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EXECUTIVE SUMMARY

Manning, M.J.; Stevenson, M.L.; Horn, P.L. (2008). The composition of the commercial and research tarakihi (*Nemadactylus macropterus*) catch off the west coast of the South Island (TAR 7) during the 2004–05 fishing year.

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This report presents the results of the first year of a three-year market sampling programme on the tarakihi catch in the mixed-species bottom-trawl fishery on the continental shelf off the west coast of the South Island over the 2004–05 to 2006–07 fishing years. An analysis of tarakihi data collected during a research trawl survey of the west coast of the South Island during March–April 2005 by RV *Kaharoa* is also presented. This work was funded by the Ministry of Fisheries under research project TAR200401 ("Stock assessment of tarakihi in TAR 7") Specific Objectives 1 ("To conduct sampling in fish processing sheds to determine the length and age structure of the commercial catch of tarakihi in TAR 7") and 2 ("To prepare and read tarakihi otoliths collected from the 2005 west coast South Island trawl survey").

The aim of the market sampling programme was to sample the age composition of the fishery throughout all 12 months of each fishing year in order to produce fishery catch-at-age distributions that can be used as observations in a quantitative stock assessment of the TAR 7 stock, complimenting existing survey and other data. The unit stock defined in the market sampling programme and in the stock assessment is that portion of the TAR 7 fishstock area that excludes eastern Cook Strait ("TAR 7(W)"). Sampling effort was allocated to the three major ports on the west coast of the South Island by month proportionally to historic trends in catch in the fishery by these factors. A so-called "direct-age" sampling design was used, where otolith pairs from individual fish are sampled randomly from the fishery and are scaled up to the stratum totals in the analysis without using an intermediate age-length key. A variance target of a mean-weighted coefficient of variation (c.v.) of 30% was set on the fishery catch-at-age. No formal variance target was set for the survey proportions-at-age estimated.

A target of 60 sampled landings was set across the three ports over the 2004–05 fishing year. A total of 47 sampled landings was achieved. A total of 1860 sagittal otolith pairs were sampled from the fishery, from which a random subsample of 1031 otoliths was selected, prepared, and read. All landings were retained in the analysis, but as some landings were found to have come from vessels that had actually fished in eastern Cook Strait despite this area being outside the stock area assumed in the sampling programme and in the stock assessment, separate strata consisting of landings of fish caught in eastern Cook Strait, Tasman and Golden Bays, and on the open west coast of the South Island were assumed in the corresponding length and age frequency calculations. Nevertheless, the sampled landings are thought to be representative of the larger mixed-species bottom-trawl fleet in the TAR 7(W) stock area and the same sampling design was recommended for the remaining years of the sampling programme. A brief, updated description of the fishery and derivation of a catch history over the 1931–32 to 2004–05 fishing years are also provided. A mean-weighted c.v. of 28.9% was obtained for the catch-at-age pooled across both sexes, all strata, and all age classes.

Of the 261 tarakihi sagittal otolith pairs collected during the March–April 2005 survey, 260 were prepared and read. Age estimates derived from these readings were converted to age-length keys and applied to scaled length frequency distributions calculated from length and other data collected during the survey to yield scaled age frequency distributions by sex and survey stratum. A mean-weighted c.v. of 37.9% was obtained for the survey proportions-at-age distribution pooled across both sexes, all strata, and all age classes. Similar trends were apparent when the proportions-at-age distributions were pooled across Tasman and Golden Bays (TBGB) and west coast of the South Island (WCSI) survey regions and compared with the corresponding catch-at-age strata from the fishery. In both the fishery and survey catches, fish exceeding their 30^{th} year were observed. However, there are very few fish

older than 20 in either catch. In general, the survey appears to catch smaller and younger fish than the fishery, although this was particularly marked in TBGB. The median age of the fishery catch in the 2004–05 fishing year was 4 years in TBGB and 5 years on the WCSI. The median age of the survey catch in March–April 2005 was 1 year in the TBGB survey region and 5 years in the WCSI survey region. This is likely to be due to the different selectivities of the commercial and survey bottom-trawl gear. Unlike in previous surveys, there were very few 0 and 1 year old fish present in the 2005 survey catch, suggesting that recent (i.e., 2003 and 2004) year classes may be weak and should be monitored in the future. Sex ratios in the survey catches over 1992–2005 are consistently skewed in favour of female fish (i.e., more female than male fish are caught). This was also found to be the case in the fishery in 2004–05. The implications of these results are discussed. Whether tarakihi otolith collection during the WCSI survey voyages is adequate is also discussed.

The results of within and between-reader comparison tests suggest that no systematic differences in the interpretation of tarakihi otoliths exists either within or between readers over the course of this study. Otolith reading precision appeared to be slightly worse in this study than in the last age and growth study of tarakihi from the west coast of the South Island.

1. INTRODUCTION

Tarakihi (*Nemadactylus macropterus*) is one of New Zealand's most commercially important inshore teleost fish species. Total reported landings in the New Zealand Exclusive Economic Zone (EEZ) have ranged between 4090 and 6119 t and averaged about 5236 t per fishing year since the Quota Management System (QMS) was introduced at the start of the 1986–87 fishing year. Since then, tarakihi in the New Zealand EEZ has been managed as eight separate Quota Management Areas (QMAs) or "fishstocks": TAR 1–5, 7–8, and 10 (Figure 1). Total reported landings in fishstock TAR 7, which encompasses the west coast of the South Island and Tasman and Golden Bays as well as western and eastern Cook Strait, have ranged between 629 and 1178 t and average about 870 t per fishing year. Virtually all of the TAR 7 commercial catch is caught by bottom-trawl fishing (Hanchet & Field 2001, results below). Biological stock structure, including the true number of biological stock units and their inter-relationships, is not well understood.

Although target tarakihi trawl fisheries exist on both the west coast of the South Island and in Cook Strait, most of the TAR 7 catch (70%, Hanchet & Field 2001) is caught as bycatch of bottom-trawl fishing targeting barracouta (*Thyrsites atun*) and other species. Peak catches in the target fisheries off the west coast of the South Island and in Cook Strait coincide with the summer-autumn tarakihi spawning season. The non-target catch is more evenly spread throughout the fishing year (Hanchet & Field 2001). Both the west coast of the South Island around Jackson Bay and Cook Strait east of Cape Campbell were identified as major tarakihi spawning sites by Annala (1987) in his review of tarakihi biology and fisheries. The target fisheries probably exploit inwards and outwards migrations as well as fish massing on the spawning grounds.

