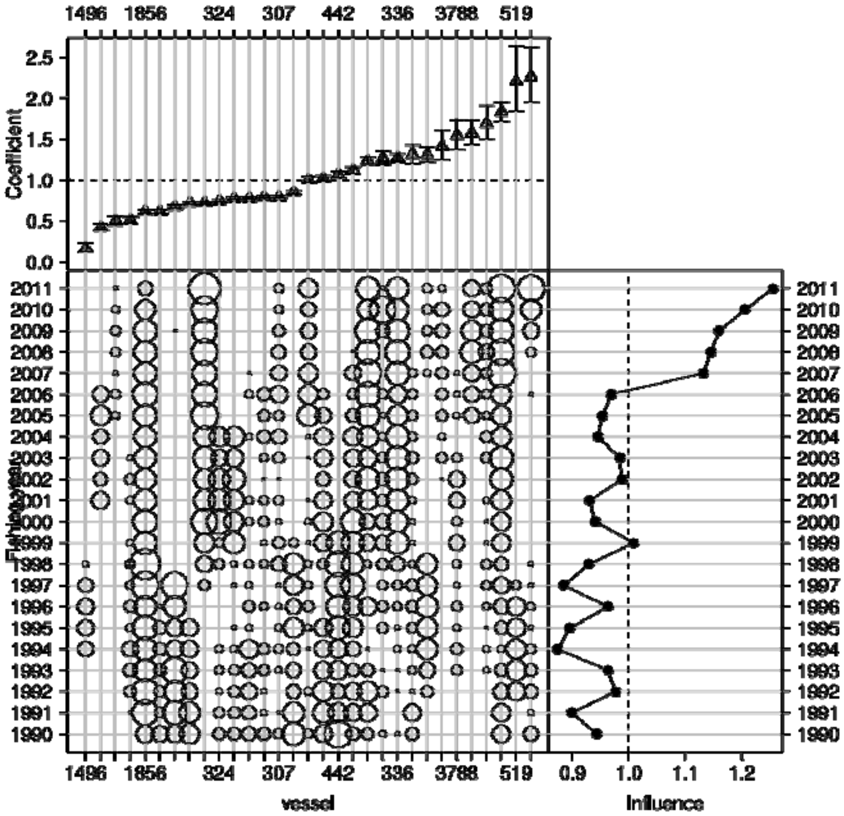


Figure K.18: Effect of vessel in the Weibull model for the BoP_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.

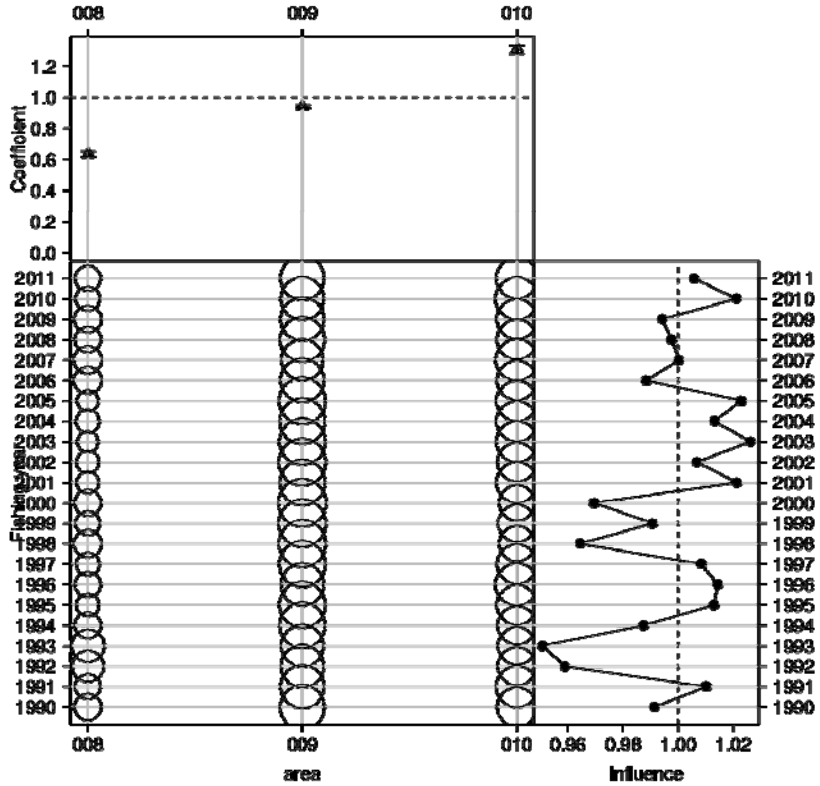


Figure K.19: Effect of area in the Weibull model for the BoP_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.

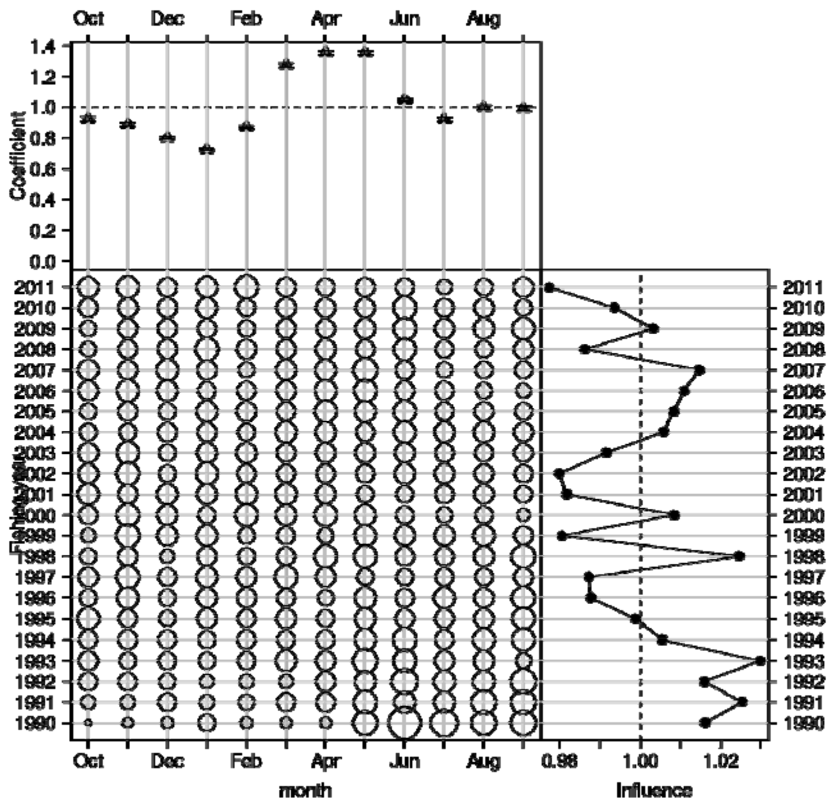


Figure K.20: Effect of month **in the Weibull model for the BoP_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

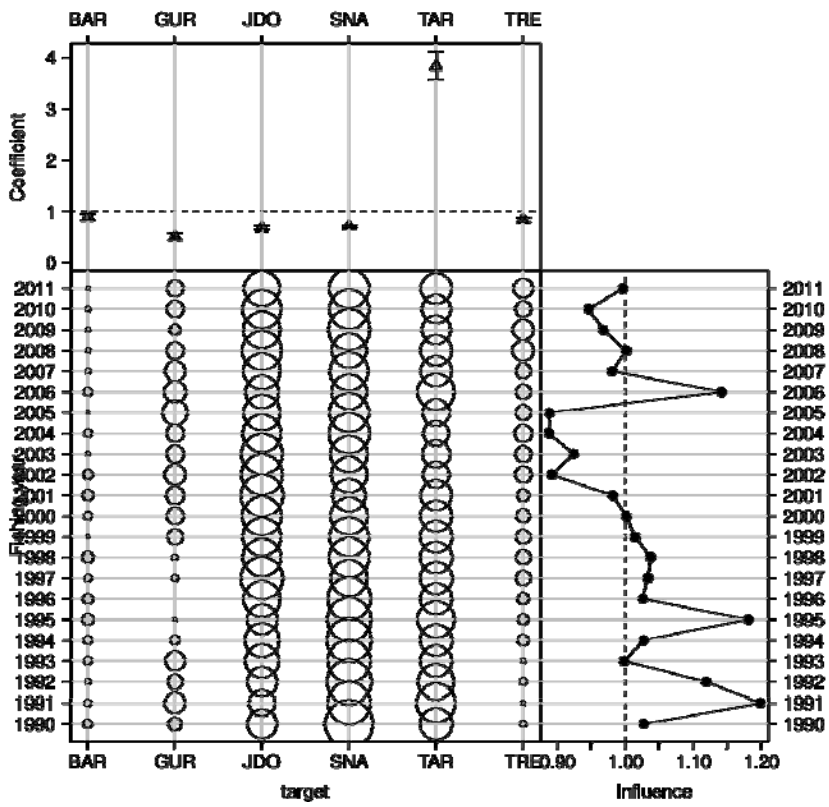


Figure K.21: Effect of target **in the Weibull model for the EN_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

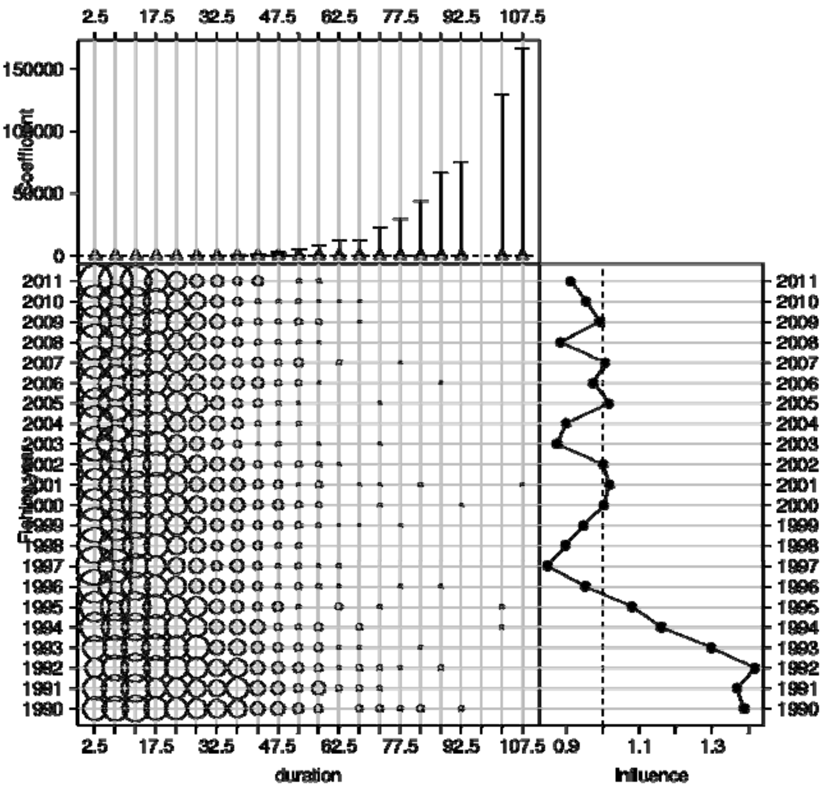


Figure K.22: Effect of duration **in the Weibull model for the EN_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

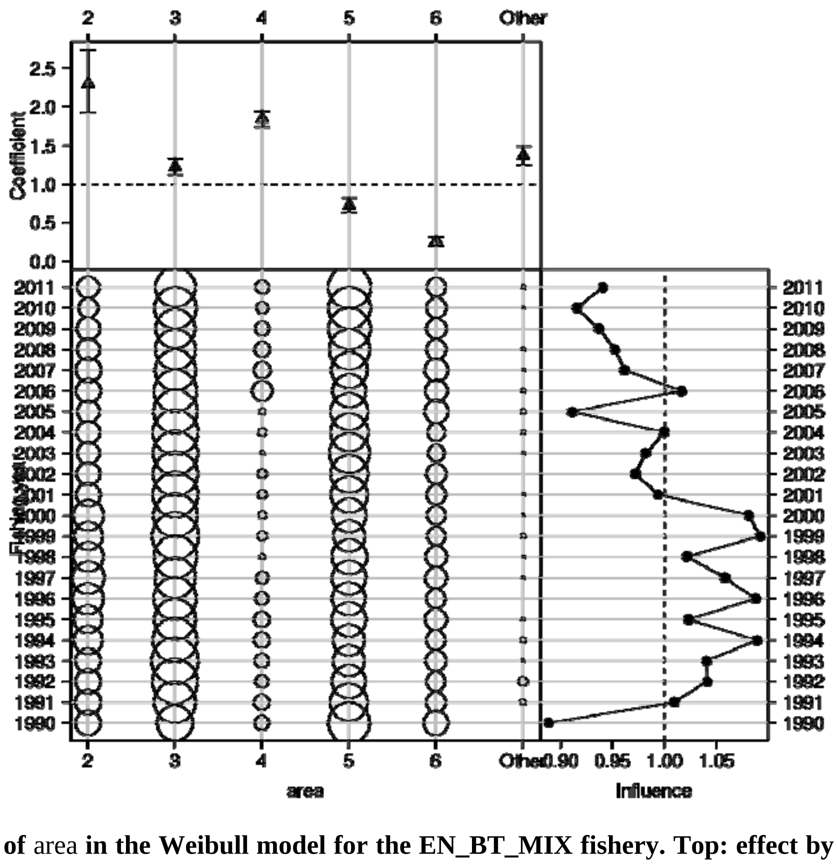


Figure K.23: Effect of area **in the Weibull model for the EN_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

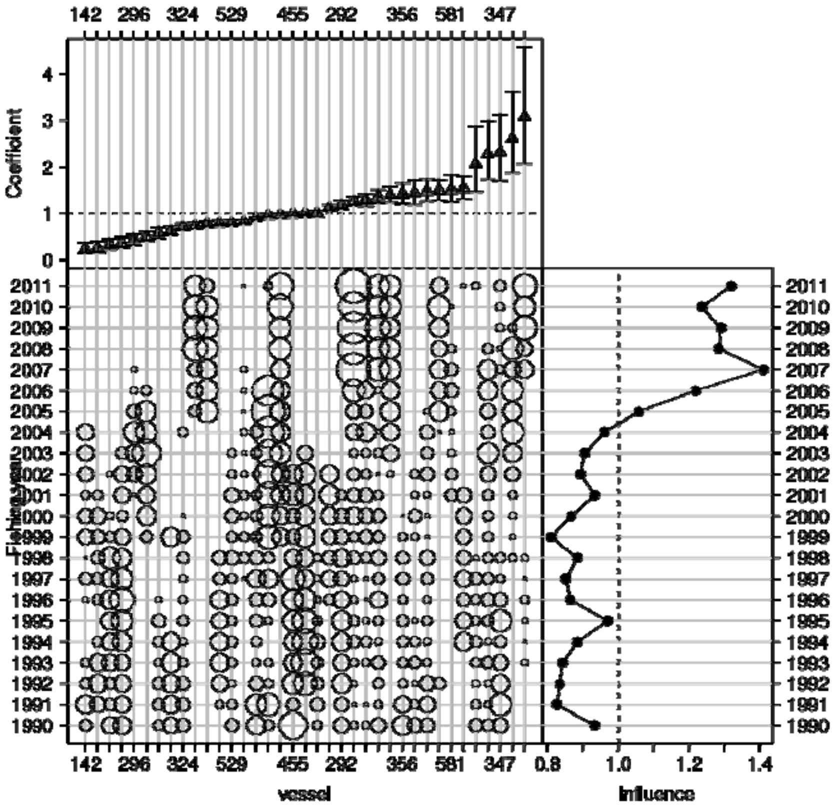


Figure K.24: **Effect of** vessel **in the Weibull model for the EN_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

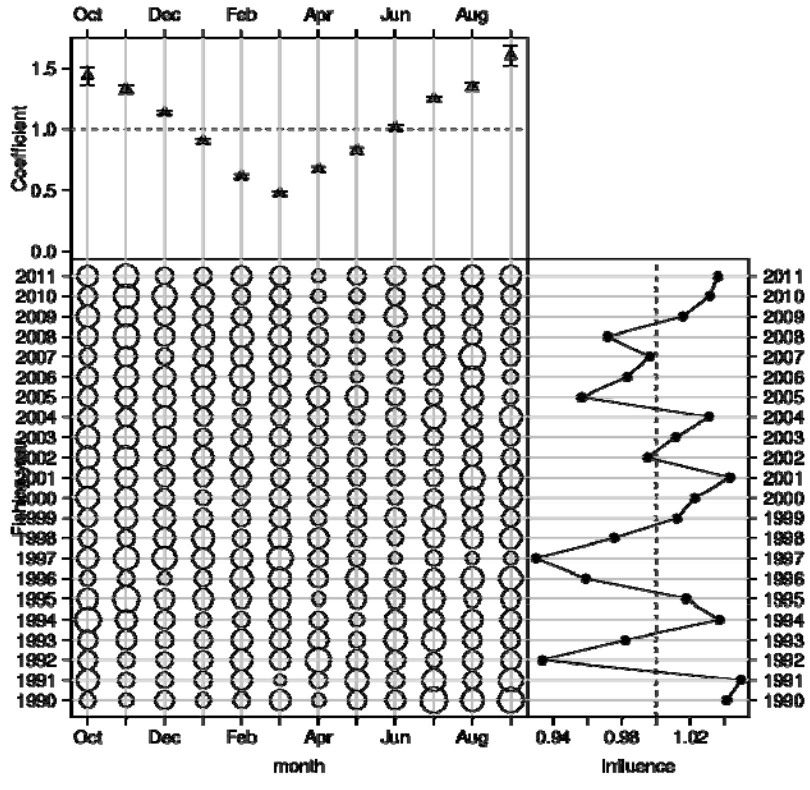


Figure K.25: **Effect of** month **in the Weibull model for the EN_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

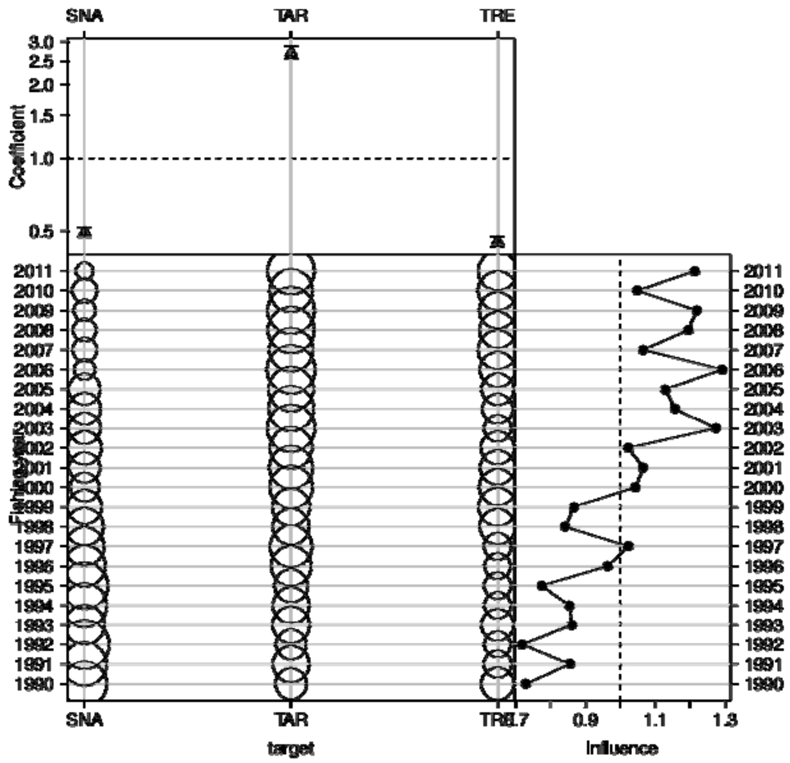


Figure K.26: Effect of target **in the Weibull model for the WCNI_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

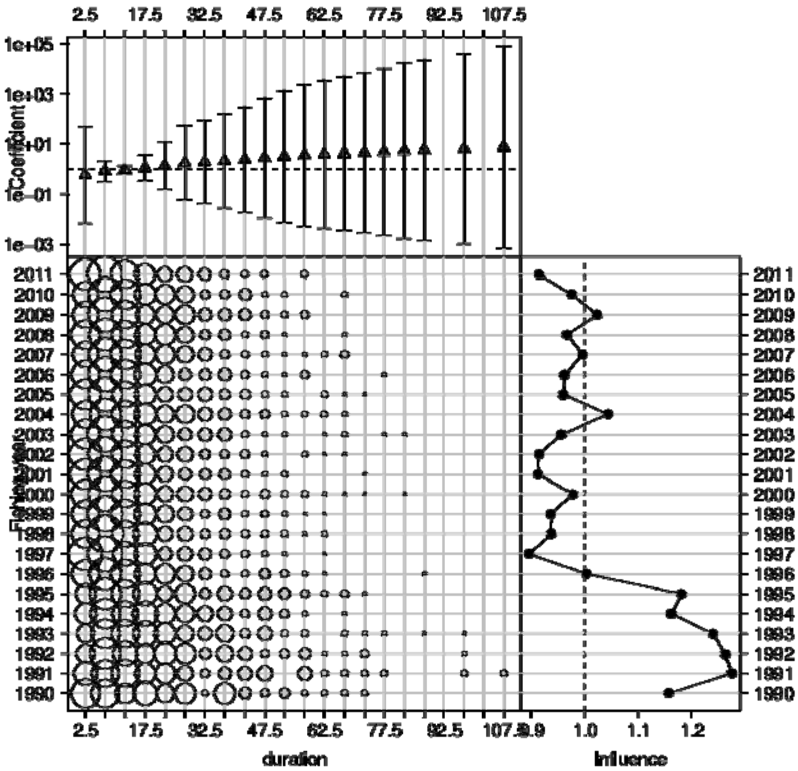


Figure K.27: Effect of duration **in the Weibull model for the WCNI_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