Recently, concern has been raised about the status of the tarakihi stock in TAR 7. Although total reported landings in TAR 7 remained relatively consistent throughout the mid-to-late 1990s and during the early 2000s (Table 1), relative biomass estimates derived from data collected aboard RV *Kaharoa* during five research trawl surveys of the west coast of the South Island over 1995–2003 had declined by about 30% by 2003 (Stevenson 2004), and there is some evidence of recent weak year classes in the 2003 catch (Stevenson & Horn 2004). The western and eastern Cook Strait subareas are not monitored by the RV *Kaharoa* survey and may be part of a separate biological stock.

In this report, we present the results of the first year of a three-year commercial market sampling programme, and an analysis of age and growth data collected aboard RV *Kaharoa* during the March–April 2005 west coast South Island survey. Both analyses were carried out to support a quantitative stock assessment that is currently underway. Preliminary results of the stock assessment were presented by Manning (2007). A revised stock assessment incorporating the 2007 trawl survey relative biomass index and all data from the market sampling programme is scheduled for February–May 2008 (Manning, unpublished results). A target mean-weighted coefficient of variation (c.v.) of 30% averaged over all age classes was set for the catch-at-age distributions calculated from the market-sampling data. No formal variance target was set for the survey proportions at age distributions. This report fulfils Reporting Requirement 1 of New Zealand Ministry of Fisheries research project TAR2004-01 Specific Objective 2.

2. METHODS

2.1 Commercial market sampling programme

2.1.1 Aim

No published data were available on the length- or age-composition of the tarakihi catch in the mixed-species bottom-trawl fishery (BT-MIX) in TAR 7 or on the selectivity (by length or age) of the

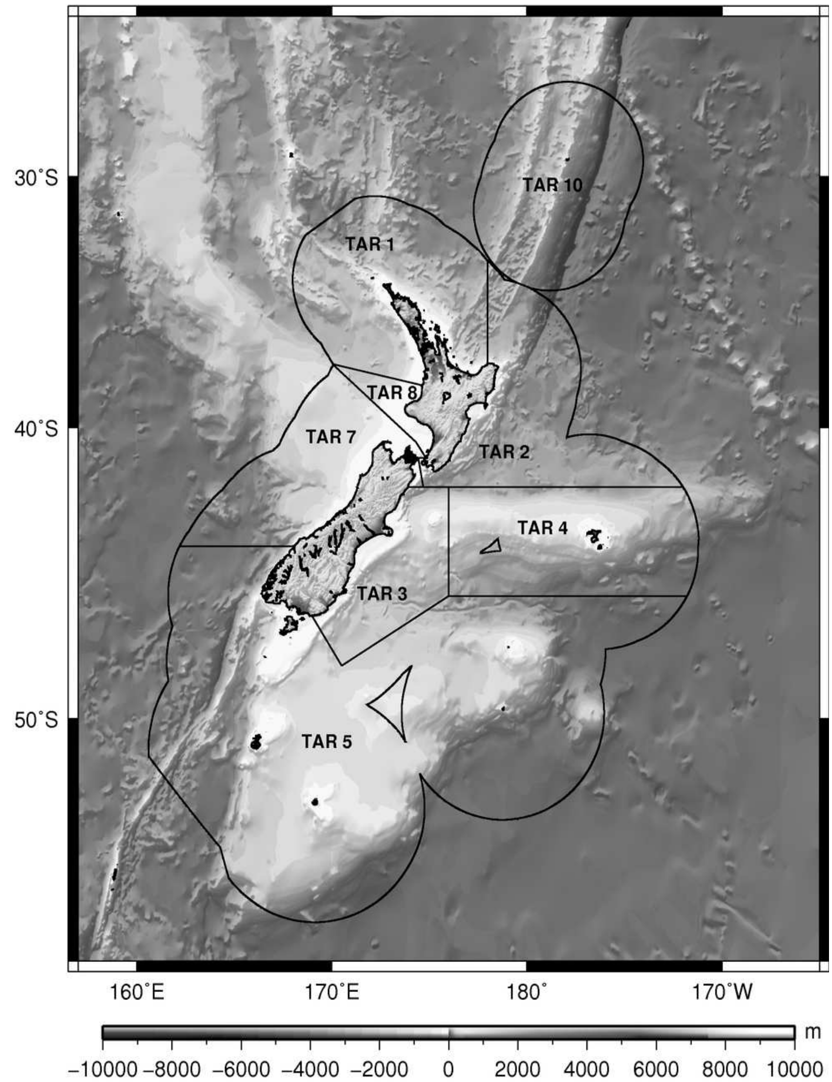


Figure 1: New Zealand tarakihi Quota Management Areas (QMAs). At this time, tarakihi in the New Zealand EEZ is managed as eight separate fishstocks: TAR 1–5, 7–8, & 10. The QMAs do not necessarily correspond to individual biological stock units.

commercial trawl gear used in this fishery before this study. Stock composition data are an important input to any modern cohort-dynamic quantitative stock assessment model, allowing the selectivity of the fishing gear or gears to be estimated within the model fit. The aim of the market sampling programme is to address this information need by sampling the tarakihi catch in the BT-MIX fishery during the 2004–05, 2005–06, and 2007–08 fishing years. These data will supplement the research survey age composition data presented by Stevenson & Horn (2004) and in this report and will be included in the assessment model fits, allowing the corresponding gear selectivities to be estimated directly in the assessment. A target mean-weighted coefficient of variation (c.v.) of 30% averaged over all age classes was set for the market sampling catch-at-age distributions. No formal variance target was set for the survey proportions at age distributions.

2.2 The unit stock and spatial extent of the sampling programme

As noted, fishstock TAR 7 extends north from Jackson Bay on the west coast of the South Island, around and encompassing Tasman and Golden Bays and the Marlborough Sounds, to just north of Kaikoura on the east coast. The area east of D’Urville Island is part of the Cook Strait fishery,

Table 1: The total reported landed tarakihi catch by fishing year and QMA (Ministry of Fisheries Science Group 2006). *, New Zealand Fisheries Statistics Unit data (1984–86); †, New Zealand QMS data (1986–87 to 2004–05).

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

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

however, and may be a separate biological stock or sub-stock with different biological characteristics (Hanchet & Field 2001, Phillips & Hanchet 2003). Hence, the sampling programme was restricted to BT-MIX catch on the west coast of the South Island (WCSI; statistical areas 033–036, 701–706), in Tasman and Golden Bays (TBGB; statistical area 038), and in what we call "western Cook Strait" (CKST.W; statistical areas 037, 039–040). Catches from eastern Cook Strait (CKST.E; New Zealand fisheries statistical areas 017 and 018) were ignored. The sampled region of the TAR 7 QMA, referred to as "TAR 7(W)" elsewhere in this report, is the same as the stock definition used in the assessment model. Tarakihi stock structure is discussed in more depth below (see Section 4).