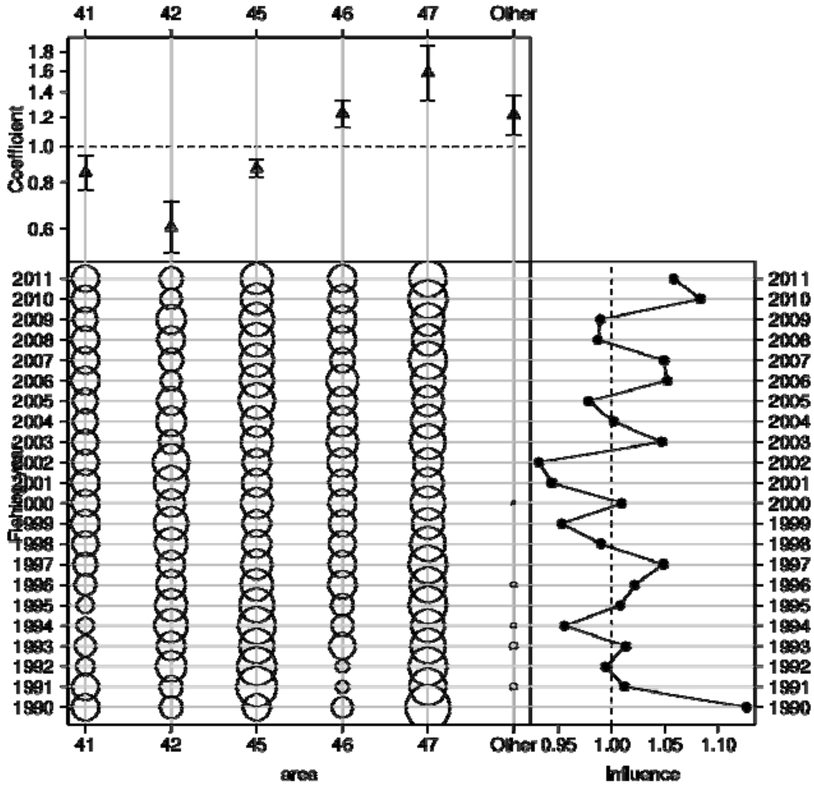


Figure K.28: **Effect of** area **in the Weibull model for the WCNI_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

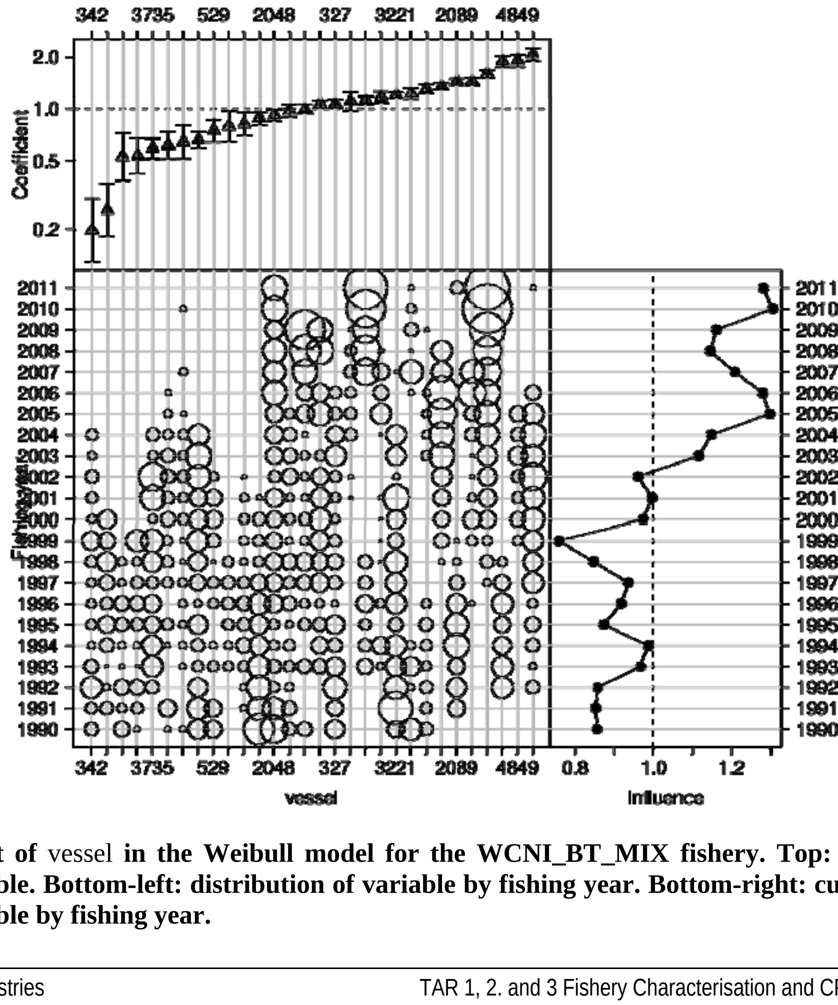


Figure K.29: **Effect of** vessel **in the Weibull model for the WCNI_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

K.5 CPUE indices

Table K.2: Arithmetic indices for the total and core data sets, geometric and lognormal standardised indices and associated standard error for the core data set by fishing year for each of the three CPUE models.

	BoP_BT_MIX					EN_BT_MIX					WCNI_BT_MIX				
Fishing	All	Core				All	Core				All	Core			
Year	Arithmetic	Arithmetic	Geometric	Standardised	SE	Arithmetic	Arithmetic	Geometric	Standardised	SE	Arithmetic	Arithmetic	Geometric	Standardised	SE
1990	0.420	0.518	0.694	1.014	0.064	0.576	0.637	1.502	1.965	0.082	0.358	0.304	0.753	1.039	0.105
1991	0.672	0.757	0.828	0.918	0.051	0.518	0.619	1.305	1.191	0.075	0.325	0.290	0.592	1.038	0.114
1992	0.687	0.730	0.899	0.889	0.046	0.786	1.136	1.227	1.451	0.064	0.554	0.488	0.439	1.218	0.086
1993	0.763	0.807	0.999	0.921	0.046	0.675	0.705	0.756	1.057	0.063	0.363	0.366	0.529	0.924	0.062
1994	0.854	0.804	0.900	1.044	0.044	0.930	0.801	0.897	1.004	0.062	0.416	0.416	0.538	0.986	0.065
1995	0.915	0.871	0.848	0.984	0.046	0.995	0.945	0.964	0.872	0.068	0.528	0.512	0.517	1.252	0.067
1996	1.165	1.072	0.935	1.007	0.047	1.155	1.194	0.895	0.966	0.056	0.843	0.839	0.854	1.045	0.064
1997	0.900	0.932	0.815	1.058	0.046	1.576	1.163	1.122	1.320	0.057	1.231	1.192	0.906	0.902	0.053
1998	0.917	0.999	0.994	1.010	0.047	1.271	1.088	1.028	1.277	0.054	0.861	0.836	0.468	0.815	0.049
1999	0.911	0.916	1.133	1.011	0.041	1.069	1.013	1.225	1.274	0.049	1.135	1.092	0.491	1.019	0.053
2000	0.740	0.775	0.843	0.902	0.047	1.143	1.151	1.528	1.371	0.048	1.704	1.667	1.376	1.188	0.053
2001	1.243	1.219	1.022	1.355	0.042	1.262	0.981	1.339	1.304	0.052	0.975	0.965	0.981	0.804	0.055
2002	1.663	1.677	1.378	1.546	0.038	1.266	0.998	0.922	1.214	0.055	1.283	1.294	0.715	0.807	0.057
2003	1.454	1.371	1.347	1.443	0.037	0.847	0.890	1.029	1.144	0.056	1.813	1.918	2.262	1.016	0.061
2004	1.491	1.457	1.336	1.389	0.036	1.020	0.926	0.848	1.097	0.057	1.290	1.304	1.631	0.951	0.059
2005	1.186	1.145	1.083	1.084	0.037	1.475	1.128	0.615	0.928	0.059	1.671	1.655	2.102	1.128	0.061
2006	1.061	0.923	0.978	0.891	0.040	1.636	1.561	0.965	0.730	0.059	2.099	2.123	1.915	0.934	0.075
2007	1.072	1.068	1.038	0.822	0.044	1.141	1.197	0.682	0.554	0.056	1.942	1.712	1.181	0.893	0.075
2008	1.114	1.096	0.939	0.784	0.042	0.934	1.173	0.881	0.572	0.055	1.647	1.614	1.940	1.108	0.068
2009	1.180	1.131	1.122	0.798	0.040	1.021	1.196	1.043	0.680	0.058	1.440	1.565	1.649	0.947	0.070
2010	1.390	1.337	1.376	0.858	0.039	0.811	1.008	0.959	0.674	0.056	1.455	1.897	1.781	1.012	0.098
2011	1.211	1.141	0.869	0.728	0.044	0.823	0.988	0.856	0.574	0.059	1.639	2.183	2.034	1.148	0.095

K.6 Binomial and combined models

K.6.1 BoP_BT_MIX Mixed target Bottom trawl in TAR 1

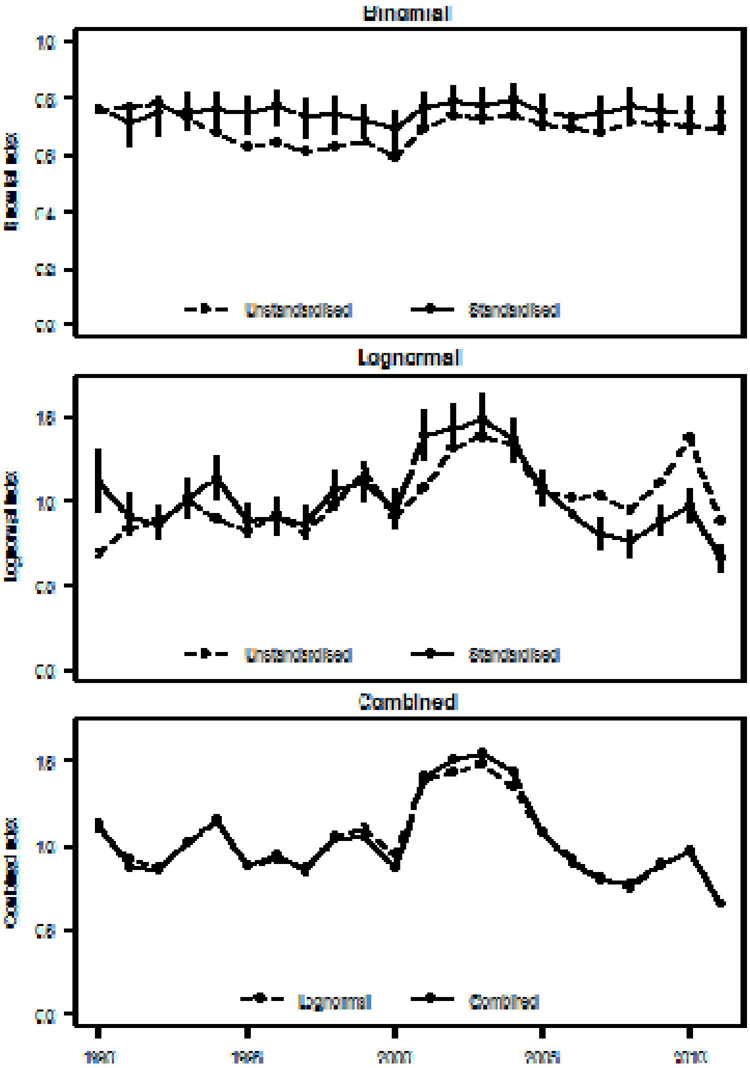


Figure K.30: The effect of standardisation on the raw CPUE of tarakihi by core vessels in the BoP_BT_MIX fishery. Top: Binomial index of probability of capture. Middle: Lognormal index of magnitude of catch. broken line is the raw CPUE (kg / tow) the solid line is the standardised CPUE canonical indices with ± 2 * SE error bars. Bottom: The effect on the lognormal index of combining it with the Binomial index.

K.6.2 EN_BT_MIX Mixed target Bottom trawl in TAR 1

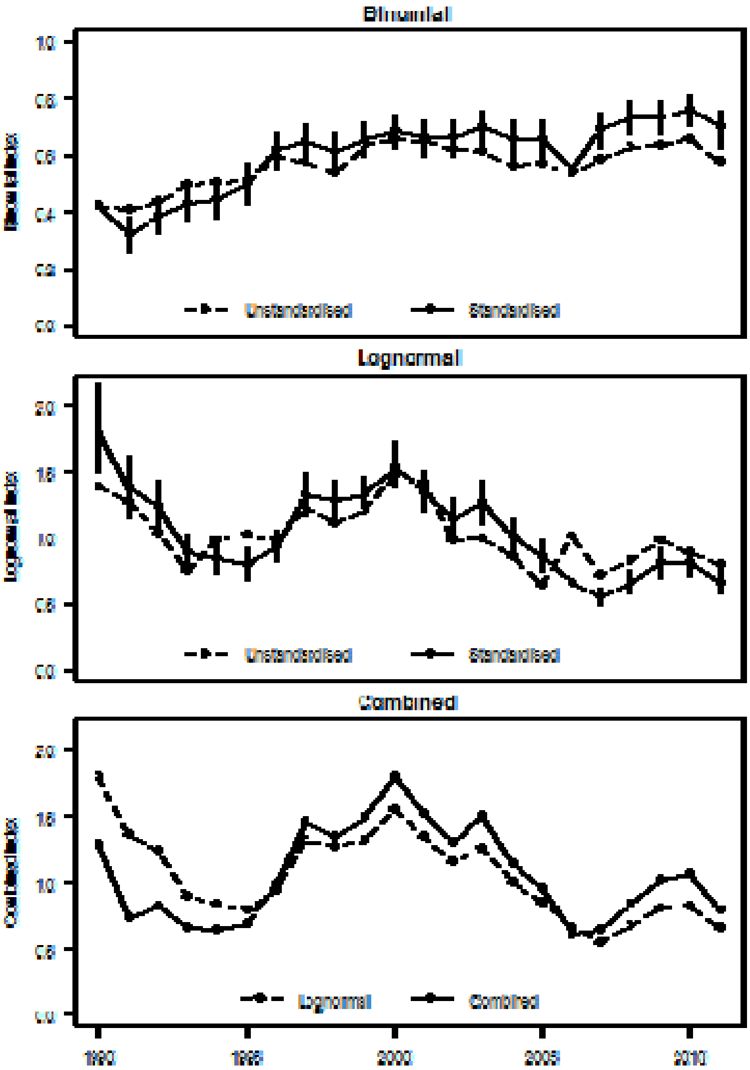


Figure K.31: The effect of standardisation on the raw CPUE of tarakihi by core vessels in the EN_BT_MIX fishery. Top: Binomial index of probability of capture. Middle: Lognormal index of magnitude of catch. broken line is the raw CPUE (kg / tow) the solid line is the standardised CPUE canonical indices with ± 2 * SE error bars. Bottom: The effect on the lognormal index of combining it with the Binomial index.

K.6.3 WCNI_BT_MIX Mixed target Bottom trawl in TAR 1

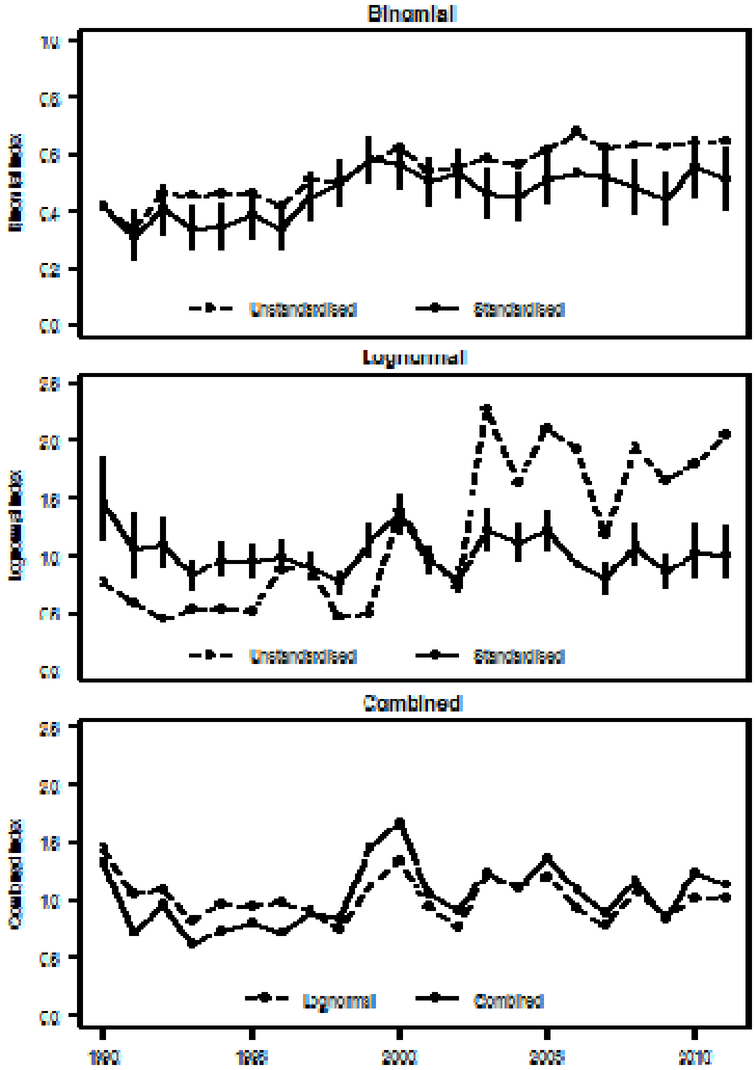


Figure K.32: The effect of standardisation on the raw CPUE of tarakihi by core vessels in the WCNI_BT_MIX fishery. Top: Binomial index of probability of capture. Middle: Lognormal index of magnitude of catch. broken line is the raw CPUE (kg / tow) the solid line is the standardised CPUE canonical indices with ± 2 * SE error bars. Bottom: The effect on the lognormal index of combining it with the Binomial index.

Appendix L. INVESTIGATION OF THE EFFECTS OF CHANGING STRATIFICATION OF REPORTING FORM TYPE

L.1 Introduction

When the current catch reporting system was implemented in 1989, inshore fishermen operating vessels less than 28 m in length were only required to report their daily aggregated catch and effort using the Catch Effort Landing Form (CELR, Ministry of Fisheries 2010). This form was replaced by an "event-based" form for setnet vessels larger than 6 m in October 2006 and for trawl vessels larger than 6 m in October 2007 (Ministry of Fisheries 2010). An "event" was defined as a trawl shot (tow) or a single length of net set. Inshore trawlers fishing in FMA 1 and FMA 9 elected to voluntarily[2] switch to an event-based form (TCEPR) in 1995–96. In other parts of the NZ EEZ, this form was primarily used by deepwater vessels larger than 28 m in length. Most of these smaller inshore operators now use the TCER form which was designed for use by smaller vessels, even those operating in FMA 1 and FMA 9.

Analysts using these data realised that the switch from daily reporting to event reporting had implications for the continuity and comparability of catch/effort data collected in each of these two reporting periods. This in turn has implications for the comparability of CPUE indices estimated during each reporting regime. A common analytic approach has been to amalgamate ("roll-up") the event-based data to mimic the previously collected daily information. This has been done for this report, although the approach followed has not been to emulate the daily data. Instead, both daily and event-based data have been "rolled-up" to the level of a complete trip, defined from the time a vessel leaves the dock, followed by fishing activity, returns to port and disposes of the catch. This Appendix presents preliminary analyses undertaken to understand the nature of the changing data forms and accompanying reporting behaviour, along with trying to determine if the change has inadvertently introduced bias into the preparation of standardised CPUE indices.

The following 7 data sets, drawn from the combined TAR 1, TAR 2, and TAR 3 data described in Section 2.3.1, have been used to describe the changes in the data caused by the form changes documented above:

Major Area grouping	Method	Code	Statistical Area definition	Target species definition
West coast, North Island	BT	WCNI_BT_MIX	041–048, 101–104	TAR, SNA, TRE
East Northland	BT	EN_BT_MIX	001–007,105, 106	TAR, SNA, TRE, BAR, JDO, GUR
Bay of Plenty	BT	BoP_BT_MIX	008–010, 107	TAR, SNA, TRE, BAR, SKI, JDO, GUR
East coast, North Island	BT	TAR 2_BT_MIX	011-016, 201–206	TAR, SNA, BAR, SKI, WAR, GUR
East coast, North Island	BT	TAR 2_BT_TAR	011-016, 201–206	TAR
East coast, South Island	BT	TAR 3_BT_MIX	017–026, 301–303	TAR, BAR, RCO, WAR, GUR
Kaikoura, South Island	SN	TAR 3_SN_TAR	018	TAR

L.2 Trends in mean effort indicators

Figure L.1 to Figure L.5 compare the mean number of hours and the mean number of tows per day by fishing year with the same measures for each trip for each of the seven data sets described in Section L.1. The range of results from these data sets shows that it is difficult to generalise about the "formtype" effect, given the variability of responses shown by the different fisheries and data types. In general, the effect is greatest for the "hours/day" measure, with clear upward steps in the three data sets from the east coasts of the North and South Islands, without a corresponding strong increase in the "hours/trip" indicator (Figure L.2). The effect is slightly less dramatic for "tows/day" in these same

[2] The actual decision was made by the two major companies working in FMA 1 and 9 at the time (Simunovitch Fisheries and Sanford Fisheries). Individual fishers elected to report using either TCEPR or CELR forms, but once the decision was made, it was enforced by statute.

three fisheries, because there appears to be confounding with an overall increasing trend in “tows/trip” (Figure L.4). These measures are more difficult to interpret for the three more northerly fisheries (WCNI_BT_MIX, EN_BT_MIX, BoP_BT_MIX) because of the longer period using the event-based formtypes and again apparent confounding with underlying trends in the data (Figure L.1 and Figure L.3). As for the setnet fishery (TAR 3_SN_TAR), there appears to be no “formtype” effect on net length set because it is well known that this fishery is almost exclusively a single day fishery, with most trips lasting about 24 hours (but may span more than one day). However, “hours fished”, as a measure of effort, appears to be misreported in this fishery (with mean duration exceeding 50 hours for a single-day trip; Figure L.5) after the introduction of the new forms and probably should be discarded.

L.3 Distributions of effort indicators by trip and by day over time

Box plots of the mean number of hours/trip, tows (or net_length) per trip and the equivalent measures by day, have been prepared for each of the seven data sets described in Section L.1. The purpose of these comparisons is to show that, at the level of a trip, the distributions of these effort indicators have not markedly changed with the introduction of the new level reporting stratification. This can be seen for hours/trip in the three northern NZ BT fisheries (Figure L.6) and the three east coast NZ BT fisheries (Figure L.7), as well as in the tows/trip for the same three northern NZ BT fisheries (Figure L.8) and the three east coast NZ BT fisheries (Figure L.9). The TAR 3_SN_TAR fishery appears to have misinterpreted the duration instructions when the new NCELR form was introduced ([left panel] Figure L.10), but there has been no change in the reporting of the length of net set ([right panel] Figure L.10). These plots can be contrasted with the equivalent plots for hours/day (Figure L.11 and Figure L.12), both of which show marked distributional changes at the point of the introduction of new formtypes. Similarly, the equivalent plots for tows/day (Figure L.13 and Figure L.14) show the same distributional shift as seen for hours/day.

L.4 Comparison of “influence” series adjustment with trends in mean effort/day indicators

One of the diagnostic outputs from the regression analyses that result in index series of standardised CPUE are “influence” CDI plots as described by Bentley et al. (2011). These outputs show the relative compensation that is being made on every index year by any explanatory variable in the standardisation procedure. There is a strong resemblance between the influence series derived from a standardisation model fit to the data sets described in Section L.1 and the equivalent series of mean effort by day for the effort variable with the greatest model explanatory power. A comparison of these two measures is made for the three northern NZ BT fisheries in Figure L.15 and for the four east coast fisheries in Figure L.16, showing very close correspondence in all seven fisheries. This comparison suggests that the standardisation procedure may be compensating for the changes in reporting behaviour.

L.5 Investigation of models incorporating an interaction term for [effort]X[formtype]

The results presented in Figure L.15 and Figure L.16 suggest that additional explanatory power might be achieved if the interaction between the effort explanatory variable and the formtype used to report each trip were explicitly modelled. These models were prepared for each of the data sets described in Section L.1, but will not be presented in detail. A comparison of the resulting standardised annual CPUE indices shows no effect from the addition of the interaction term in every model (Figure L.17).

L.6 Discussion

In the future, once sufficient data have accumulated, the two formtypes can be modelled separately without concern about the change in reporting behaviour. However, this situation is not yet available for the east coast New Zealand fisheries, with only four years of information collected under the new regime. There are sufficient years for independent modelling in the northern NZ fisheries, but there is always the desire to obtain the longest possible time series for use in stock assessment modelling. Further analyses such as those presented here are required on additional data sets to better understand the potential biases that may stem from these clearly evident changes in reporting requirements.

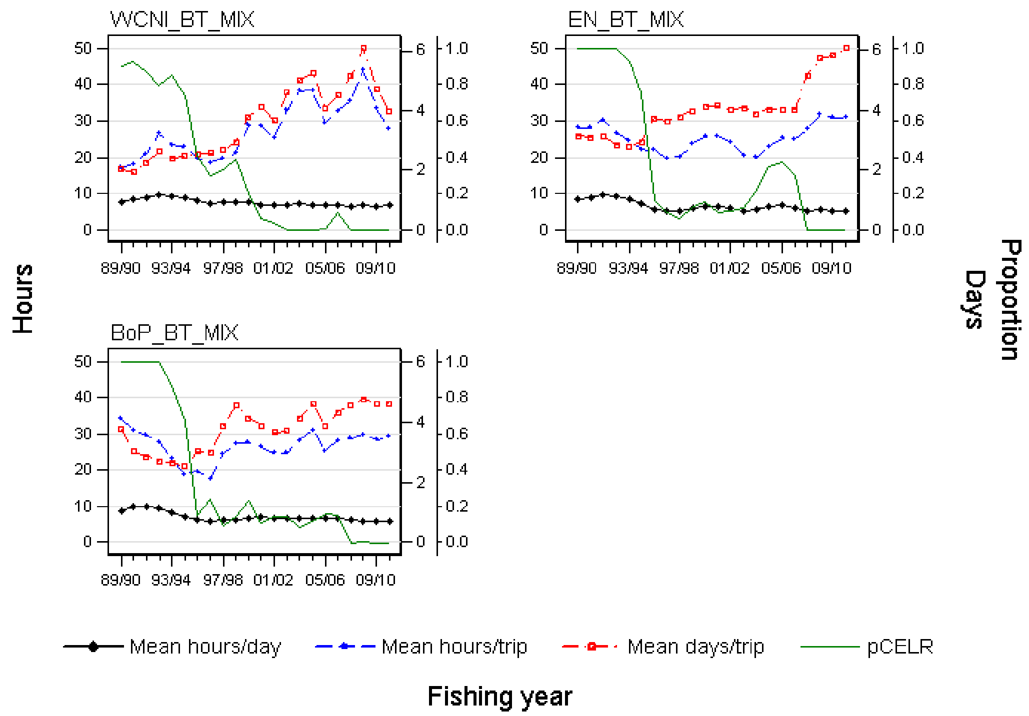


Figure L.1: Mean hours/day, mean hours/trip and mean days/trip for three North Island BT fisheries, plotted by fishing year. Also shown is the proportion of records reporting on the daily CELR form instead of an event-based form.

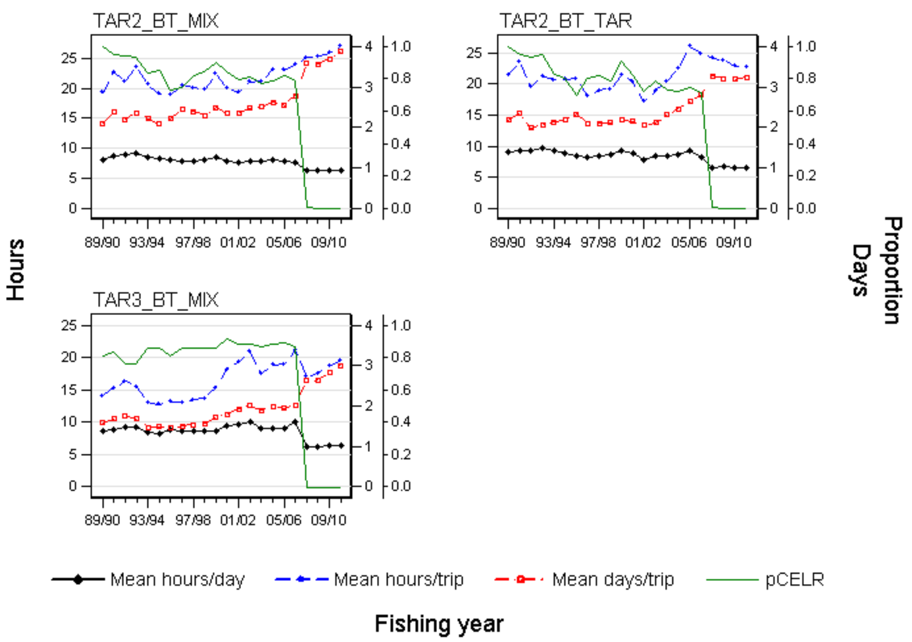


Figure L.2: Mean hours/day, mean hours/trip and mean days/trip for two North Island east coast BT fisheries and one east coast South Island BT fishery, plotted by fishing year. Also shown is the proportion of records reporting on the daily CELR form instead of an event-based form.

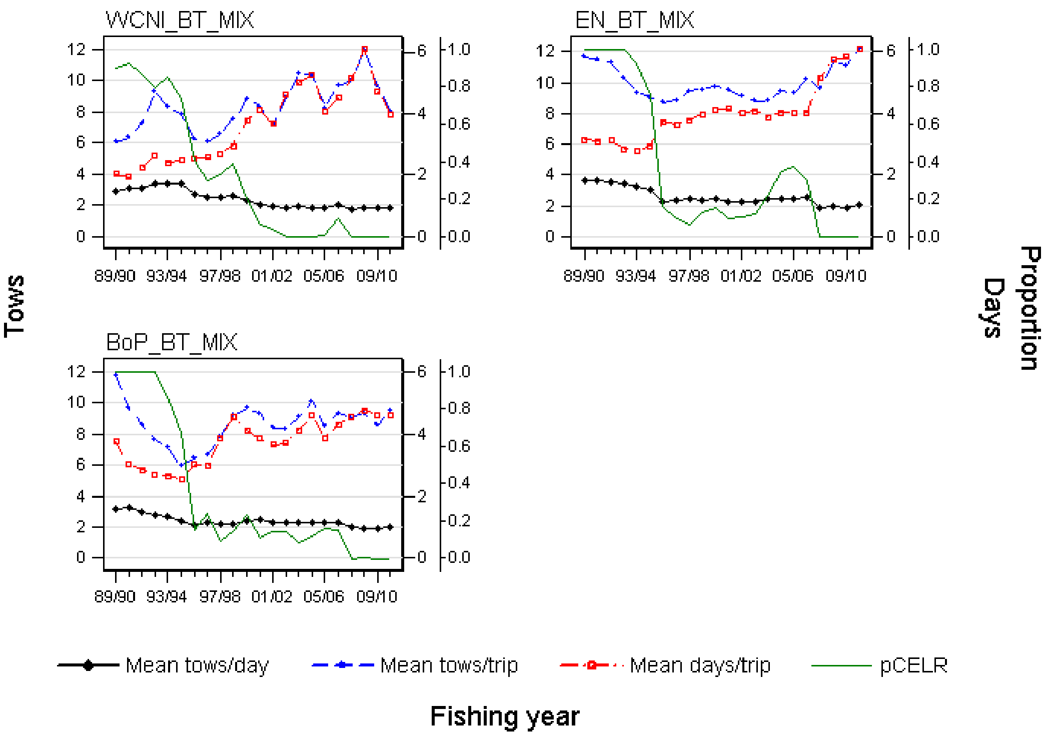


Figure L.3: Mean tows/day, mean tows/trip and mean days/trip for three North Island BT fisheries, plotted by fishing year. Also shown is the proportion of records reporting on the daily CELR form instead of an event-based form.

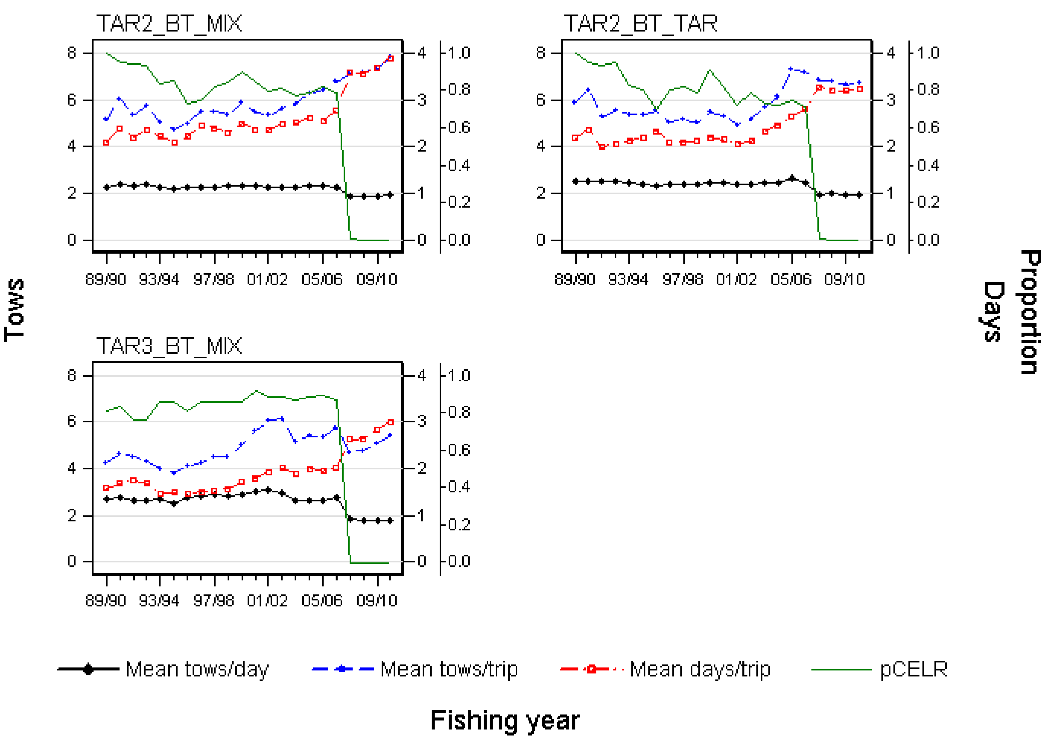


Figure L.4: Mean tows/day, mean tows/trip and mean days/trip for two North Island east coast BT fisheries and one east coast South Island BT fishery, plotted by fishing year. Also shown is the proportion of records reporting on the daily CELR form instead of an event-based form.

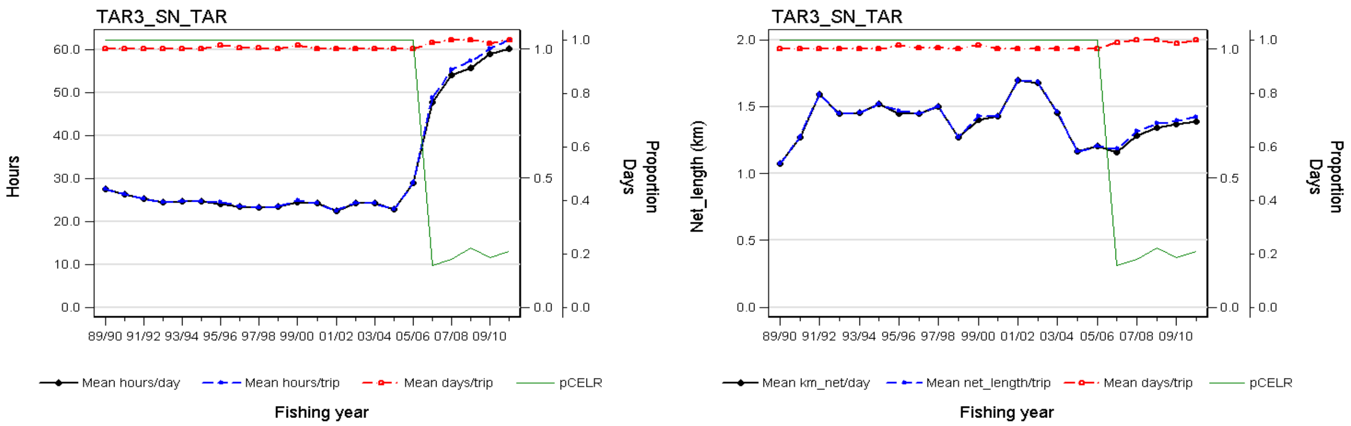


Figure L.5: [left panel]: mean hours/day, mean hours/trip and mean days/trip and [right panel] mean net length set per day, mean net length set per trip and mean number days/trip for the Kaikoura SN fishery, plotted by fishing year. Also shown is the proportion of records reporting on the daily CELR form instead of the NCELR event-based form.

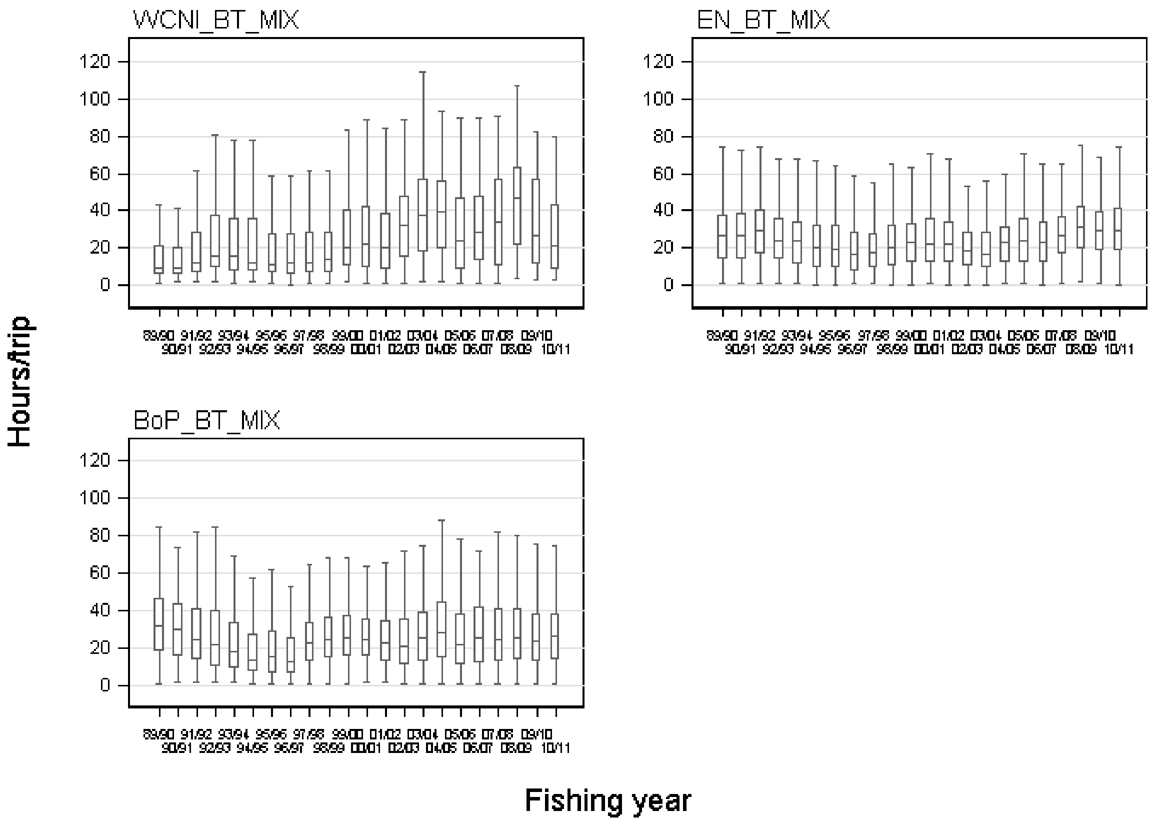


Figure L.6: Box plots of the hours/trip for all trips for three North Island BT fisheries, plotted by fishing year. The formtype reporting changed in these fisheries about 1995–96.