2.2.1 The sampling design

Proportions at age in New Zealand fisheries are usually estimated using one of three methods (Francis 2002):

(i) by collecting length-frequency data from the catch and using a modal separation program such as MIX to decompose the length-frequency distribution into an age-frequency distribution (the "indirect length-frequency" approach);

(ii) by collecting both a large sample of length-frequency data and a small sample of otoliths from the catch to generate an "age-length" key to transform the length-frequency distribution to an age-frequency distribution (the "indirect age-length key" approach); or

(iii) by collecting representative samples of otoliths and estimating the catch-at-age directly from the age-frequency distribution derived from the otoliths collected (the "direct-age estimation" approach).

The first is of little use for tarakihi given their moderate longevity (at least 43 years) (Stevenson & Horn 2004)). The second is likely to be difficult to apply to the TAR 7(W) stock given the temporal distribution of the catch, fish growth, and probable migrations through the stock area within a given fishing year. Although there is a seasonal peak in the catch from October to March (Hanchet & Field 2001), there is considerable catch outside these months, and an inward migration of young, maturing fish from Tasman and Golden Bays to adult habitat on the west coast of the South Island may also occur (Vooren 1975), although this is not well understood. Jackson Bay is recognised as a major tarakihi spawning site for this stock (Annala 1987), but the dynamics of the probable southward migration of pre-spawning fish and presumed northward return migration of spent fish along the west coast within a given spawning season are also not well understood.

The main advantage of method two is low cost: large numbers of fish can be measured relatively cheaply and the relatively more expensive age estimation component is restricted to relatively few fish. However, the cost advantage is reduced or lost when multiple age-length keys are needed. The number of age-length keys that would be required for TAR 7(W) is unclear, although it is probably at least eight: separate in-season and out-season keys each for males and females in Tasman and Golden Bays as well as for fish on the west coast. Each key needs to be derived from sufficient otoliths to define the length-at-age relationship for a species with probably more than 40 year-classes in the catch, requiring considerable sampling effort. On balance, the third method, the direct-age estimation approach, appeared most appropriate for the TAR 7 (W) stock and was selected.

2.2.2 Allocation of sampling effort

To assist with allocating sampling effort, all landing and all associated fishing event records for all fishing trips from 1 October 1989 to 30 September 2004 where at least one non-zero landing event in

TAR 7 was recorded were extracted from the MFish catch-effort and landings database *warehou* (Duckworth 2002). These data were then merged using the restratification and landed catch allocation algorithm described by Manning et al. (2004). Figure 2 shows the distribution of the catch in each fishing year by month of the fishing year and gear type. Figure 3 shows the distribution of the total catch declared port of landing and gear type. Tarakihi caught by bottom-trawl fishing clearly dominate the catch, verifying the results of Hanchet & Field (2001) based on fewer data and justifying the decision to restrict the market sampling programme to bottom-trawl fishing. The seasonality in the catch is apparent, but varies from year to year; in some years as much as 30–40% of the catch is caught outside the October–March peak season. The ports of Greymouth, Nelson, and Wellington contribute most to the total catch across all subareas, with much smaller contributions from Jackson Bay, Picton, and Westport. However, most of the catch landed into Nelson appears to be from outside the TAR 7(W) stock area (from CKST.E or eastern Cook Strait; see Figure 4).

Given that no published data were available on spatial and temporal trends in the composition of the tarakihi catch before the start of this sampling programme, the optimal number of landings to sample to achieve the target mean-weighted c.v. on the catch-at-age cost-effectively could not be evaluated directly. However, market sampling of commercial landings of trawl-caught snapper in fishstock SNA 7 (which overlaps exactly with TAR 7) have been carried out for some time. Given the similarities in life histories, habitat, and fisheries between the two species, it seems reasonable to us that strategies that worked for snapper in this area may also work for tarakihi. Using a direct-age design, Blackwell & Gilbert (2002) observed a mean-weighted c.v. of 27% for the SNA 7 catch during the 2000–01 fishing year, and Blackwell & Gilbert (2001) observed a mean-weighted c.v. of 25% during the 1999–2000 fishing year, sampling 60 and 56 SNA 7 landings, respectively.

Sampling effort during the first year of the programme was stratified by port of landing and time of the year. Effort was restricted to bottom-trawl vessels landing in the ports of Greymouth, Nelson, Jackson Bay, and Westport as these four ports account for the largest share of the catch. Catches unloaded in Picton and Wellington are mainly from the eastern Cook Strait fishery and are outside the TAR 7(W) stock area assumed in the sampling programme. The BT-MIX fishery was divided into 18 port and two-month block divisions and the 60 landings to be sampled allocated to the blocks in proportions equivalent to the distribution of catch in the groomed and merged catch-effort and landings dataset over these factors in an effort to ensure that sampling effort was as closely as possible proportional to the historic distribution of catch in the fishery in time and space (Table 2), although there is no guarantee that the observed catch in any given fishing year will follow the historic (average) trend.

A typical result in market sampling programmes is that there is usually (much) more variation in fish size and other quantities between rather than within landings. More precision in the observations of these quantities can usually be obtained by sampling fewer fish from many landings than many fish from few landings. To account for this, given that no direct information is available to guide the development of the sampling design, in the first year of the sampling programme we proposed to sample 60 landings, 30 per stratum. We proposed to randomly sample 20 sagittal otolith pairs from landings of 1000 kg or lighter and 50 sagittal otoliths pairs from landings heavier than 1000 kg. The empirical cumulative frequency distribution of landing weights in the TAR 7 (W) stock over the 1989–90 to 2003–04 fishing years shows that about 81% of all landings were 1000 kg or lighter (Figure 5). This suggests that if 60 landings were sampled during the first year of the sampling programme, about 1500 sagittal otolith pairs would be collected, of which we propose to prepare and read about 1000 individual otoliths. Collecting more otoliths than we propose to prepare and read will allow us to post- stratify the otoliths collected in the future to control sources of variation in the catch that are currently unknown but may be shown later to be important.