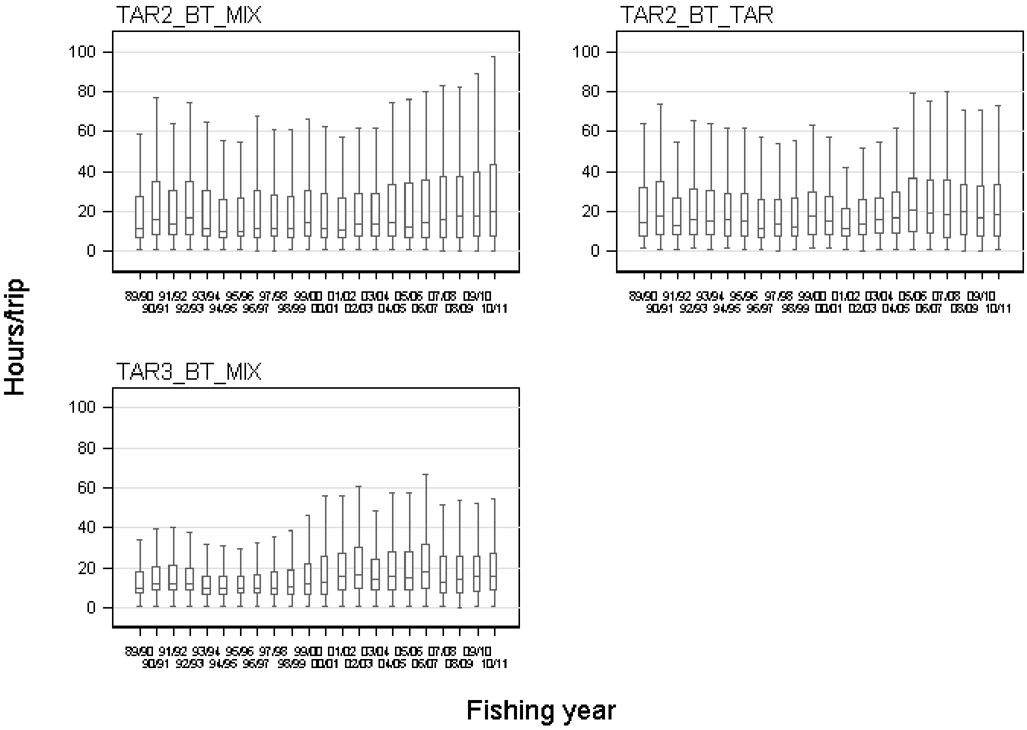


Figure L.7: Box plots of hours/trip for all trips for two North Island east coast BT fisheries and one east coast South Island BT fishery, plotted by fishing year. The formtype reporting in these fisheries changed in 2007–08.

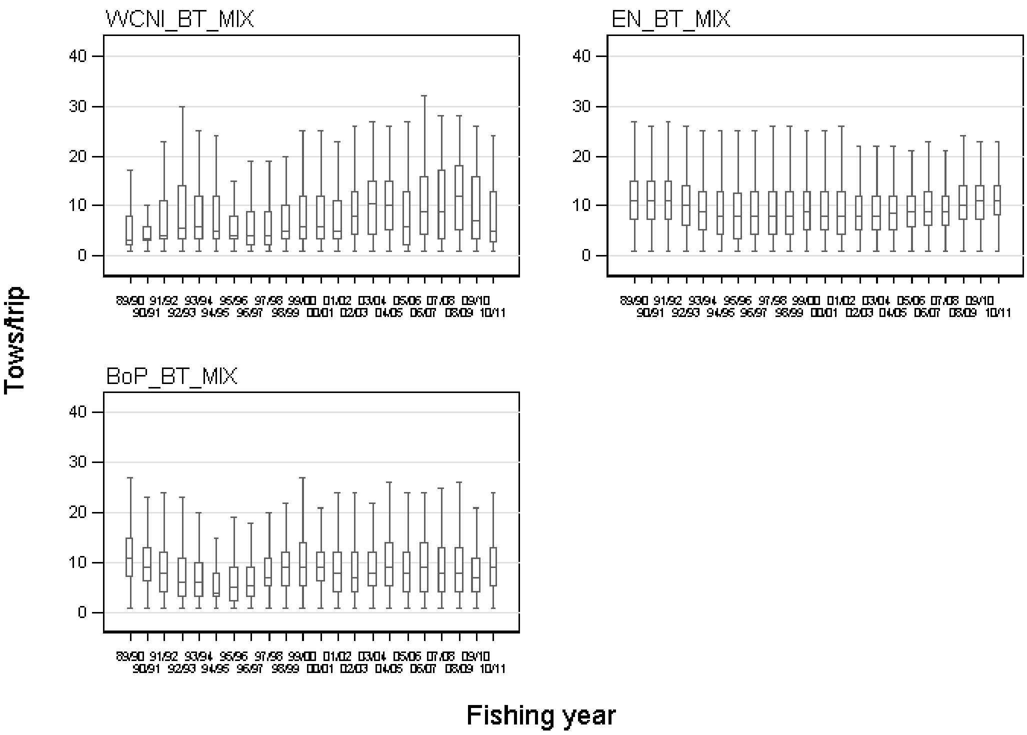


Figure L.8: Box plots of the tows/trip for all trips for three North Island BT fisheries, plotted by fishing year. The formtype reporting changed in these fisheries about 1995–96.

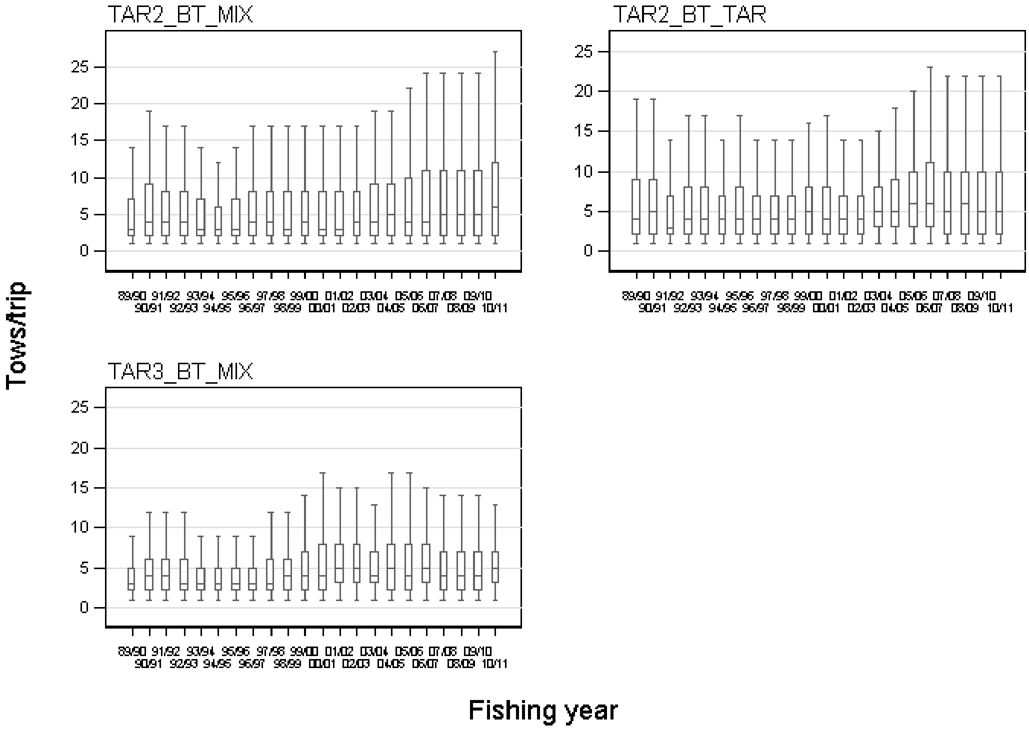


Figure L.9: Box plots of tows/trip for all trips for two North Island east coast BT fisheries and one east coast South Island BT fishery, plotted by fishing year. The formtype reporting in these fisheries changed in 2007–08.

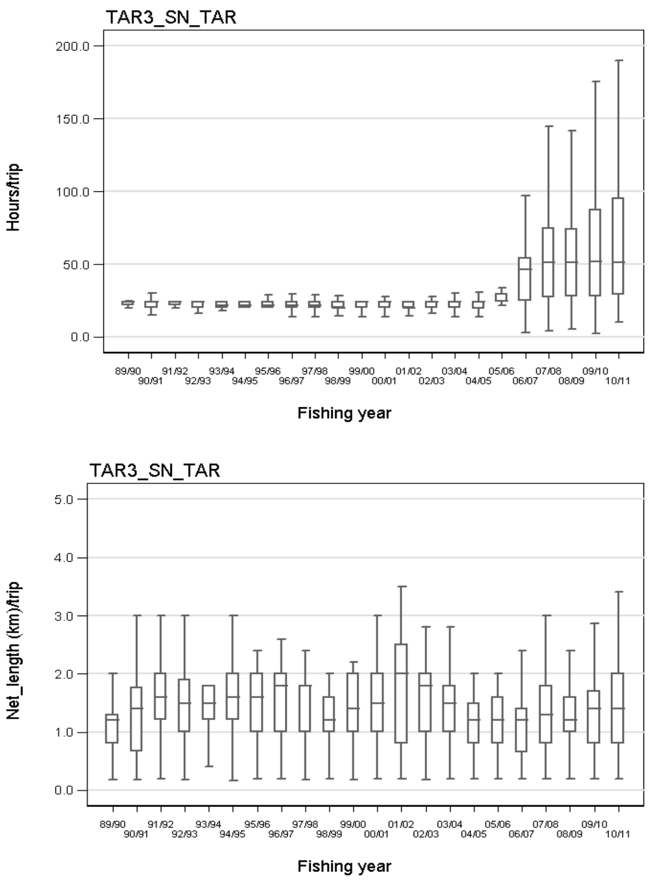


Figure L.10: Box plots for [left panel] hours/trip and [right panel] net length set per trip for the Kaikoura SN fishery, plotted by fishing year. The formtype reporting in these fisheries changed in 2006–07.

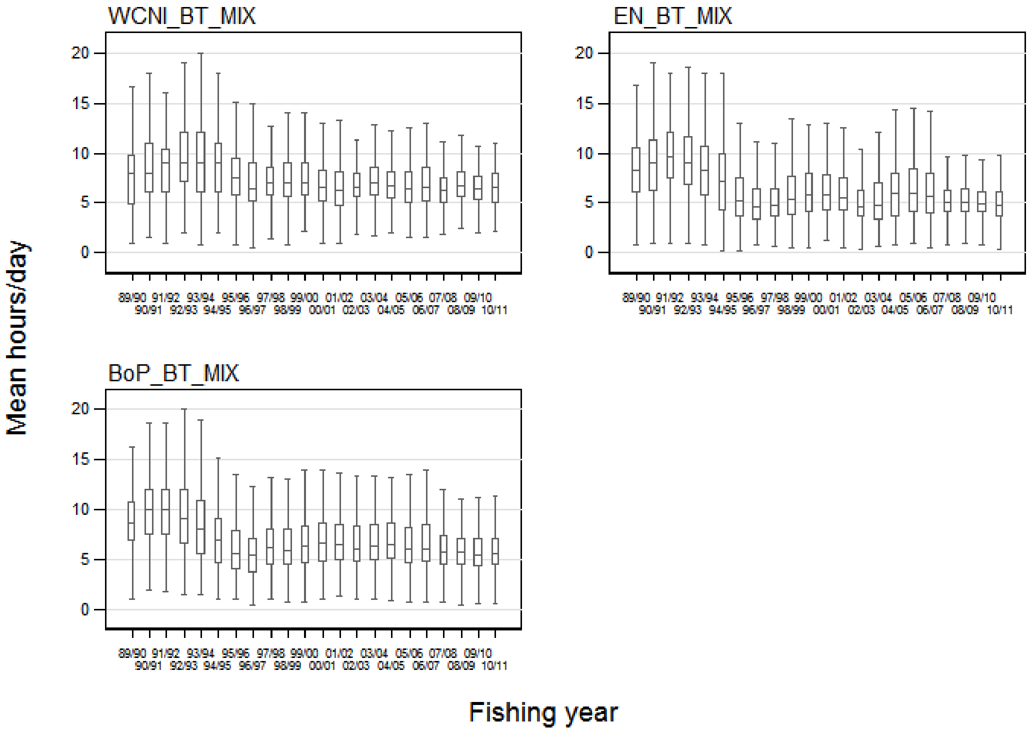


Figure L.11: Box plots of the mean hours/day for all trips for three North Island BT fisheries, plotted by fishing year. The formtype reporting changed in these fisheries about 1995–96.

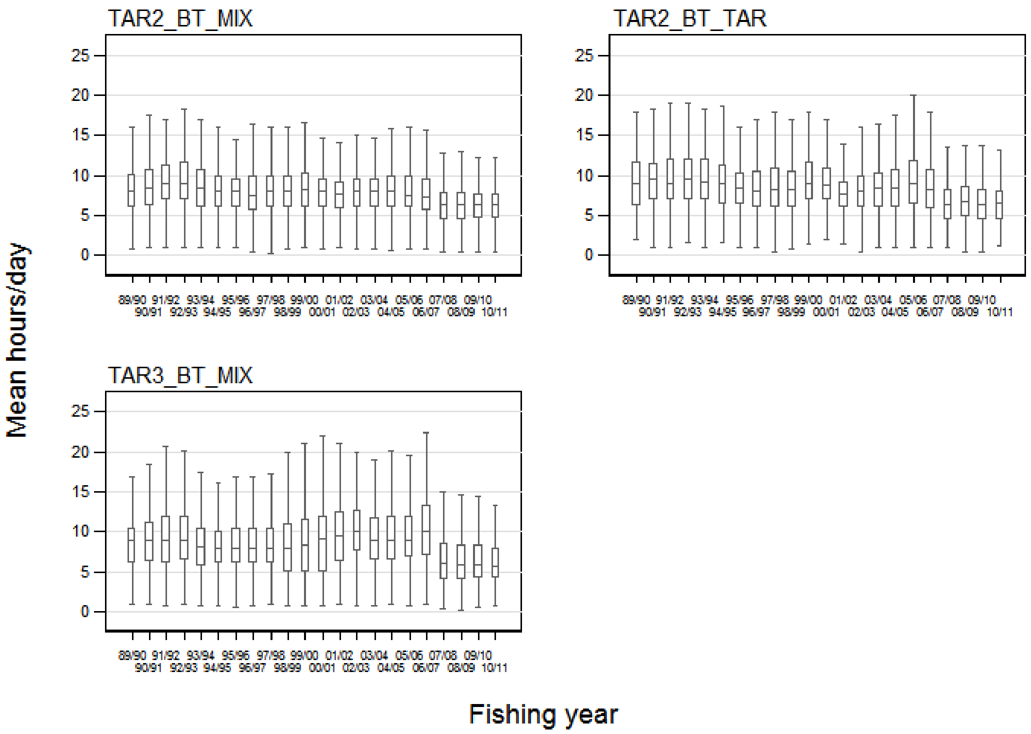


Figure L.12: Box plots of the mean hours/day for all trips for two North Island east coast BT fisheries and one east coast South Island BT fishery, plotted by fishing year. The formtype reporting in these fisheries changed in 2007–08.

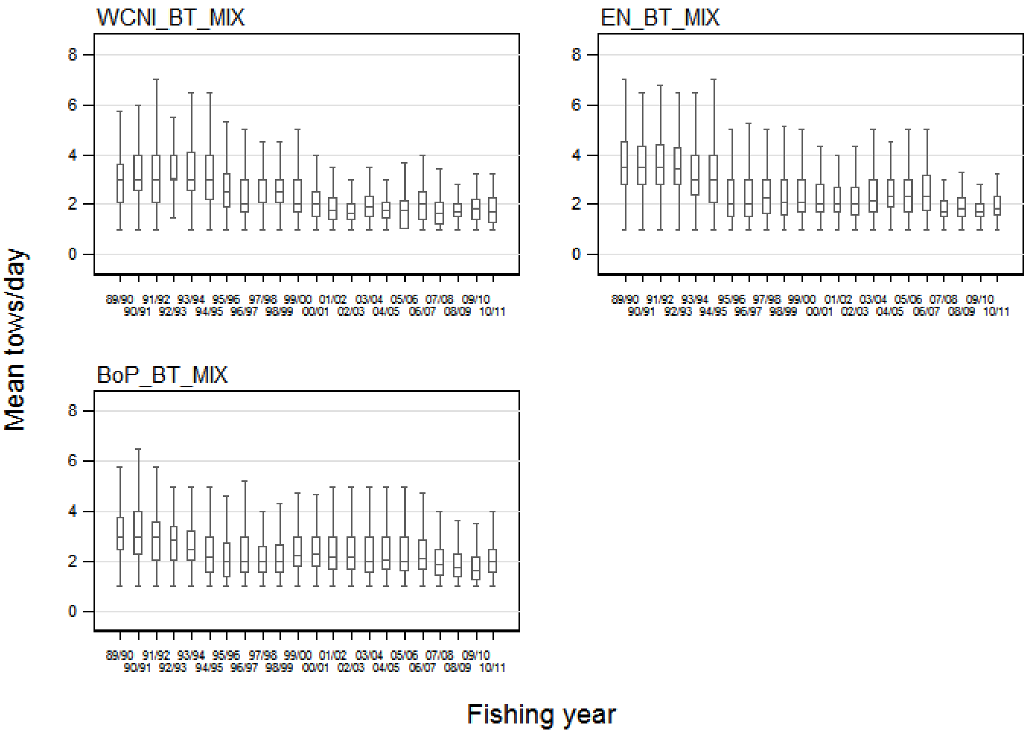


Figure L.13: Box plots of the mean tows/day for all trips for three North Island BT fisheries, plotted by fishing year. The formtype reporting changed in these fisheries about 1995–96.

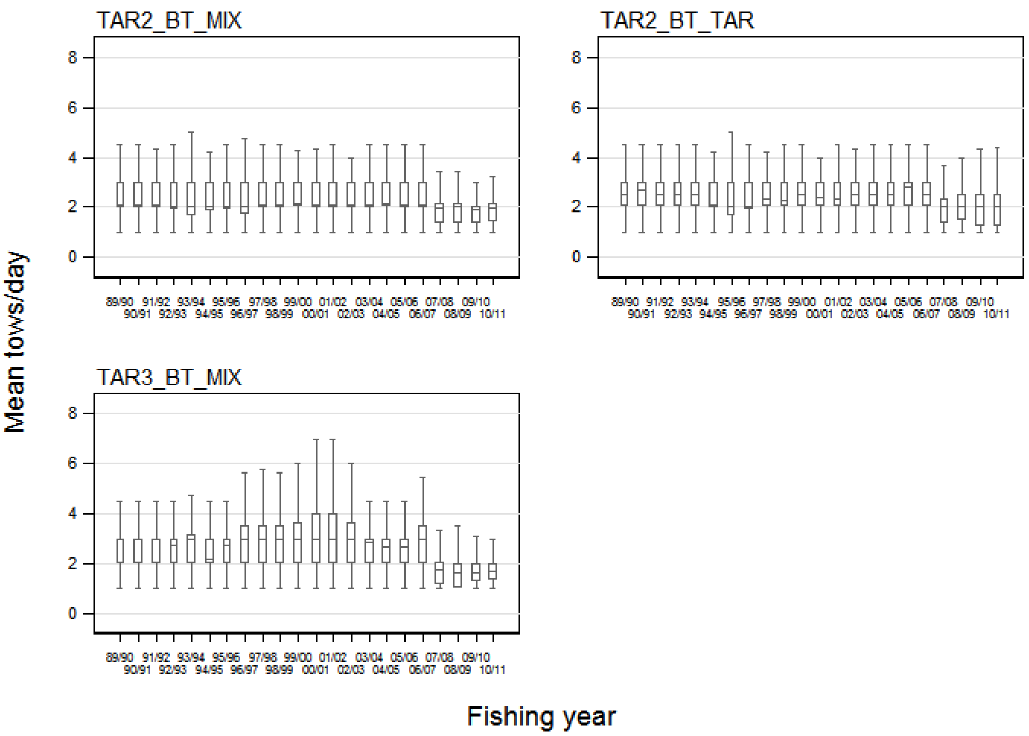


Figure L.14: Box plots of the mean tows/day for all trips for two North Island east coast BT fisheries and one east coast South Island BT fishery, plotted by fishing year. The formtype reporting in these fisheries changed in 2007–08.