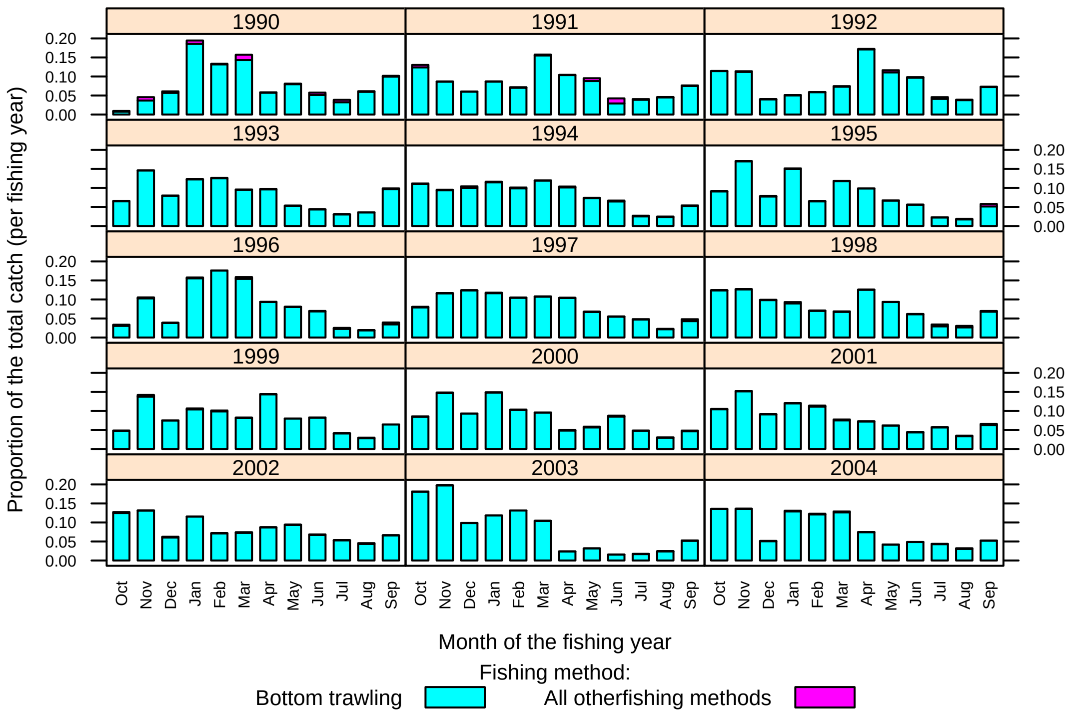


Figure 2: **The distribution of the total catch in each fishing year in the merged catch-effort and landings dataset by gear type and month. BT, bottom-trawl.**

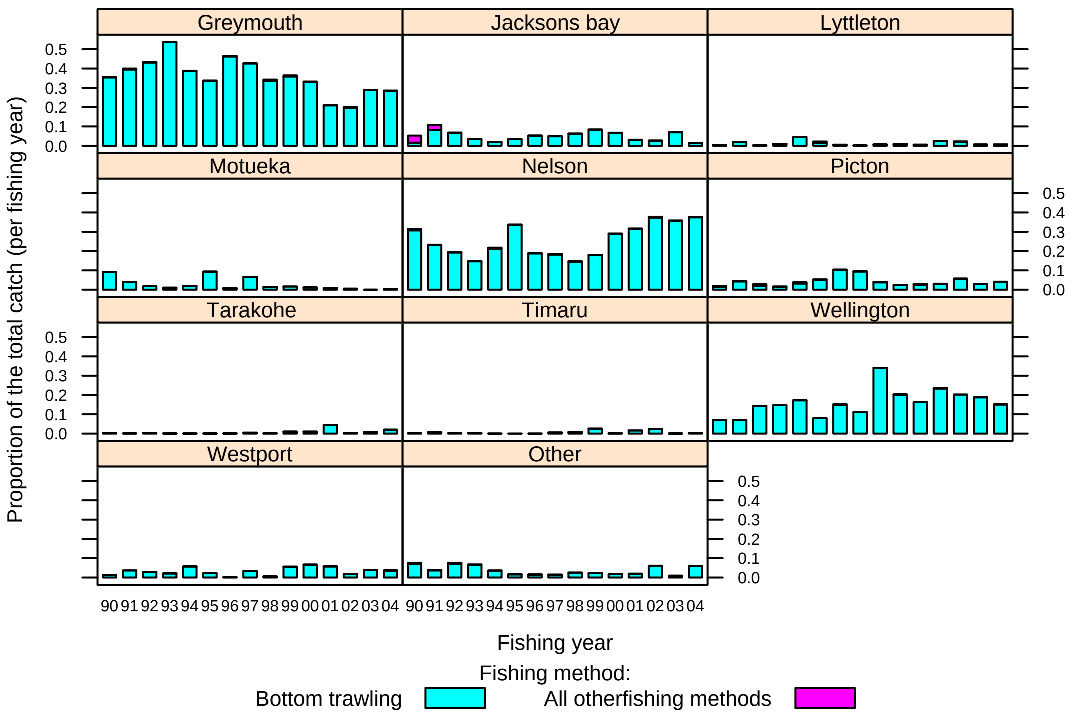


Figure 3: **The distribution of the total catch for all fishing years in the merged catch-effort and landings dataset by gear type, month of the fishing year, and declared port of landing. BT, bottom-trawl.**

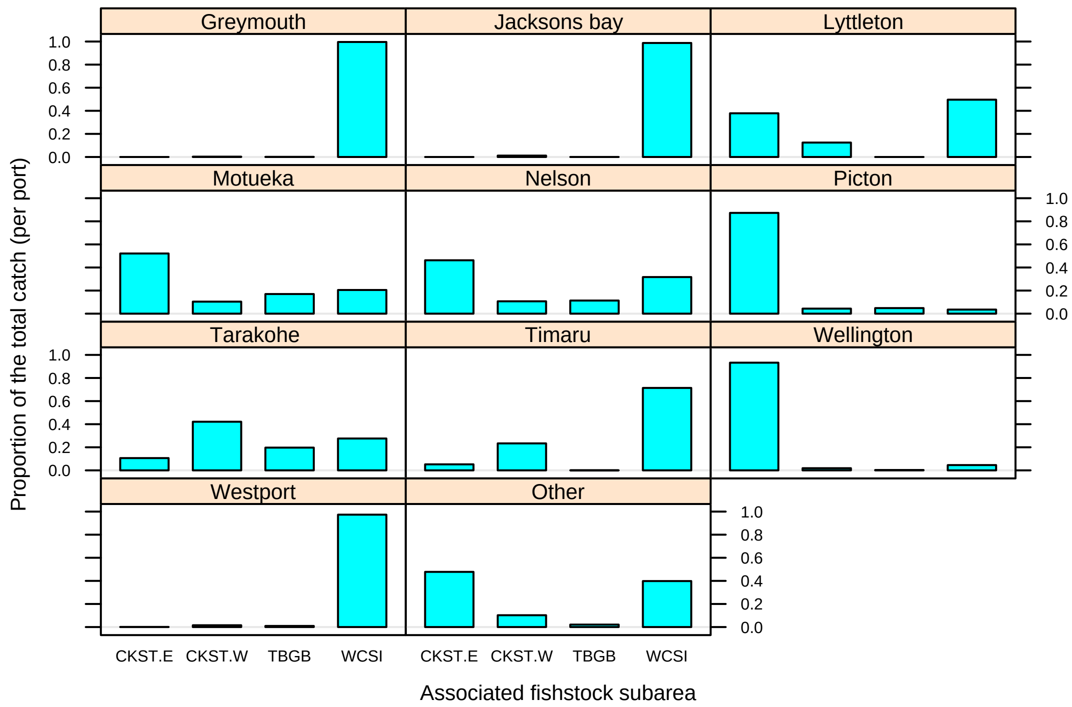


Figure 4: The distribution of the total catch for all fishing years in the merged catch-effort and landings dataset by port of landing and associated fishstock subarea. Catches are plotted as proportions of the total catch for each port.

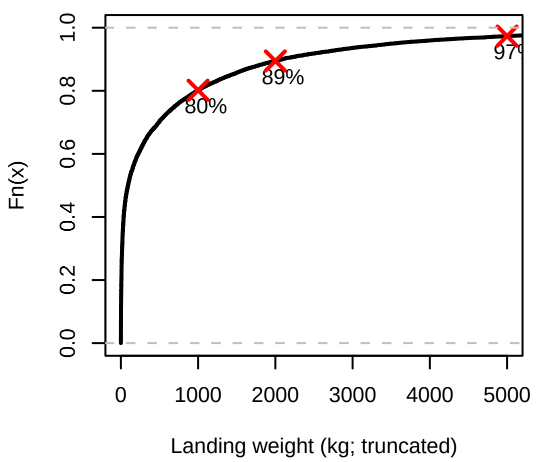


Figure 5: Empirical cumulative frequency distribution of greenweight (kg) for all reported landings of TAR 7 (groomed but unmerged) during the fishing years 1989–90 to 2003–04. Interpolated quantiles at 1000 kg, 2000 kg, and 5000 kg landing weights are noted. The *x*-axis is truncated at 5000 kg.

Table 2: Allocating sampling effort: (a) proportions of the total catch in the merged dataset by port (Greymouth, Jackson Bay, Nelson, Westport, and all other ports) and month of the fishing year; (b) proportions of the total catch in the merged dataset by port (Greymouth, Jackson Bay, Nelson, Westport only) and month of the fishing year; (c) allocated sampling effort (numbers of landings).

Catch by port (Greymouth, Jackson Bay, Nelson, Westport, and all other ports) and month:

	Months of the fishing year						
	Oct–Nov	Dec–Jan	Feb–Mar	Apr–May	Jun–Jul	Aug–Sep	Total
Greymouth	0.09	0.07	0.08	0.05	0.03	0.03	0.35
Jackson Bay	0.02	0.00	0.01	0.01	0.00	0.00	0.04
Nelson	0.07	0.06	0.05	0.04	0.02	0.02	0.26
Westport	0.01	0.01	0.01	0.00	0.00	0.00	0.03
Other	0.04	0.06	0.07	0.05	0.04	0.04	0.30
Total	0.24	0.20	0.21	0.16	0.10	0.09	1.00

Catch by port (Greymouth, Jackson Bay, Nelson, Westport only) and month:

	Months of the fishing year						
	Oct–Nov	Dec–Jan	Feb–Mar	Apr–May	Jun–Jul	Aug–Sep	Total
Greymouth	0.13	0.10	0.11	0.07	0.04	0.04	0.49
Jackson Bay	0.03	0.01	0.01	0.01	0.01	0.01	0.08
Nelson	0.10	0.09	0.08	0.06	0.03	0.03	0.39
Westport	0.02	0.01	0.01	0.00	0.01	0.01	0.06
Other	–	–	–	–	–	–	–
Total	0.27	0.20	0.20	0.15	0.09	0.08	1.00

Allocated sampling effort (numbers of landings):

	Months of the fishing year						
	Oct–Nov	Dec–Jan	Feb–Mar	Apr–May	Jun–Jul	Aug–Sep	Total
Greymouth	8	8	8	4	4	4	36
Jackson Bay	1	1	1	1	1	1	6
Nelson	4	3	2	1	1	1	12
Westport	1	1	1	1	1	1	6
Other	–	–	–	–	–	–	–
Total	14	13	12	7	7	7	60

2.3 March–April 2005 WCSI trawl survey by RV *Kaharoa*

2.3.1 Overview

The seventh in an ongoing (1992–) series of research trawl surveys of selected inshore benthic and demersal fish species on the west coast of the South Island was carried out aboard RV *Kaharoa* during March–April 2005 (voyage KAH0503). As with earlier surveys in the series, the design of the 2005 survey was optimised to monitor giant stargazer, red cod, red gurnard, and tarakihi abundance on the survey ground (Figure 6). The survey methods and results, including scaled length-frequency distributions and relative biomass estimates for each target and other associated species encountered during the survey, were presented by Stevenson (2006). An analysis of tarakihi age and growth