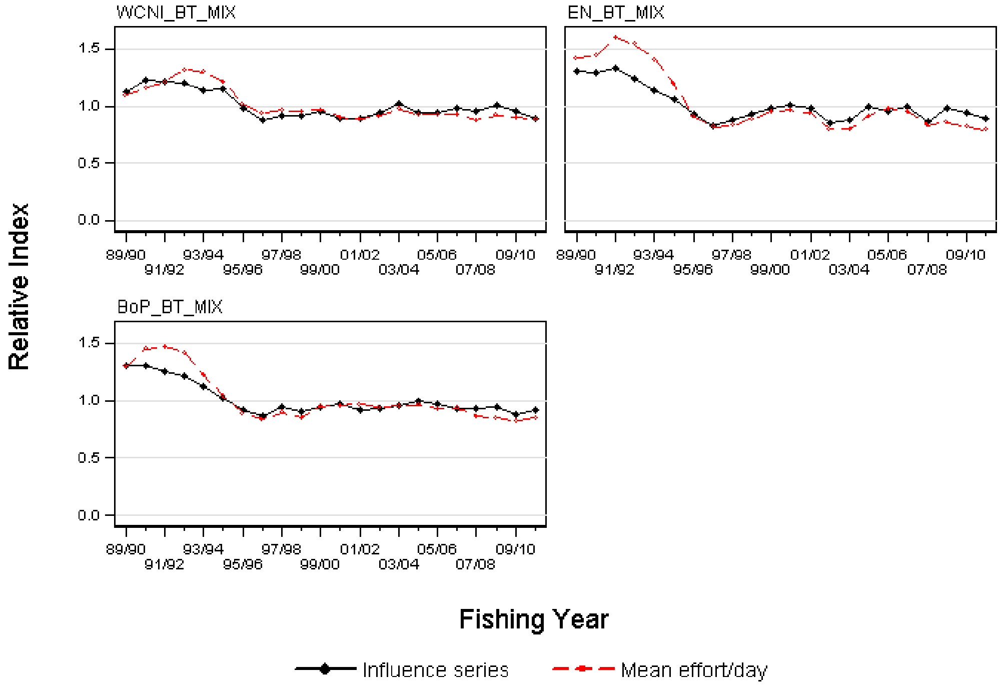


Figure L.15: Comparison of the mean hours/day for each of three northerly TAR BT fisheries (Figure L.1 and Figure L.3) with the "influence" series (Bentley et al. 2011) calculated for each standardised regression. Hours was the effort variable that had the most explanatory power in the standardised regression analysis.

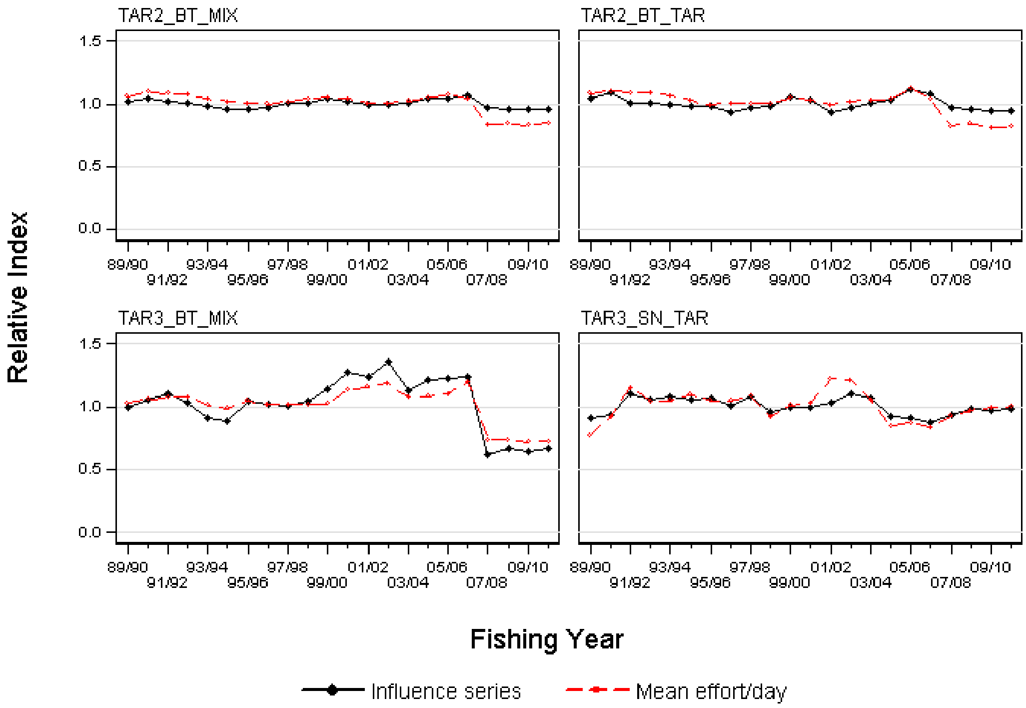


Figure L.16: Comparison of the mean "effort"/day for each of four east coast TAR fisheries (Figure L.2 and Figure L.5) with the "influence" series (Bentley et al. 2011) calculated for each standardised regression. Where "effort" was the effort variable that had the most explanatory power in each standardised regression analysis. The variable was "tows" for both TAR 2_BT fisheries, duration for the TAR 3_BT fisheries and net length set for the TAR 3_SN fishery.

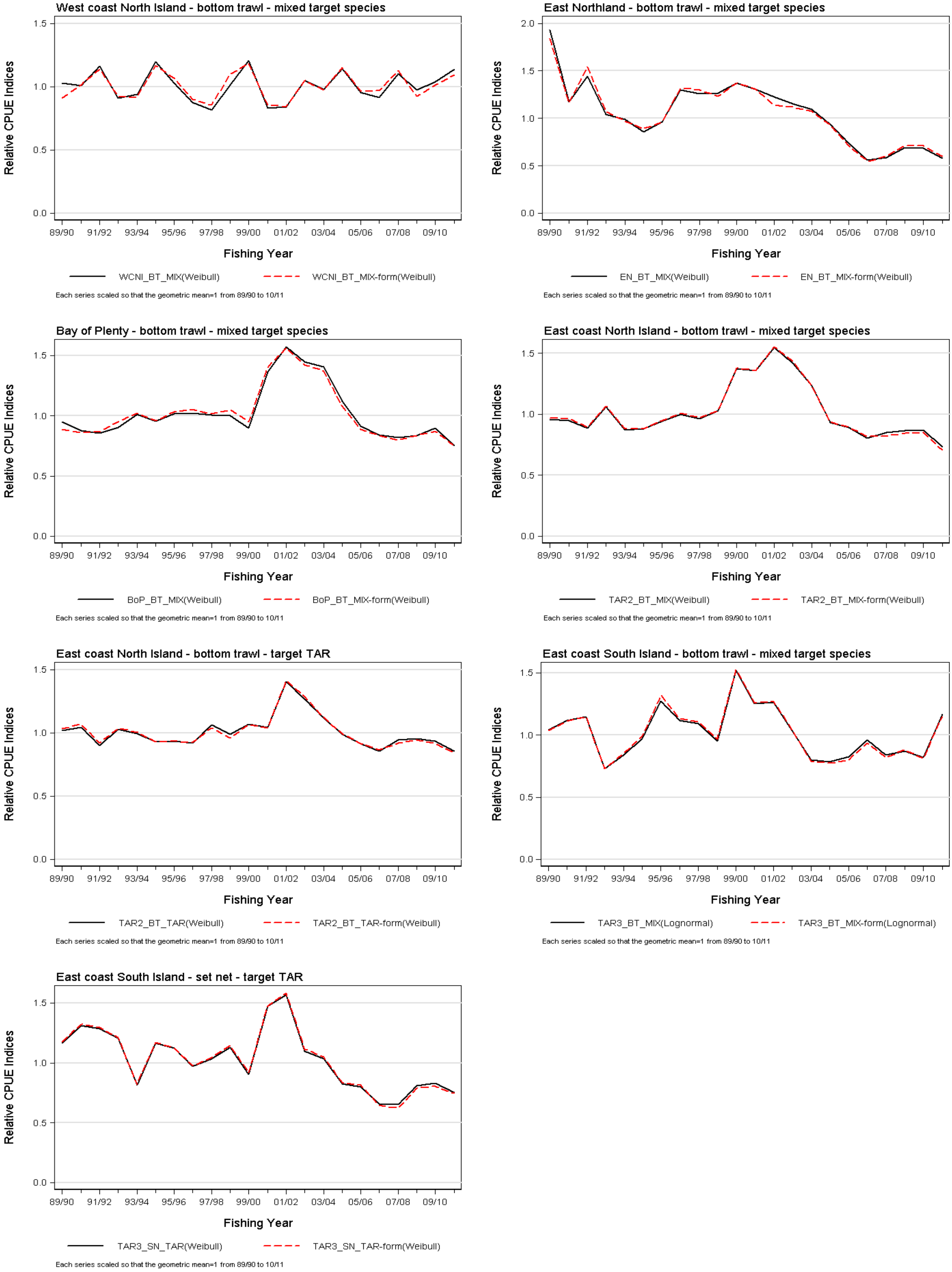


Figure L.17: Comparison of CPUE series with and without a [formtype]X[effort] interaction term for the seven fisheries listed in Section L.1.

Appendix M. EAST COAST NORTH/SOUTH ISLAND TARAKIHI: SUPPLEMENTARY CPUE ANALYSES

M.1 Introduction

As described in Section 3 and Appendix H, three lognormal CPUE series were developed for input into a stock assessment of east coast tarakihi in TAR 2 and TAR 3 (Langley & Starr 2012). Ultimately, that stock assessment was not accepted by the NINSWG for the management of these two tarakihi QMAs, primarily because the data were not sufficiently informative to distinguish between alternative movement/migration hypotheses. Given this uncertainty, the NINSWG requested additional analyses for the three CPUE series in Appendix H, specifically to apply the methodology described in Appendix Section J.2.2 where the CPUE data sets were analysed across a range of alternative distributional assumptions.

M.2 Methods

M.2.1 Additional analytical methods used for standardisation

New updated analytical software (see Appendix Section J.2.2), which allowed the exploration of alternative distributional assumptions for the standardisation models, was not available at the time the analyses described in Appendix H were performed. The NINSWG requested that the three CPUE series defined in Appendix Section H.2.3 be reanalysed using the methods described in Appendix Section J.2.2.

M.2.2 Fishery definitions for CPUE analysis

The same data sets for the three fisheries defined in Appendix Section H.2.3 were used. These were:

TAR2_BT_MIX – East coast, North Island mixed species bottom trawl – The fishery is defined from bottom single trawl fishing events which fished in statistical Areas 011 to 016 inclusive, and targeted TAR, SNA, BAR, SKI, WAR, or GUR. This definition allows the use of total effort in the analysis of catch rates.

TAR3_BT_MIX – East coast, South Island mixed species bottom trawl – The fishery is defined from bottom single trawl fishing events which fished in statistical Areas 017, 018, 020, 022, 024, and 026, and targeted TAR, BAR, RCO, WAR, or GUR. This definition allows the use of total effort in the analysis of catch rates.

TAR3_SN_TAR – Kaikoura target tarakihi setnet -- The fishery is defined from set net fishing events which fished in statistical area 018, and targeted TAR. This definition allows the use of total effort in the analysis of catch rates.

M.3 Unstandardised CPUE

See Appendix Section H.3.1 for the description of the unstandardised CPUE for TAR2_BT_MIX: East coast, North Island mixed species bottom trawl.

See Appendix Section H.3.2 for the description of the unstandardised CPUE for TAR3_BT_MIX: East coast, South Island mixed species bottom trawl.

See Appendix Section H.3.3 for the description of the unstandardised CPUE for TAR3_SN_TAR: Kaikoura target tarakihi setnet.

M.4 Standardised CPUE analysis

M.4.1 Core fleet definitions

The core fleet definitions were unchanged and can be found in Figure I.1 (TAR 2_BT_MIX), Figure I.2 (TAR 3_BT_MIX) and Figure I.3 (TAR 3_SN_TAR). The summary for the data sets with the core vessels is presented in Table I.1.

M.4.2 Model selection and trends in model year effects

M.4.2.1 TAR2_BT_MIX: East coast, North Island mixed species bottom trawl

The Weibull distribution gave the lowest negative log-likelihood for the TAR2_BT_MIX data set among the five distributional assumptions investigated (see Figure N.1). The TAR2_BT_MIX Weibull model (Table M.1) explained 61% of the variance in log(catch), by standardising for the effect of changes in number of tows, targeting, and participation of vessels in the core fleet. Other explanatory variables were included in the model but appear to have had little effect on the final series of year indices (Figure M.1). Diagnostic residual plots are presented for the Weibull model in Figure N.2 and show a better fit of the data for the Weibull distribution assumption compared to the equivalent lognormal assumption in Figure I.4, although there is still a strong departure from the Weibull assumption in the upper tail of the residual distribution.

Table M.1: Order of acceptance of variables into the Weibull model of successful catches of tarakihi for core vessels (based on the vessel selection criteria of at least 10 trips in 5 or more fishing years) in the TAR2_BT_MIX fishery with the amount of explained deviance for each variable. Variables accepted into the model are marked with an *. Fishing year was forced as the first variable.

Term	DF	-Log likelihood	AIC	R^2 (%)	Final
fyear	23	-227 423	454 892	0.6	*
poly(log(num), 3)	26	-222 440	444 932	29.5	*
target	31	-217 660	435 383	52.6	*
vessel	217	-214 565	429 564	60.0	*
area	222	-214 190	428 825	60.6	*
poly(log(duration), 3)	225	-213 958	428 366	61.0	*
month	236	-213 901	428 274	61.0	*

The interpretation of residual implied coefficients between year and area is the same as for the lognormal version presented in Figure I.5, showing an earlier peak in Area 011 compared to Areas 012, 013 or 014 (Figure N.3). As noted in Appendix H, this result implies some difference in the fishing year trends among the statistical areas in TAR 2, with Area 011 being an important area with respect to landed catch, and this difference in trend may reduce the utility of this index series. The residual implied coefficients for target species by year show reasonable similarity between all six species, particularly with the years of peak catch for tarakihi and gurnard (Figure N.4). However, there is departure away from the main year trend by gurnard before and after the peak years in the late 1990s and early 2000s. Additional analyses (not reported here) showed that the addition of gurnard to the analysis added information by monitoring the more shallow inshore locations which tended to catch smaller tarakihi than were present in the target fishery population.

The interpretation of the explanatory variables will be similar between the analysis presented here compared to the lognormal analysis described in Appendix Section H.4.2.2. In particular, a drop in the importance of the target tarakihi fishery and an increase in tarakihi by-catch in non-target fisheries affected the overall pattern of CPUE (Figure N.9). Coefficient distribution plots are presented for all of the variables in this model: number tows (Figure N.8), target species (Figure N.9), vessel (Figure N.10), area (Figure N.11), duration (Figure N.12) and month (Figure N.13). The effect on year coefficients and the relative influence of each model variable are presented in Figure M.1.

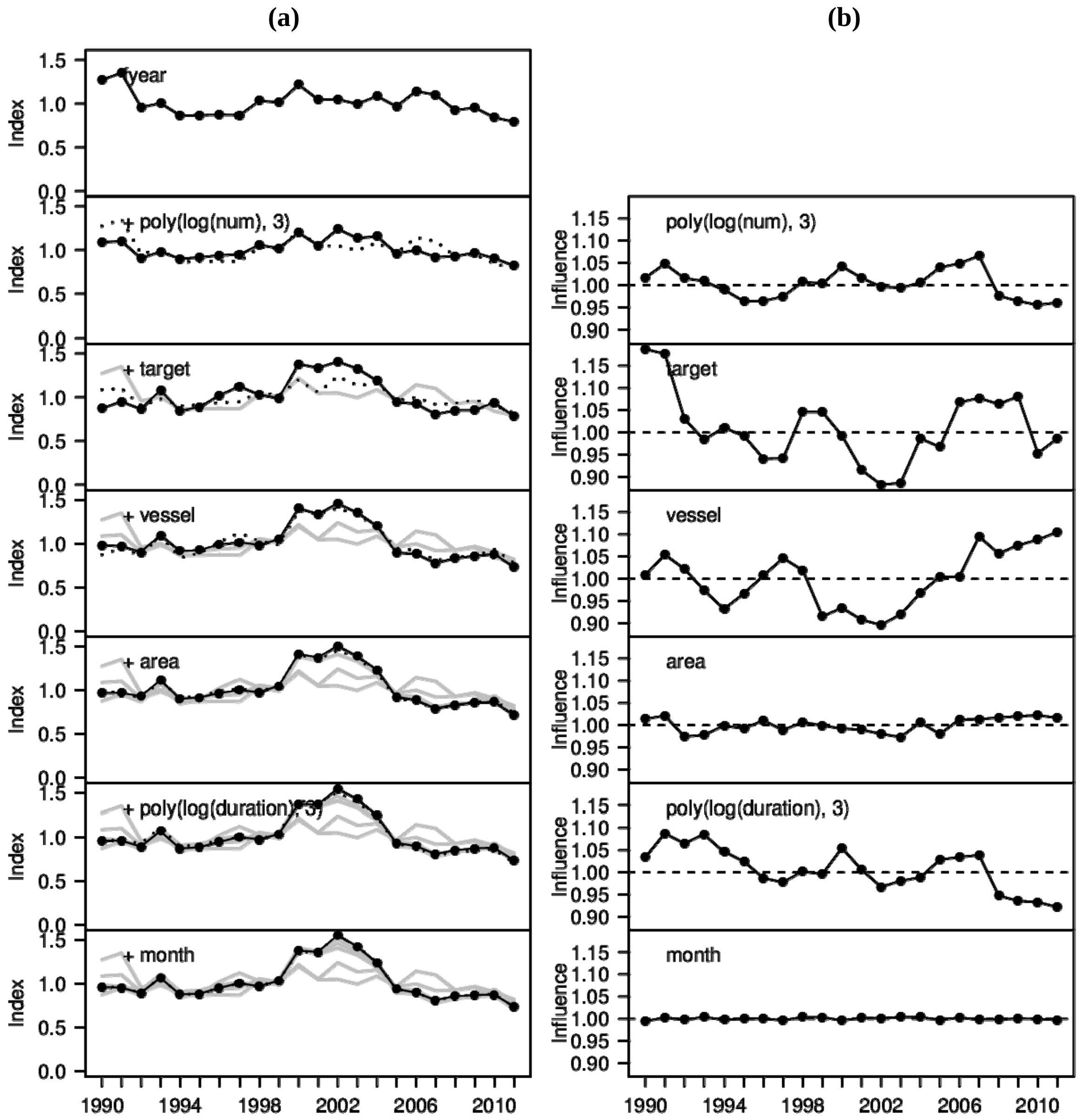


Figure M.1: Step and annual influence plot for the Weibull TAR2_BT_MIX analysis. (a) CPUE index at each step in the selection of variables. The index obtained in the previous step (if any) is shown by a dotted line and for steps before that by grey lines. (b) Annual influence on observed catches arising from a combination of its GLM coefficients and its distributional changes over years, for each explanatory variable in the final model.

A plot showing the year coefficients from the three of the distributional assumptions is shown in Figure M.2. The overall pattern is the same for all three distributional assumptions, except that the peak year in 2002 is a bit stronger for the lognormal series and there are minor variations between the lognormal and Weibull distributions all through the series. The year coefficients for the Weibull and gamma distributions are virtually identical.

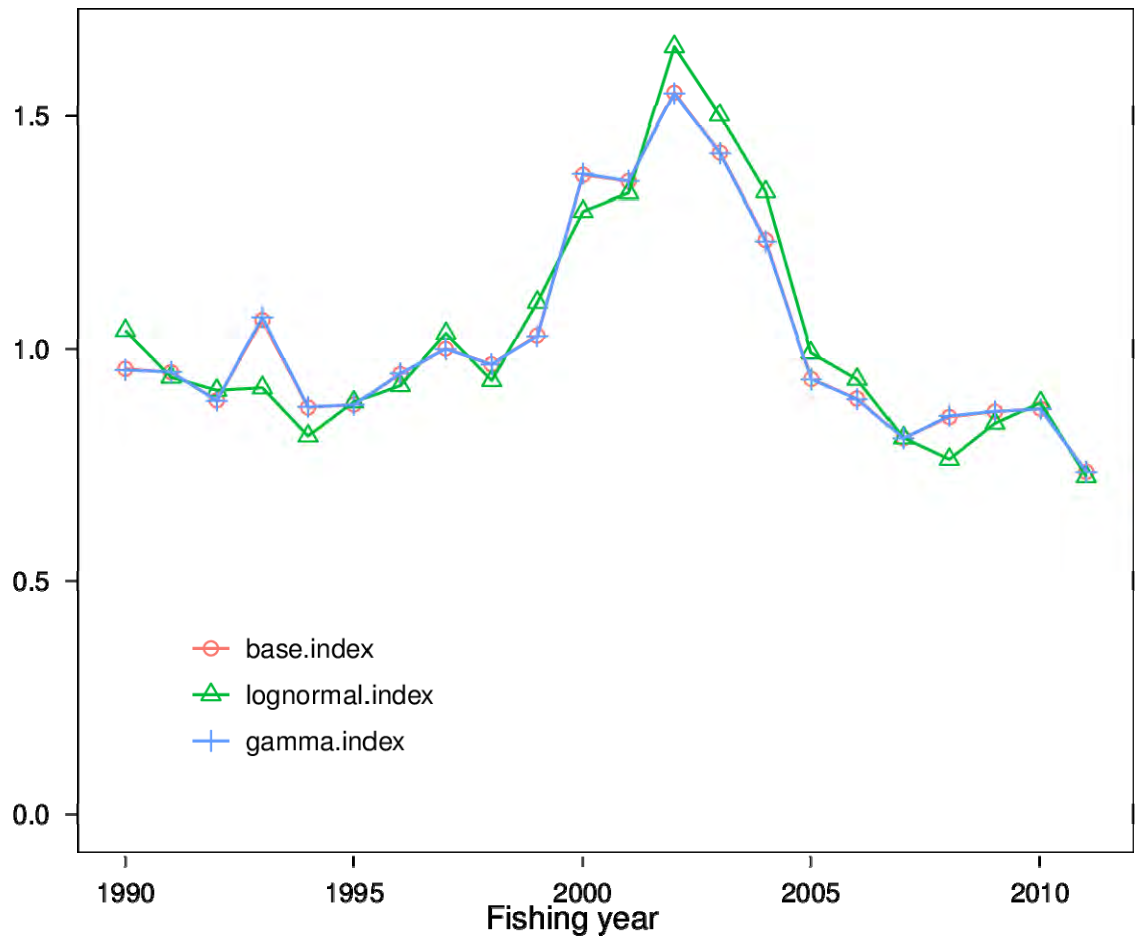


Figure M.2: Comparison of year indices for the TAR2_BT_MIX analysis derived from three of the model distributional assumptions compared in Figure N.1. The "base" index uses the Weibull distribution as this model had the lowest negative log-likelihood.

M.4.2.2 TAR3_BT_MIX: East coast, South Island mixed species bottom trawl

The lognormal distribution gave the lowest negative log-likelihood for the TAR3_BT_MIX data set among the five distributional assumptions investigated (see Figure N.5). Consequently this model is the same as that reported in Appendix Section H.4.2.3.

M.4.2.3 TAR3_SN_MIX: Kaikoura target tarakihi setnet

The Weibull distribution gave the lowest negative log-likelihood for the TAR3_SN_TAR data set among the five distributional assumptions investigated (see Figure N.6). The TAR3_SN_TAR Weibull model (Table M.2) explained 31% of the variance in log(catch), by standardising for the effect of changes in vessel configuration, net length, and, less importantly, month of capture and duration of set. Diagnostic residual plots are presented for the Weibull model in Figure N.6 and show a better fit of the data for the Weibull distribution assumption compared to the equivalent lognormal assumption in Figure I.7, although there is still a strong departure from the Weibull assumption in the upper tail of the residual distribution.

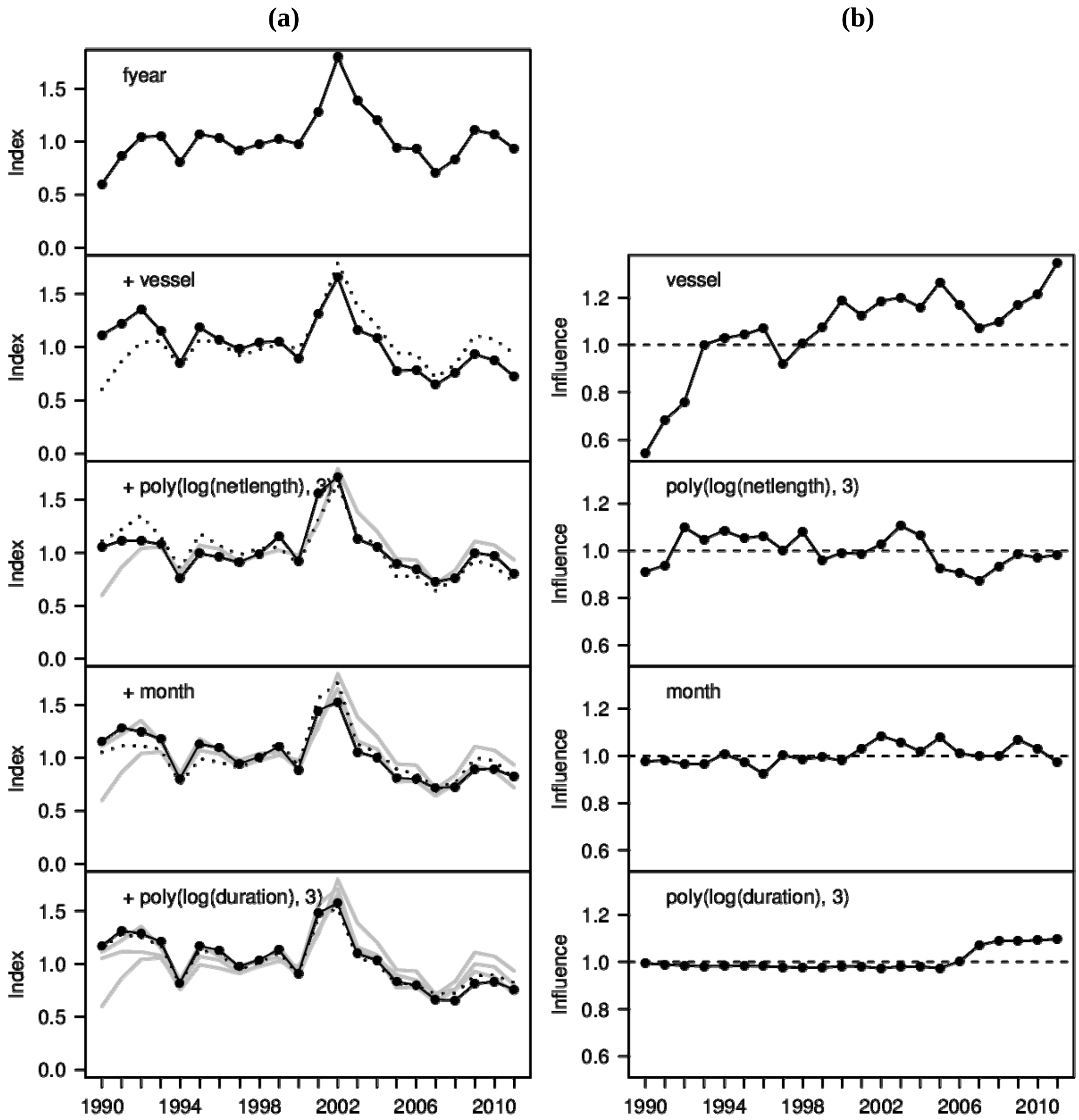


Figure M.3: Step and annual influence plot for the Weibull TAR3_SN_TAR analysis. (a) CPUE index at each step in the selection of variables. The index obtained in the previous step (if any) is shown by a dotted line and for steps before that by grey lines. (b) Annual influence on observed catches arising from a combination of its GLM coefficients and its distributional changes over years, for each explanatory variable in the final model.

Table M.2: Order of acceptance of variables into the lognormal model of successful catches of tarakihi for core vessels (based on the vessel selection criteria of at least 10 trips in 3 or more fishing years) in the TAR3_SN_TAR fishery with the amount of explained deviance for each variable. Variables accepted into the model are marked with an * . Fishing year was forced as the first variable

Term	DF	-Log likelihood	AIC	R^2 (%)	Final
fyear	23	-88 442	176 930	5.4	*
vessel	54	-86 959	174 026	16.4	*
poly(log(netlength), 3)	57	-85 910	171 935	23.1	*
month	68	-85 317	170 771	30.6	*
poly(log(duration), 3)	71	-85 294	170 729	31.2	*

The interpretation of the explanatory variables will be similar between the analysis presented here compared to the lognormal analysis for the TAR3_SN_TAR fishery described in Appendix Section H.4.2.4. Coefficient distribution plots are presented for the variables in this model: vessel (Figure N.14), net length (Figure N.15) and month (Figure N.16). The effect on year coefficients and the relative influence of each model variable are presented in Figure M.3.

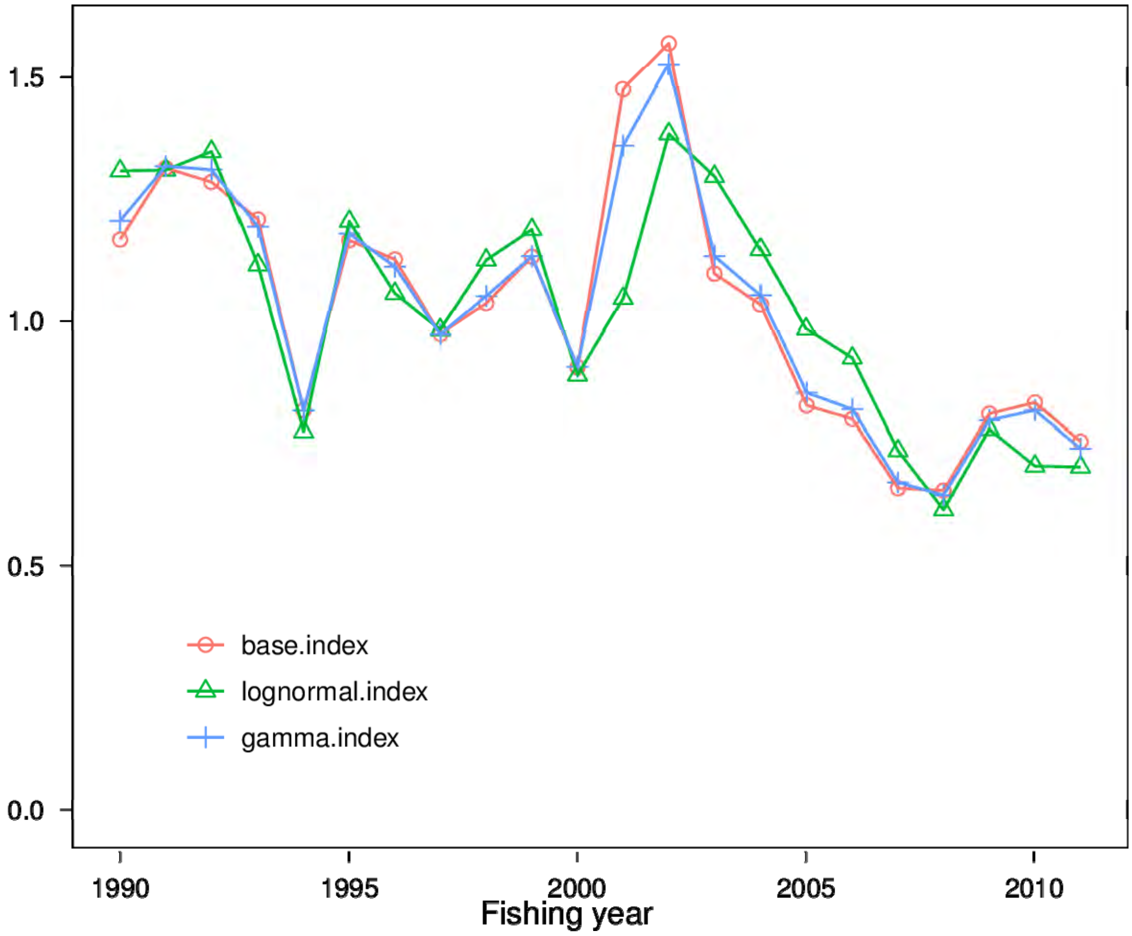


Figure M.4: Comparison of year indices for the TAR3_SN_TAR analysis derived from three of the model distributional assumptions compared in Figure N.6. The "base" index uses the Weibull distribution as this model had the lowest negative log-likelihood.

A plot showing the year coefficients from three of the distributional assumptions is shown in Figure M.4. The overall pattern is the same for all three distributional assumptions, except that the peak year in 2002 is a bit stronger for the lognormal series and there are minor variations between the lognormal and Weibull distributions all through the series. The year coefficients for the Weibull and gamma distributions are virtually identical.

Appendix N. DETAILED DIAGNOSTICS FOR TARAKIHI (EAST COAST) CPUE STANDARDISATIONS

N.1 Diagnostic plots

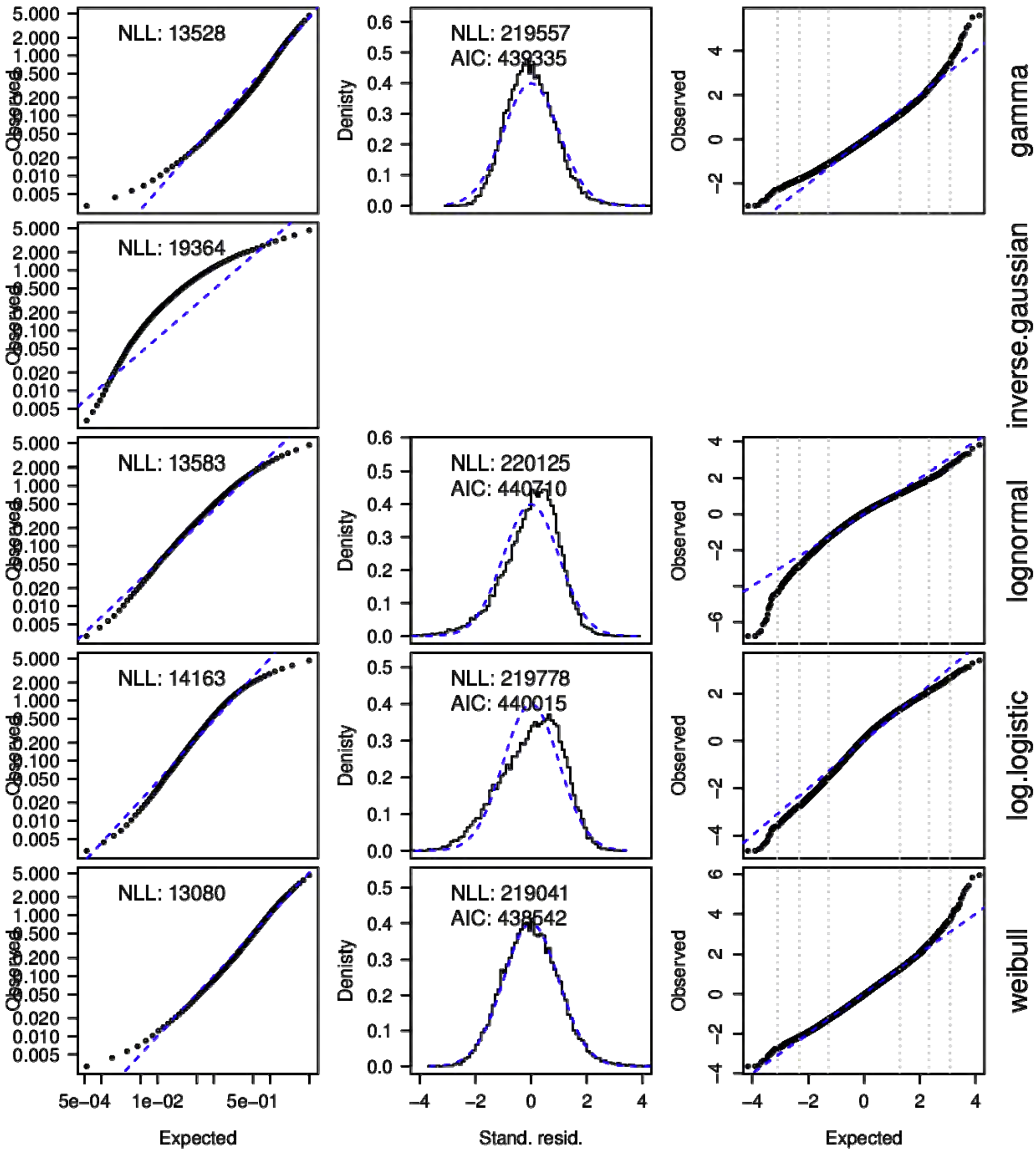


Figure N.1: Diagnostics for alternative distributional assumptions for catch in the TAR 2_BT_MIX fishery. Left: quantile-quantile plot of observed catches (centred (by mean) and scaled (by standard deviation) in log space) versus maximum likelihood fit of distribution (missing panel indicates the fit failed to converge); Middle: standardised residuals from a generalised linear model fitted using the formula catch ~ fyear + month + area + vessel + target and the distribution (missing panel indicates the model failed to converge); Right: quantile-quantile plot of model standardised residuals against standard normal (vertical lines represent 0.1%, 1% and 10% percentiles). NLL = negative log-likelihood; AIC = Akaike information criterion.

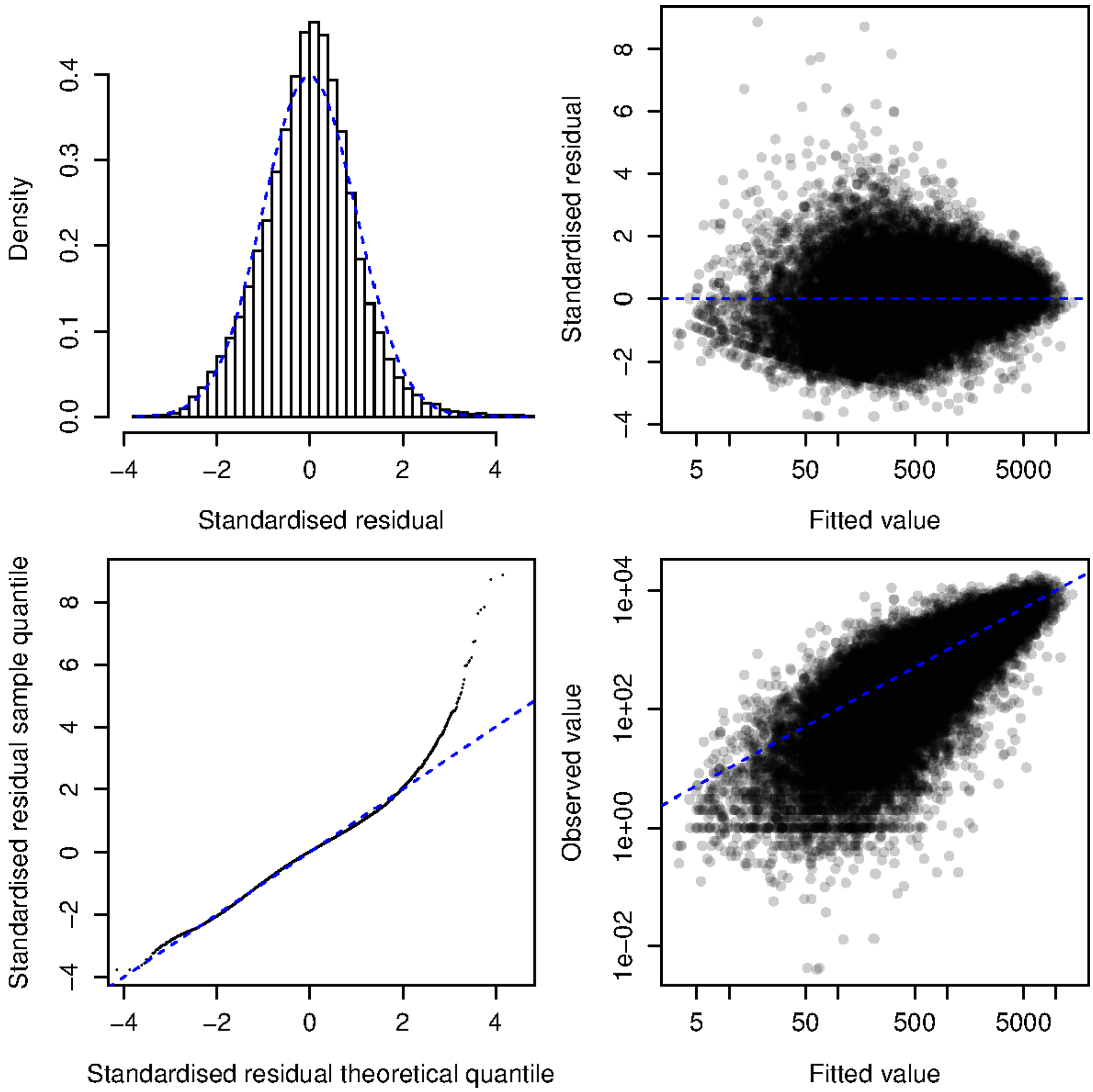


Figure N.2: Plots of the fit of the standardised Weibull CPUE model to successful catches of tarakihi in the TAR2_BT_MIX fishery. [Upper left] histogram of the standardised residuals compared to a lognormal distribution (SDSR: standard deviation of standardised residuals. MASR: median of absolute standardised residuals); [Upper right] Standardised residuals plotted against the predicted model catch per trip; [Lower left] Q-Q plot of the standardised residuals; [Lower right] Observed catch per record plotted against the predicted catch per record.