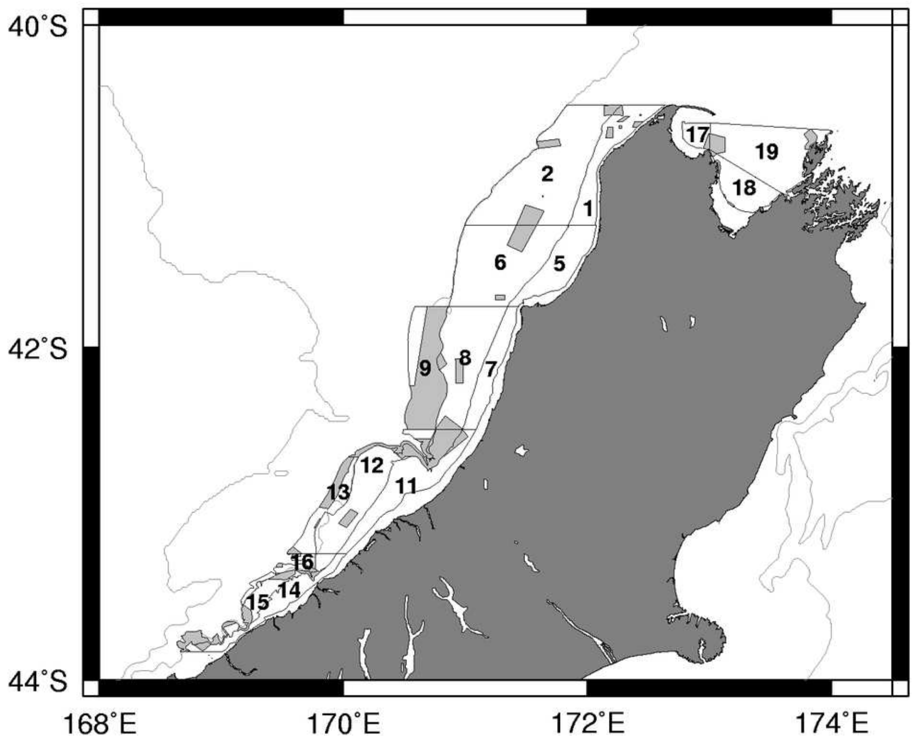


Figure 6: Survey strata used during the March–April 2005 trawl survey of the west coast of the South Island by RV *Kaharoa*. See Stevenson (2006) for a full description of survey methods and results.

derived from the 1995–2003 survey results was presented by Stevenson & Horn (2004). Tarakihi otoliths were not collected during either the 1992 or 1994 surveys (Table 3), and consequently survey proportions-at-age distributions cannot be estimated, although scaled length frequencies are available.

2.3.2 Treatment of Tasman and Golden Bays

Although all previous published analyses of the survey results (see the references cited in Table 3) have treated relative biomass estimates and scaled length-frequency distributions of fish caught in Tasman & Golden Bays separately from fish caught on the open west coast, Stevenson & Horn (2004) did not consider the age and growth of fish caught in Tasman and Golden Bays separately from fish caught on the rest of the survey ground. In this report, we calculate and present separate age-frequency distributions for fish in Tasman and Golden Bays and on the west coast to support the stock assessment. However, we are forced to assume and apply the same age-length key to the scaled length-frequency distributions from each area as the otoliths collected during the survey do not allow us to derive and apply separate age length keys for each area nor to test whether mean length-at-age differs between each area.

2.3.3 Otolith collection

A stratified, fixed-allocation sampling scheme (sensu Davies et al. 2003) was used to collect tarakihi sagittal otolith pairs from the catch during each of the 1995–2005 surveys. Up to five fish per sex per one centimetre size class were collected non-randomly from the random samples of fish selected for length measurements during each survey. Fish fork length, sex, and macroscopic gonad maturity were

Table 3: Numbers of tarakihi measured and numbers of otoliths collected during the WCSI trawl survey series, 1992–2005. TBGB, Tasman Bay–Golden Bay; WCSI, west coast; N_s, number of stations; N_f, number of fish measured; N_o, number of otoliths collected; N_r, number of otoliths prepared and read by Stevenson & Horn (2004) (surveys KAH9204–KAH0004). References documenting survey methods and results are provided.

Survey	Year	Area	N_s	N_f	N_o	N_r	Reference
KAH9204	1992	TBGB	16	486	–	–	Drummond & Stevenson (1995a)
		WCSI	102	3323	–	–	
		All	118	3809	–	–	
KAH9404	1994	TBGB	14	834	–	–	Drummond & Stevenson (1995b)
		WCSI	103	3890	–	–	
		All	117	4724	–	–	
KAH9504	1995	TBGB	16	1503	90	90	Drummond & Stevenson (1996)
		WCSI	87	3119	202	202	
		All	103	4622	292	292	
KAH9701	1997	TBGB	20	1117	46	46	Stevenson (1998)
		WCSI	68	1377	214	214	
		All	88	2494	260	260	
KAH0004	2000	TBGB	13	467	70	70	Stevenson (2002)
		WCSI	72	1656	206	206	
		All	85	2123	276	276	
KAH0304	2003	TBGB	10	187	44	44	Stevenson (2004)
		WCSI	76	1631	269	269	
		All	86	1818	313	313	
KAH0503	2005	TBGB	18	49	35	35	Stevenson (2006)
		WCSI	68	1822	226	226	
		All	86	1871	261	261	
All	1992–	TBGB	107	4643	285	285	The trawl survey series, except for the three
	2005	WCSI	576	16818	1117	1117	surveys KAH0004–KAH0503, was reviewed
		All	683	21461	1402	1402	by Stevenson & Hanchet (2000)

recorded for all fish from which otoliths were collected. Otoliths were cleaned and stored dry in paper envelopes immediately following collection. The numbers of tarakihi measured and otoliths collected and prepared and read during the WCSI series are given in Table 3. The aim of this sampling scheme is to ensure that sufficient numbers of otoliths are collected during each survey to populate the age-length keys needed to convert the scaled length-frequency distributions calculated from the length and catch data collected during each survey. However, length classes encountered and filled up early during each survey are not supplemented with otoliths collected from other areas during the voyage, potentially imposing some spatial bias on the otoliths collected, which may or may not be important. It at least prevents easily deriving and applying separate age-length keys and easily testing whether mean length-at-age differs between areas. The implications of this are discussed in more depth below (Section 4).

2.4 Otolith preparation and analysis

2.4.1 Overview

The same methods were used to prepare and read the tarakihi otoliths collected from the fishery and during the survey. Similar but not identical methods were used to analyse both sets of results. The terminology used follows the glossary for otolith studies by Kalish et al. (1995).

2.4.2 Otolith preparation and reading

All tarakihi otoliths collected during the market sampling programme and the trawl survey were retrieved from the Ministry of Fisheries otolith collection and all associated data were extracted from fisheries research database *age* (Mackay & George 2000). All associated market sampling data were extracted from database *market* (Fisher & Mackay 2000) and all associated trawl survey catch, station, and stratum definitions were extracted from research database *trawl* (Mackay 2000).

A random subsample of about 1000 otoliths was selected from the set of over 1860 sagittal otolith pairs sampled from the BT-MIX fishery. The sample inclusion probability for each otolith was weighted to be roughly proportional to the landing weight. A minimum of 10 otoliths was selected from each sampled landing. All otoliths collected during the trawl survey were selected for preparation.

Otolith preparation and reading methods followed those of Stevenson & Horn (2004). These have been partially validated (see the discussion in Stevenson & Horn (2004) and in Section 4 below). The right otolith from each pair of selected otoliths was used. Where the right otolith had not been collected or was damaged, the left was used. Otoliths from fish 25 cm or more in fork length were first baked in a ConTherm Series 5 scientific oven at 285 °C for 5 minutes until amber coloured. The baked otoliths were then embedded in layers in Araldite K142 clear epoxy resin. Once the resin blocks had cured, the embedded otoliths were sectioned transversely along the nuclear plane using a Struers Accutom-2 precision wafering saw turning a single Extec 12205 diamond-edged blade (blade thickness 0.3 mm). The cut surfaces of the resin blocks were then polished using Struers P1200 carborundum paper. Otoliths from fish less than 25 cm in fork length were read whole. Stevenson & Horn (2004) found that otoliths from fish of this size or smaller were best read whole due to their small size and fragile nature and showed that the zone counts derived from these otoliths did not underestimate fish age.

The sectioned otoliths were read under reflected light using a Wild M400 binocular microscope at × 25 magnification. A higher power of × 40 magnification was occasionally used to resolve the outer zones of otoliths from older fish. A thin layer of paraffin oil was applied to the cut surfaces of each section to improve clarity. Readings were generally made along an axis from the nucleus out towards the ventral margin to a point usually adjacent to the sulcus, but sometimes also on the dorsal margin or extended along the dorsoventral axis. Sometimes readings were started near the sulcus, but finished in some other area of the section; counts in the two areas were linked by tracing a clear zone across the section. Whole otoliths were read immersed in water under reflected light using the same microscope at the same power. All otoliths (whole or sectioned) exhibited alternating light and dark regions under reflected light. Following Stevenson & Horn (2004), we assumed that these light and dark regions were opaque and translucent zones (respectively) and that a single light (opaque) and a single dark (translucent) zone corresponds to a single year's growth (annulus). The number of fully-formed translucent zones present, a five-point "readability" score, and a three-point "margin-state" score were recorded for each otolith read (Table 4). All prepared (sectioned or whole) otoliths were read once by one reader (M. L. Stevenson). The reader had no knowledge of fish length or sex at the time of reading. Translucent zone counts were converted to decimalised age estimates using a simple algorithm (see below). An otolith protocol set is not available for New Zealand tarakihi at this time.

Table 4: Readability and margin-state scores used in otolith readings.

Five-point readability score:

Score	Description
1	Otolith very easy to read; excellent contrast between translucent and opaque zones; ± 0 between subsequent translucent-zone counts of this otolith
2	Otolith easy to read; good contrast between translucent and opaque zones, but not as marked as in “1”; ± 1 between subsequent translucent-zone counts of this otolith
3	Otolith readable; less contrast between translucent and opaque zones than in “2”, but alternating zones still apparent; ± 2 between subsequent translucent zone counts of this otolith
4	Otolith readable with difficulty; poor contrast between translucent and opaque zones, deemed to be worse than in either “2” or “3”; ± 3 or more between subsequent counts of this otolith
5	Otolith unreadable

Three-point margin state score:

Score	Description
Narrow	Last translucent zone present deemed to be fully formed; a very thin, hairline layer of opaque material is present outside the last translucent zone
Medium	Last translucent zone present deemed to be fully formed; a thicker layer of opaque material, not very thin or hairline in width, is present outside the last translucent zone; some new translucent material may be present outside the thicker layer of opaque material, but generally does not span the entire margin of the otolith
Wide	Last translucent zone present deemed not to be fully formed; a thick layer of opaque material is laid down on top of the last fully formed opaque zone, with new translucent material present outside the opaque layer, spanning the entire margin of the otolith

Otolith reading precision was quantified by carrying out within- and between-reader comparison tests after Campana et al. (1995). A subsample of 200 otoliths was randomly selected from the set of all otoliths prepared in this study. The subsampled otoliths were then re-read by the first reader and read by a second reader (P. L. Horn) and both sets of results compared with the first reader’s first set of results. The Index of Average Percentage Error, IAPE (Beamish & Fournier 1981), and mean coefficient of variation (mean c.v.) (Chang 1982), were calculated for each test. Where X_{ij} is the *i*th count of the *j*th otolith, R is the number of times each otolith is read, and N is the number of otoliths read or re-read.

$$\mathrm{IAPE} = 100 \times \frac{1}{N} \sum_{j=1}^{N} \left[\frac{1}{R} \sum_{i=1}^{R} \frac{\left| X_{ij} - X_j \right|}{X_j} \right], \tag{1}$$

and

$$\text{mean c.v.} = 100 \times \frac{1}{N} \sum_{j=1}^{N} \left[\frac{\sqrt{\sum_{i=1}^{R} \frac{\left(X_{ij} - X_j\right)^2}{R-1}}}{X_j} \right]. \tag{2}$$

2.4.3 Converting translucent-zone counts to age estimates

The following algorithm was used to convert translucent zone counts to decimalised age estimates. The algorithm involves treating estimated fish age, $\hat{a}$, as the sum of three time components, namely,

$$\hat{a}_i = t_{i,1} + t_{i,2} + t_{i,3}, \tag{3}$$

where $t_{i,1}$ is the elapsed time from spawning to the end of the first fully-formed translucent zone present in the otolith, $t_{i,2}$ is the elapsed time from the end of the first fully-formed translucent zone to the end of the outermost fully-formed translucent zone for the *i*th fish, $t_{i,3}$ is the elapsed time from the end of the outermost fully-formed translucent zone to the date when the *i*th fish was captured. Hence,

$$\begin{aligned} t_{i,1} &= t_{i,\text{ end first translucent zone}} - t_{i,\text{ spawning date}} \\ t_{i,2} &= (n_i + w) - 1 \qquad , \\ t_{i,3} &= t_{i,\text{ capture}} - t_{i,\text{ end last translucent zone}} \end{aligned} \tag{4}$$

where n_i is the total number of translucent zones present for fish *i*, and *w* is an edge interpretation correction after Francis et al. (1992) applied to n_i: $w = 1$ if the recorded margin state = “wide” *and* fish *i* was collected *after* the date when translucent zones are assumed to be fully formed, $w = -1$ if the recorded margin state = “narrow” *and* fish *i* was collected *before* the date when translucent zones are assumed to be fully formed, otherwise $w = 0$. Because the survey was run over March–April 2005, *w* always takes the value 0 or 1 in our study.

Because of our current inability to precisely estimate spawning and translucent zone completion dates for individual tarakihi, these dates were generalised for all fish. We followed Stevenson & Horn (2004) and assumed an arbitrary spawning date of 1 May for WCSI tarakihi, based on the annual reproductive cycle and winter spawning season of tarakihi supported by macroscopic gonad maturity data from the WCSI survey series, which suggest that WCSI tarakihi are very close to spawning in March–April, and assumed a date of 1 December for completion of all translucent zones. We used the matching trawl station start date as the capture date for each fish. Decimalised years were used for all time components. So, the estimated age for a fish captured on 1 April 2005 where a count of four completed translucent zones and a medium margin was made is $\hat{a} = t_1 + t_2 + t_3 = 0.58 + 3 + 0.33 = 3.91$ years.