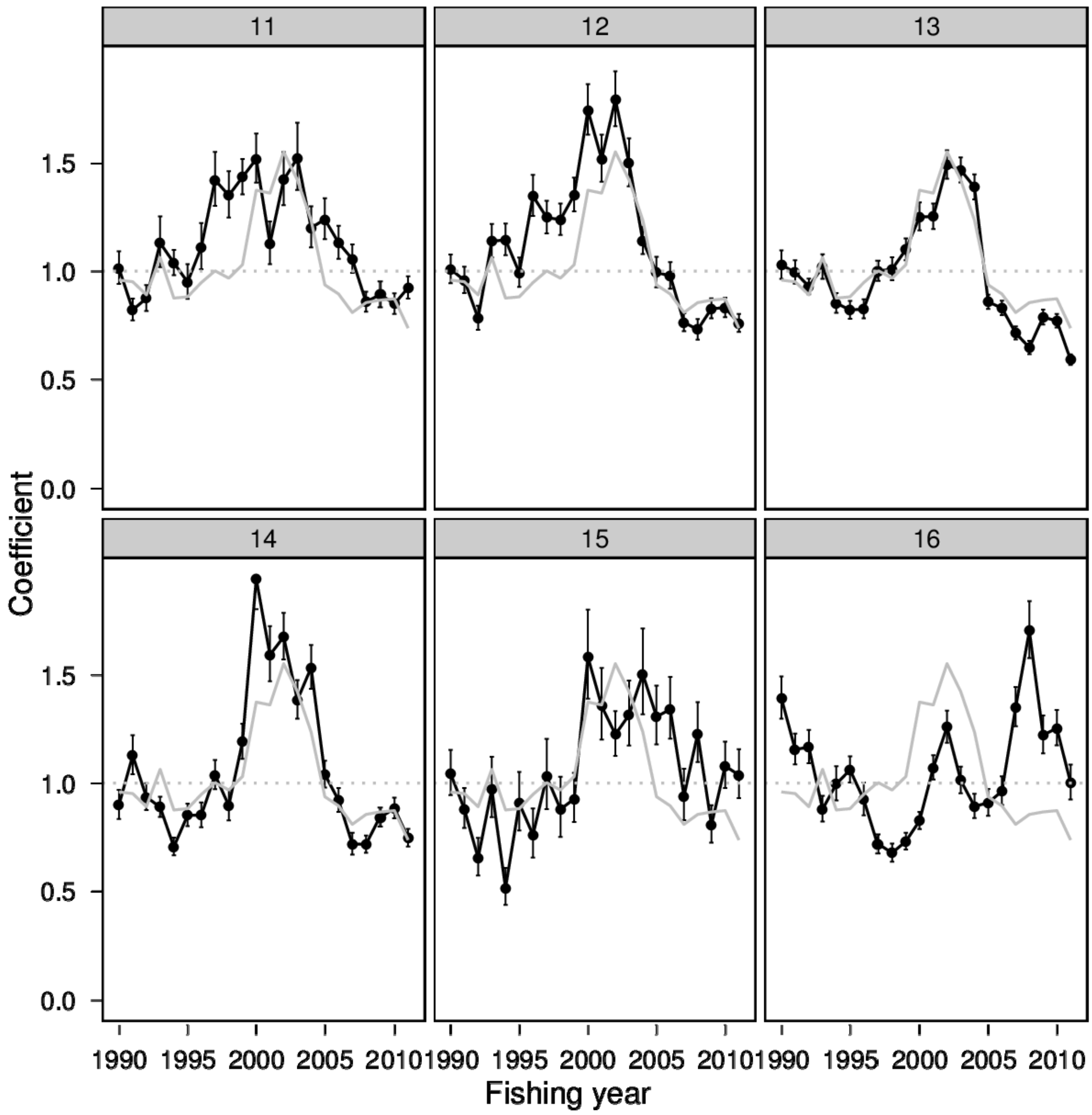


Figure N.3: Residual implied coefficients for each area in each fishing year for the Weibull TAR2_BT_MIX CPUE analysis. Implied coefficients are calculated as the sum of the fishing year coefficient plus the mean of the residuals in each fishing year in each area. The error bars indicate one standard error of residuals. The grey line indicates the model's overall fishing year coefficients.

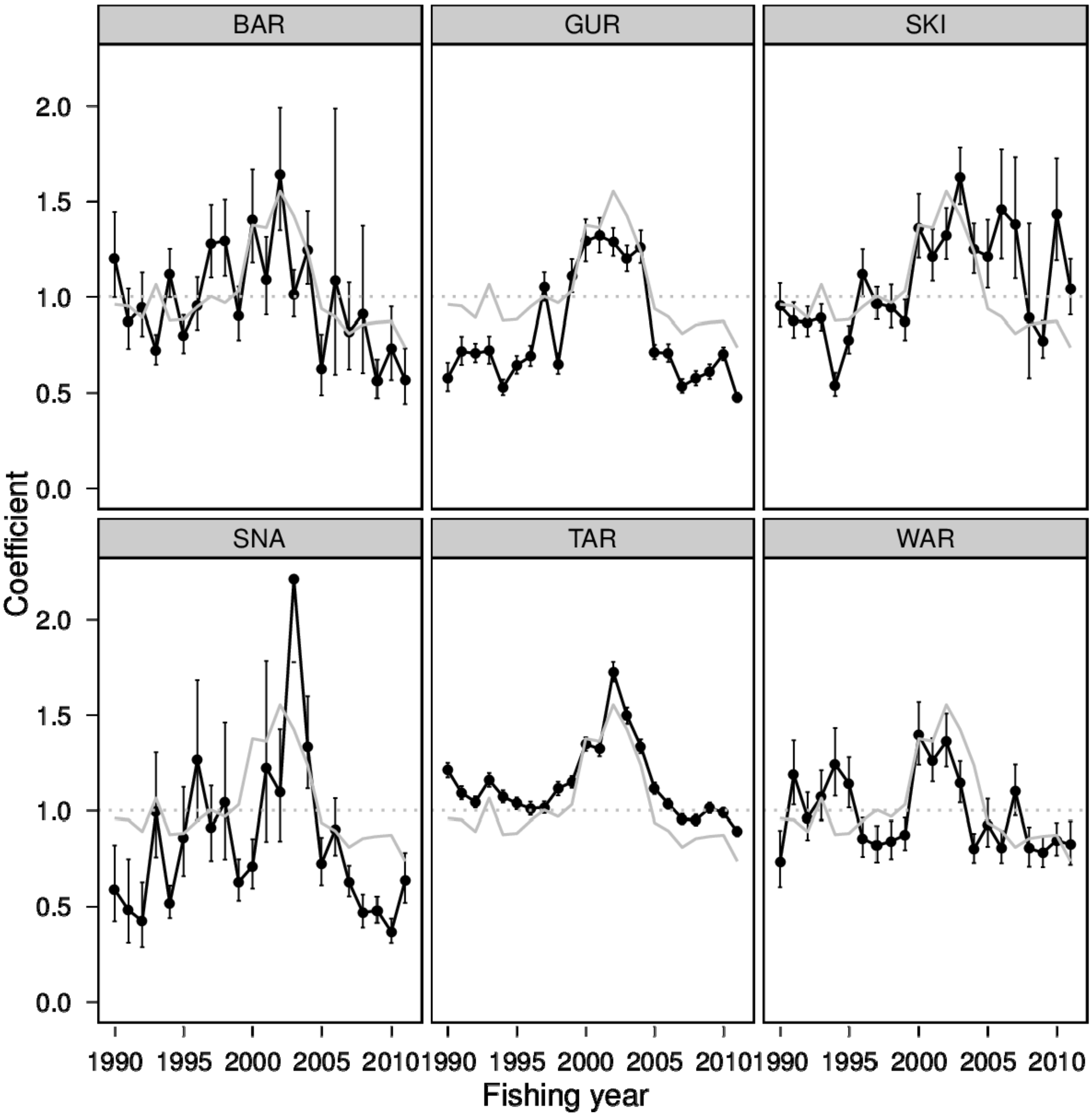


Figure N.4: Residual implied coefficients for each target species in each fishing year for the Weibull TAR2_BT_MIX CPUE analysis. Implied coefficients are calculated as the sum of the fishing year coefficient plus the mean of the residuals in each fishing year for each target species. The error bars indicate one standard error of residuals. The grey line indicates the model's overall fishing year coefficients.

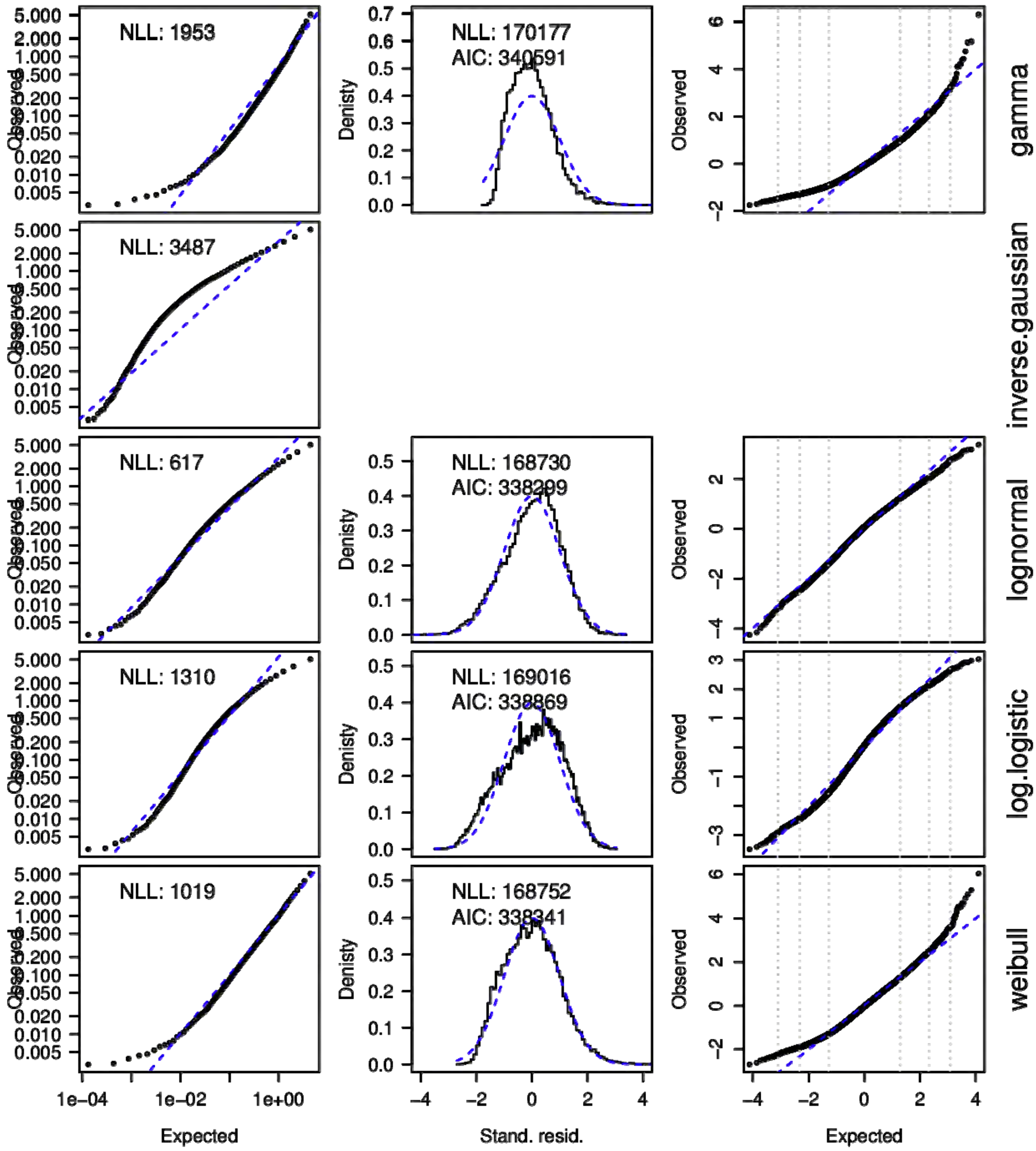


Figure N.5: Diagnostics for alternative distributional assumptions for catch in the TAR 3_BT_MIX fishery. Left: quantile-quantile plot of observed catches (centred (by mean) and scaled (by standard deviation) in log space) versus maximum likelihood fit of distribution (missing panel indicates the fit failed to converge); Middle: standardised residuals from a generalised linear model fitted using the formula catch ~ fyear + month + area + vessel + target and the distribution (missing panel indicates the model failed to converge); Right: quantile-quantile plot of model standardised residuals against standard normal (vertical lines represent 0.1%, 1% and 10% percentiles). NLL = negative log-likelihood; AIC = Akaike information criterion.

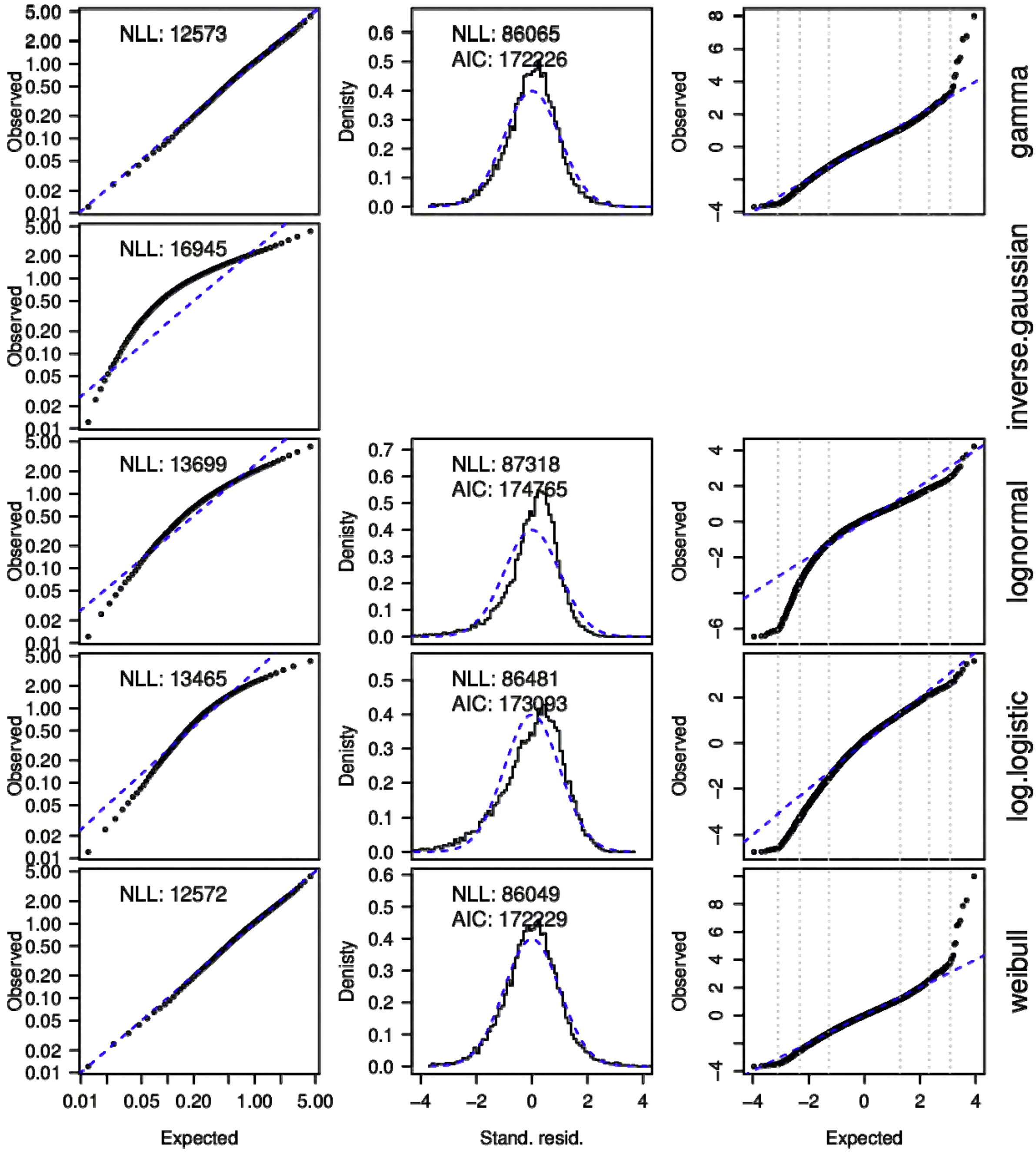


Figure N.6: Diagnostics for alternative distributional assumptions for catch in the TAR 3_SN_TAR fishery. Left: quantile-quantile plot of observed catches (centred (by mean) and scaled (by standard deviation) in log space) versus maximum likelihood fit of distribution (missing panel indicates the fit failed to converge); Middle: standardised residuals from a generalised linear model fitted using the formula catch ~ fyear + month + area + vessel + target and the distribution (missing panel indicates the model failed to converge); Right: quantile-quantile plot of model standardised residuals against standard normal (vertical lines represent 0.1%, 1% and 10% percentiles). NLL = negative log-likelihood; AIC = Akaike information criterion.

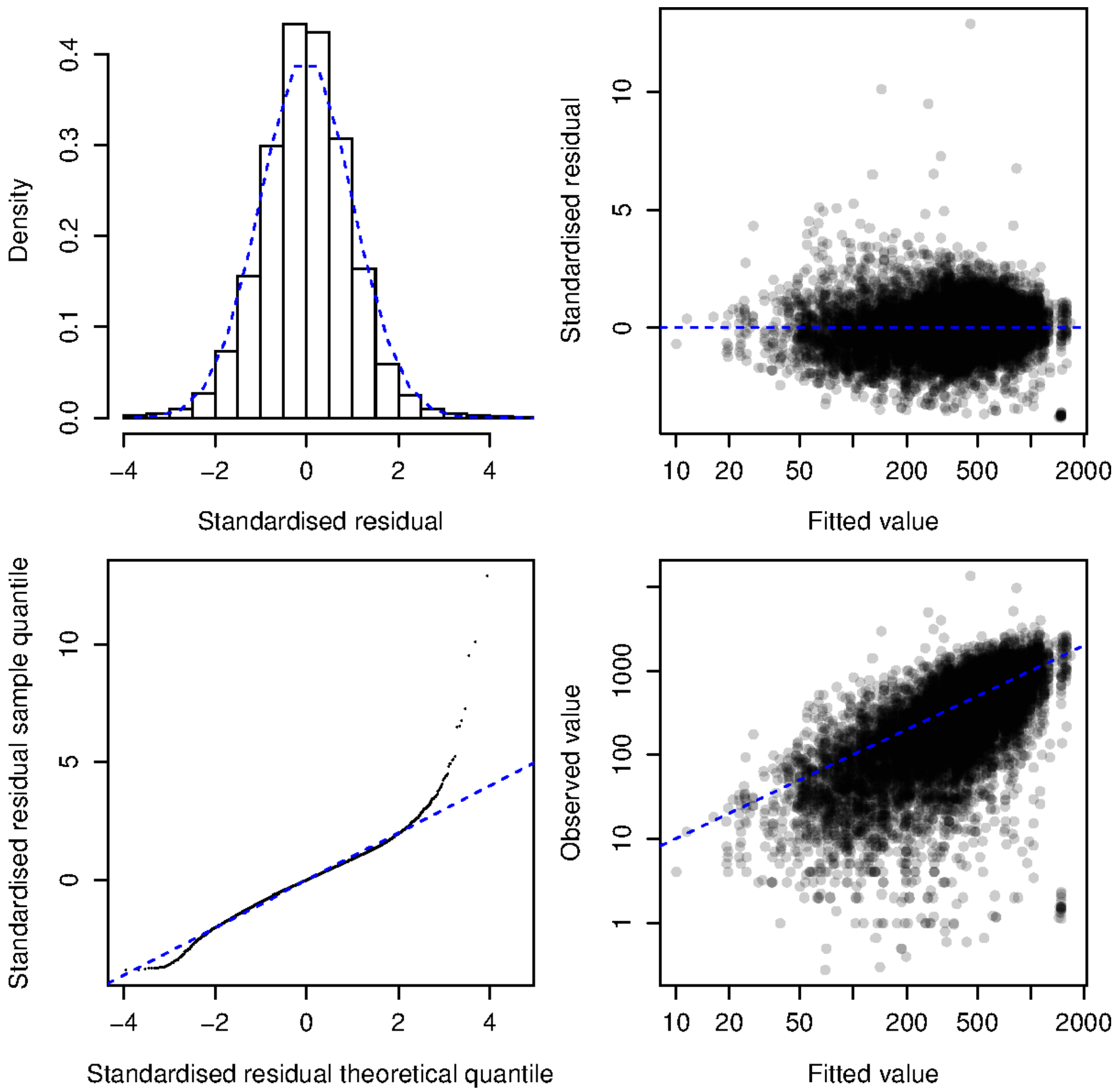


Figure N.7: Plots of the fit of the standardised CPUE model to successful catches of tarakihi in the Weibull TAR3_SN_MIX fishery. [Upper left] histogram of the standardised residuals compared to a lognormal distribution (SDSR: standard deviation of standardised residuals. MASR: median of absolute standardised residuals); [Upper right] Standardised residuals plotted against the predicted model catch per trip; [Lower left] Q-Q plot of the standardised residuals; [Lower right] Observed catch per record plotted against the predicted catch per record.

N.2 Model coefficients

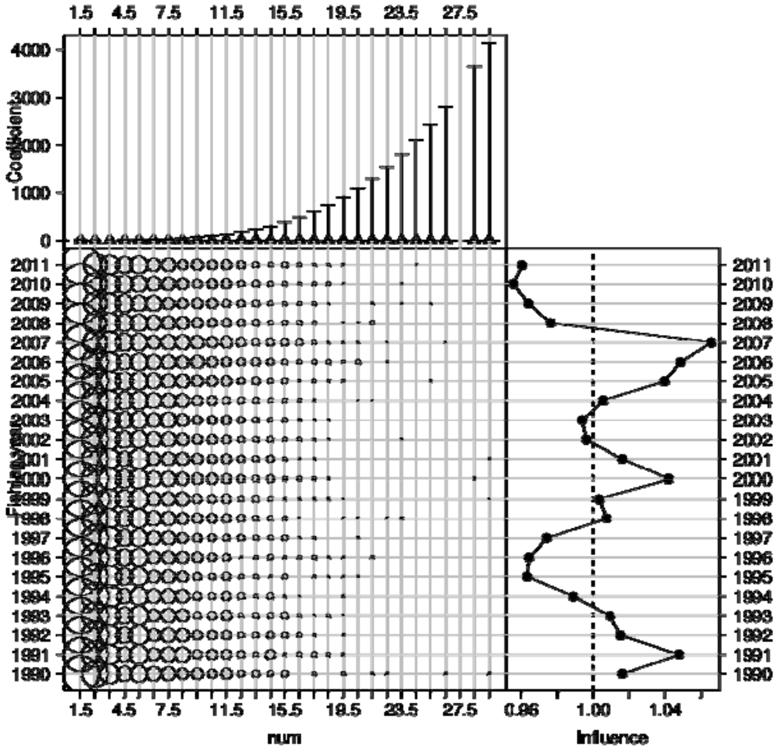


Figure N.8: Effect of `number tows` in the Weibull model for the TAR2_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.

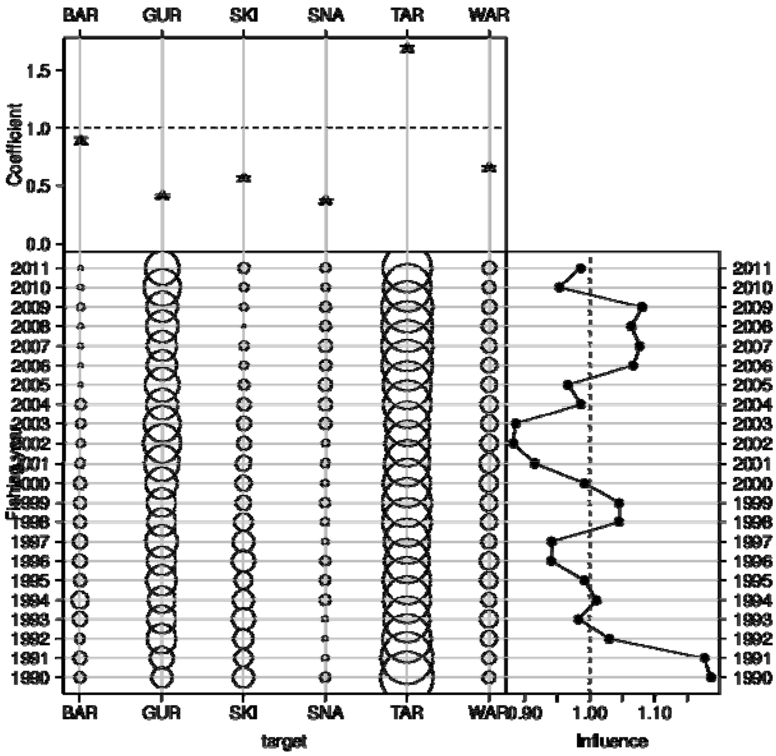


Figure N.9: Effect of `target` in the Weibull model for the TAR2_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.

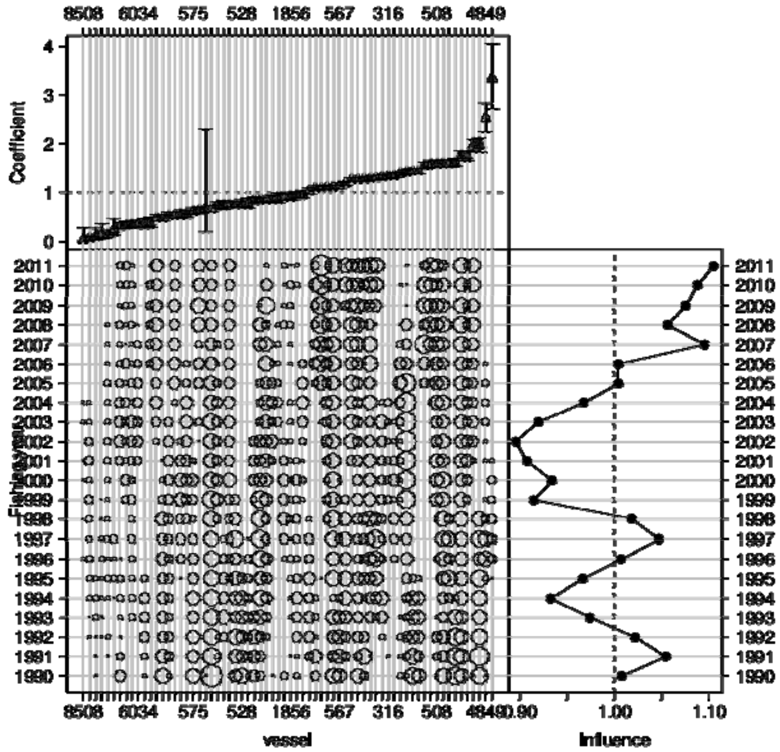


Figure N.10: Effect of `vessel` in the Weibull model for the TAR2_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.

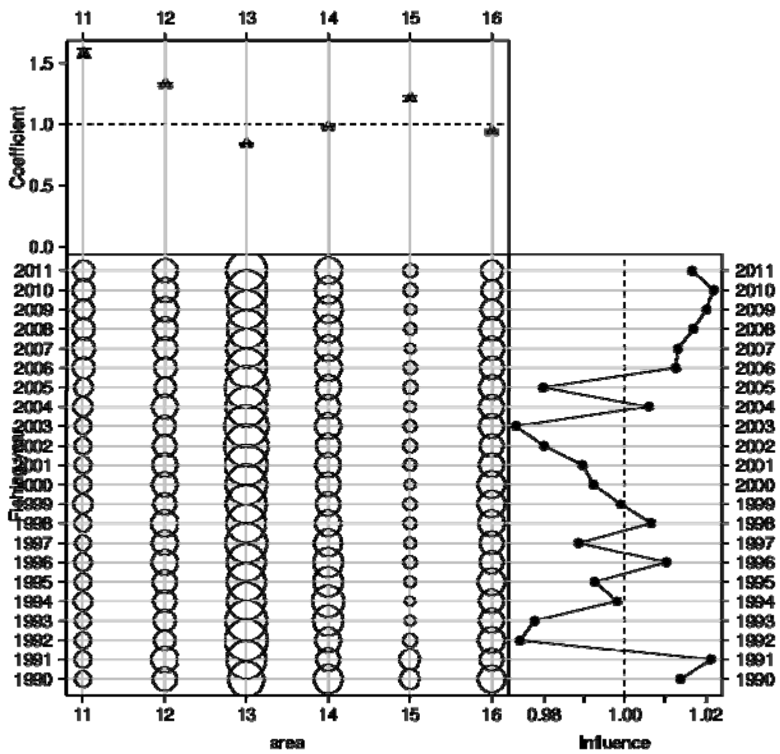


Figure N.11: Effect of `area` in the Weibull model for the TAR2_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.

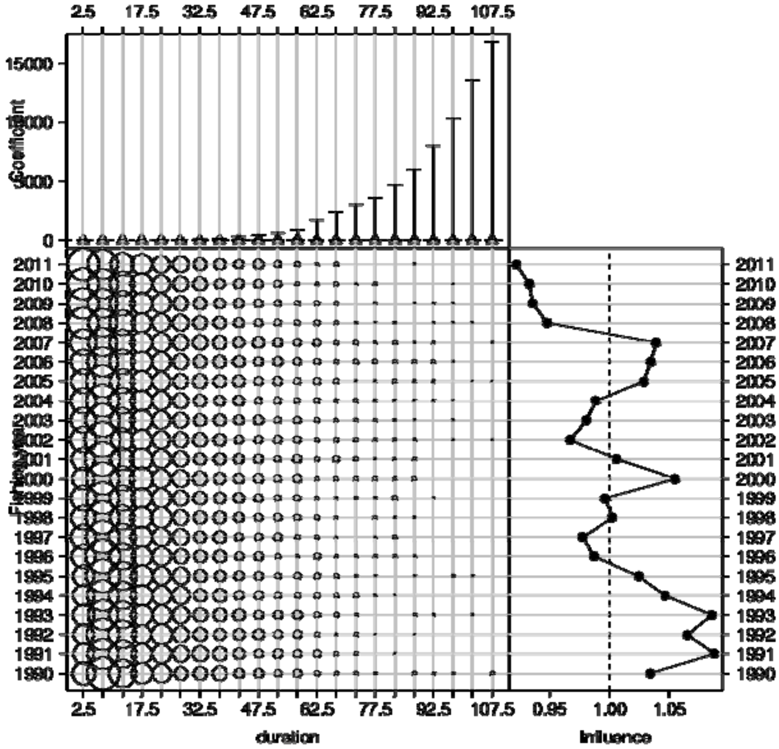


Figure N.12: Effect of `duration` in the Weibull model for the TAR2_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.

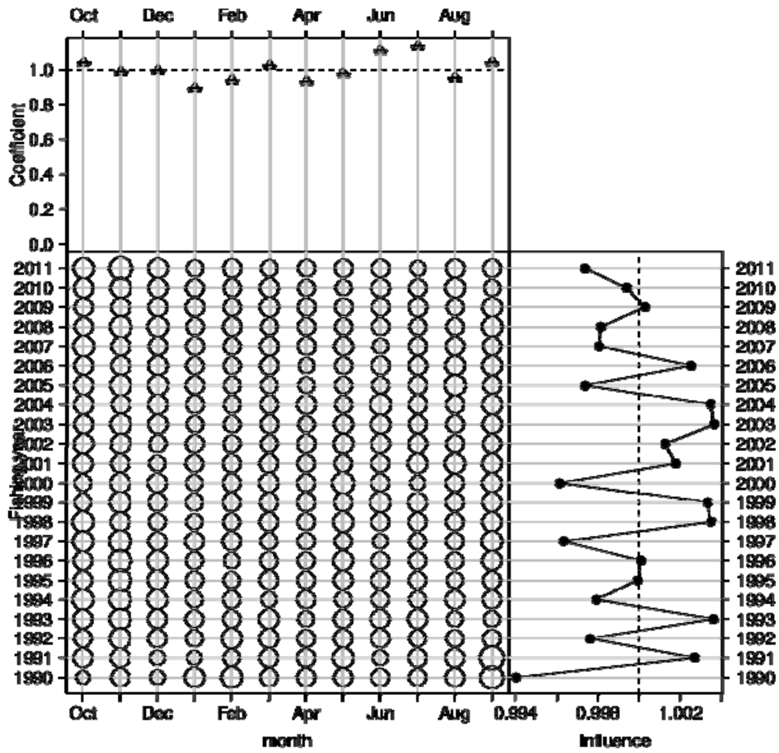


Figure N.13: Effect of `month` in the Weibull model for the TAR2_BT_MIX fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.

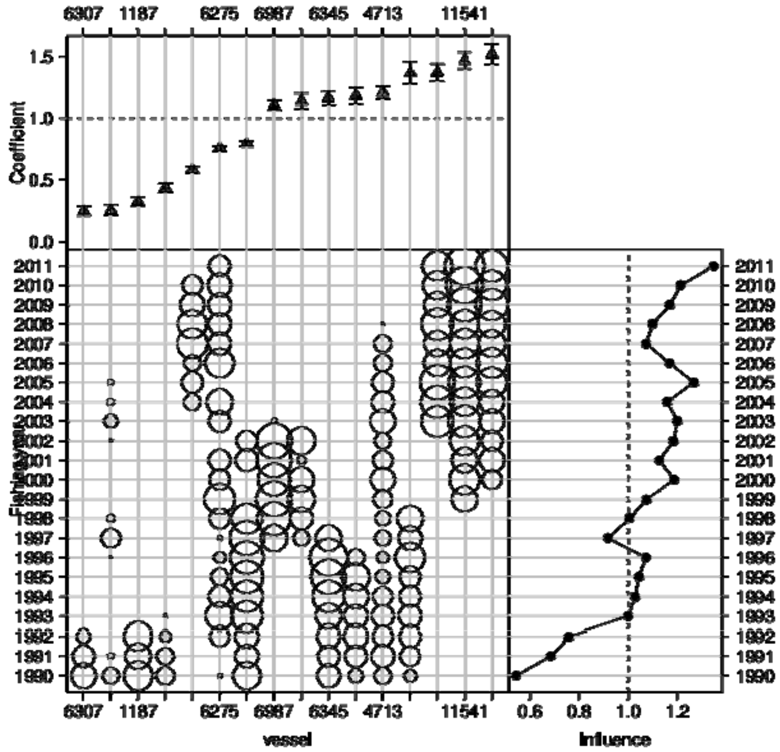


Figure N.14: Effect of `vessel` in the Weibull model for the TAR3_SN_TAR fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.

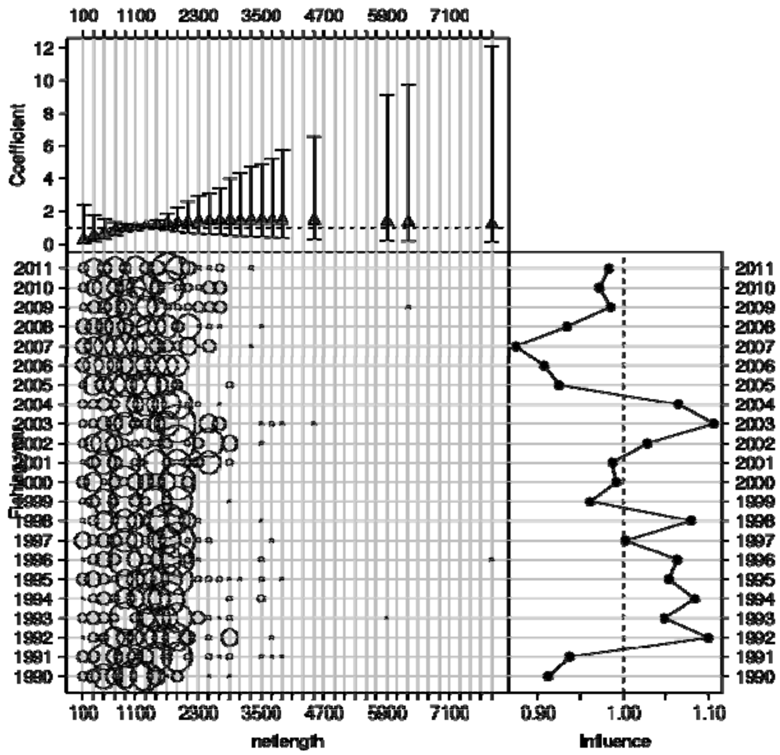


Figure N.15: Effect of `net length` in the Weibull model for the TAR3_SN_TAR fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.

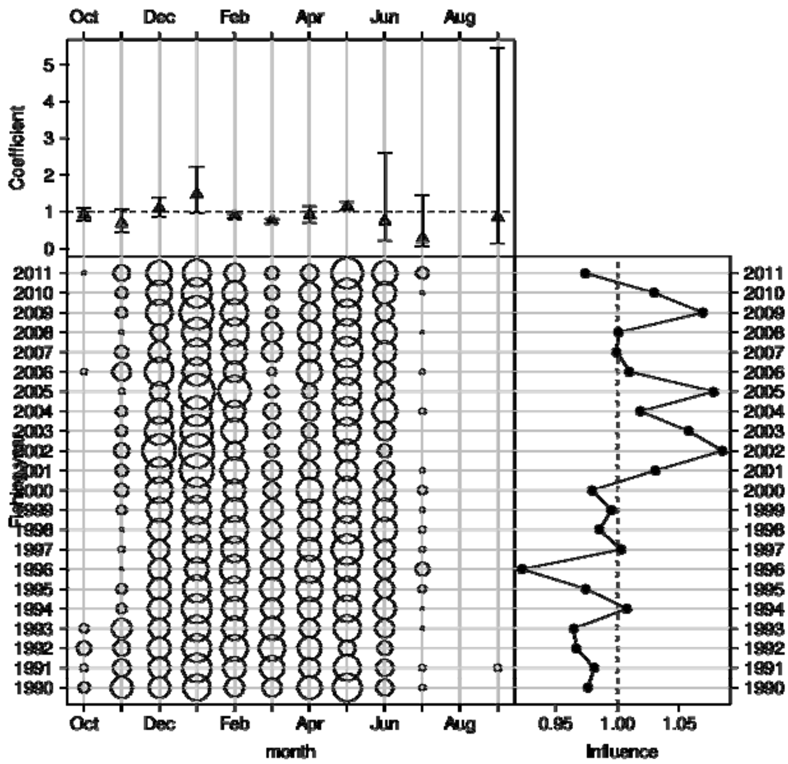


Figure N.16: Effect of `month` in the Weibull model for the TAR3_SN_TAR fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.

N.3 CPUE indices

Table N.1: Arithmetic, geometric and standardised indices based on the Weibull distribution and associated standard error for the core data set by fishing year for the two CPUE models which preferred this distribution (see Figure N.5 and Figure N.6).

	TAR 2_BT_MIX					TAR 3_SN_TAR				
Fishing	All	Core				All	Core			
Year	Arithmetic	Arithmetic	Geometric	Weibull	SE	Arithmetic	Arithmetic	Geometric	Weibull	SE
1990	0.9238	0.9973	1.3399	0.9571	0.0388	0.7245	0.7149	0.6633	1.1666	0.0353
1991	0.9329	0.9846	0.9853	0.9497	0.0341	0.9329	0.9846	0.9853	1.3129	0.0338
1992	0.8220	0.8755	0.9180	0.8891	0.0298	0.8220	0.8755	0.9180	1.2842	0.0319
1993	0.9323	0.9677	1.0265	1.0617	0.0309	0.9323	0.9677	1.0265	1.2077	0.0313
1994	0.8681	0.9259	0.9551	0.8739	0.0306	0.8681	0.9259	0.9551	0.8169	0.0354
1995	0.9512	0.9469	0.9695	0.8799	0.0299	0.9512	0.9469	0.9695	1.1650	0.0358
1996	0.9469	0.9405	0.9353	0.9458	0.0322	0.9469	0.9405	0.9353	1.1260	0.0397
1997	0.9422	0.8862	0.8550	1.0000	0.0304	0.9422	0.8862	0.8550	0.9728	0.0377
1998	1.0482	1.0422	0.9551	0.9662	0.0306	1.0482	1.0422	0.9551	1.0360	0.0330
1999	1.0224	1.0360	0.9576	1.0284	0.0291	1.0224	1.0360	0.9576	1.1313	0.0349
2000	1.1281	1.1162	1.0685	1.3722	0.0298	1.1281	1.1162	1.0685	0.9047	0.0338
2001	1.1234	1.0658	1.0507	1.3590	0.0289	1.1234	1.0658	1.0507	1.4746	0.0328
2002	1.4584	1.4154	1.4438	1.5497	0.0278	1.4584	1.4154	1.4438	1.5688	0.0372
2003	1.2599	1.2706	1.2351	1.4201	0.0269	1.2599	1.2706	1.2351	1.0968	0.0351
2004	1.1743	1.1898	1.1814	1.2338	0.0285	1.1743	1.1898	1.1814	1.0335	0.0333
2005	1.0817	1.0303	1.0104	0.9351	0.0270	1.0817	1.0303	1.0104	0.8271	0.0410
2006	1.0164	0.9817	0.9717	0.8929	0.0278	1.0164	0.9817	0.9717	0.7995	0.0348
2007	0.9021	0.8952	0.9261	0.8075	0.0288	0.9021	0.8952	0.9261	0.6591	0.0371
2008	0.8919	0.9009	0.8658	0.8532	0.0274	0.8919	0.9009	0.8658	0.6546	0.0406
2009	0.9422	0.9424	0.9312	0.8647	0.0265	0.9422	0.9424	0.9312	0.8103	0.0415
2010	0.9715	0.9543	0.9634	0.8709	0.0256	0.9715	0.9543	0.9634	0.8329	0.0432
2011	0.8493	0.8521	0.8687	0.7354	0.0265	0.8493	0.8521	0.8687	0.7543	0.0454