2.4.4 Calculating scaled length- and age-frequency distributions using `Catchatage` (Bull & Dunn 2002)

Description

`Catchatage` is a package of `R` functions (R Development Core Team 2005) developed and maintained by NIWA (Bull & Dunn 2002). It computes biomass estimates and scaled length-frequency distributions by sex and by stratum for trawl survey and market-sampling data using the calculations in Bull & Gilbert (2001) and Francis (1989). If passed a set of length-at-age data, it can construct an age-length key, which can then be applied to scaled length-frequency distributions to compute scaled age-frequency distributions, also by sex and stratum. A "direct-age" subroutine also exists, where individual age observations are weighted up to stratum catch totals using specified length-at-age and weight-at-length relationships. The coefficients of variation (c.v.) for each length and age-class and the overall mean-weighted c.v. for each length and age-frequency distribution are computed using a bootstrapping routine (Efron & Tibshirani 1993): fish length (or age) records are resampled within each station (or sample), stations (or samples) are resampled within each stratum, and the length-at-age data used to construct an age-length key are simply resampled, all with replacement. The bootstrap length- and age-frequency distributions are computed from each resample and the c.v.s for each length- and age-class and mean-weighted c.v.s for each length and age distribution computed from the bootstrap distributions.

Analyses performed

`Catchatage` was used to calculate scaled length-frequency distributions for both the commercial trawl and survey catches. Scaled age-frequency distributions were calculated for the commercial catch using the direct-age routine and for the survey catch using an age-length key calculated from the survey length-at-age observations. Bootstrapped c.v.s and mean-weighted c.v.s were computed for each length and age class and length- and age-frequency distribution from 1000 iterations of the resampling algorithm. The weight-at-length relationships for both the commercial and survey length frequency calculations were parameterised using the results of a geometric mean regression of fish weight (in kilogrammes) on length (fork length in centimetres) for male, female, and all tarakihi measured during the KAH0503 voyage after the removal of obvious outliers (fish deemed to be anomalously light or heavy at length). The results of the von Bertalanffy mean length-at-age models fitted by Stevenson & Horn (2004) to the 1995–2003 survey otolith data were assumed in the direct age calculations for the commercial catch. The relationship parameters used are specified in Table 5. Only those catches and length-frequency records from valid biomass stations (i.e., where the recorded gear performance score was "2" or better (Stevenson 2006); see Mackay (2000) for definitions of the gear performance scores used by NIWA) were used in the survey length- and age-frequency calculations.

Table 5: Biological relationships for WCSI (TAR 7W) tarakihi used in the scaled length- and age-frequency distribution calculations in this study.

Relationship	Parameter	Male	Female	All fish	Source
Weight-at-length	a	1.412×10^{-5}	1.493×10^{-5}	1.432×10^{-5}	Stevenson (2006)
	b	3.070	3.058	3.068	
Length-at-age	$L_{\infty,s}$	43.2	46.1	–	Stevenson & Horn (2004)
	k_s	0.252	0.221	–	
	$t_{0,s}$	-0.55	-0.69	–	

Data matching

Catch-effort and landings data stored in the *warehou* database for the 2004–05 fishing year were matched to each sampled landing to allow sampling representativeness to be investigated. Landings were matched to particular *warehou* trip keys using the concatenation of vessel name and landing date.

3. RESULTS

3.1 A brief description of the TAR 7 fishery

Hanchet & Field (2001) evaluated of a series of alternative fishery-dependent (standardised catch-per-unit-effort) and independent (trawl survey) relative biomass indices as potential monitoring methods for the TAR 1–3 & 7 fishstocks. The standardised CPUE indices they discussed were presented in full by Field & Hanchet (2001) along with supporting fishery descriptions spanning the 1989–90 to 1998–99 fishing years. No updated description of the fishery has been published since their work. Here we present an updated but brief summary of the main features of the fishery as background to and to aid with interpreting the market sampling results that we present below. A full, detailed, fishery characterisation will be presented at the end of the market sampling programme at the end of the 2006–07 fishing year.

3.1.1 Historic trends

We constructed a catch-history for the TAR 7 and TAR 7(W) stock areas from the 1931–32 to 2004–05 fishing years using several published data sources. The derivation of the catch history is described in full in Appendix A. The derived catch history is plotted by stock subregion in Figure 7. The TBGB and WCSI catches over the 1986–87 to 2004–05 fishing years are plotted in Figure 8. The corresponding relative biomass indices from the RV *Kaharoa* survey series are overlaid for comparison. Catches by domestic and foreign vessels over the 1931–32 to 1988–89 fishing years are plotted separately in Figure 9.

Trends in the catch

Although the catch history is not without problems given the limitations of the different data sources that were used to derive it (see Appendix A), the TAR 7 (and TAR 7(W)) stock has clearly been subjected to a moderately long period of exploitation, although the intensity of this exploitation has varied considerably over time. Commercial exploitation appears alto have begun in the 1930s, but the catch was very light until the late 1960s, averaging only 28 t per annum from 1931–32 to 1965–66. The period from the late 1960s to the full implementation of the QMS at the start of the 1986–87 fishing year is marked by a dramatic increase in the catch, which averaged 891 t per annum. There is also considerable interannual variability. The period from 1986–87 to the end of the 2004–05 fishing year shows a gradual increase in the average annual catch to 904 t with apparently less interannual variability. The catch has generally approached but not exceeded the TACC since the full implementation of the QMS, although the TACC was exceeded during the 2000–01 and 2003–04 fishing years by 8% and 2%, respectively.

The relative importance of the four stock subregions

There also appears to have been considerable variation in the relative importance of the different stock subregions within the total catch. The period from 1966–67 to 1985–86 is marked by a very large amount of catch taken out of TBGB relative to the total catch during this period (during the 1966–67 and 1967–68 fishing years in particular). How accurate these catch data are is uncertain (see Appendix A), but the nominal TBGB catch declines towards the end of this period and is relatively unimportant thereafter, while the WCSI catch in particular begins to increase. Post 1986–87, the CKST.E and WCSI catch subregions dominate the catch. The CKST.E catch is, of course, outside the definition of the unit stock assumed in the market sampling programme and in the stock assessment (i.e., TAR 7(W)).

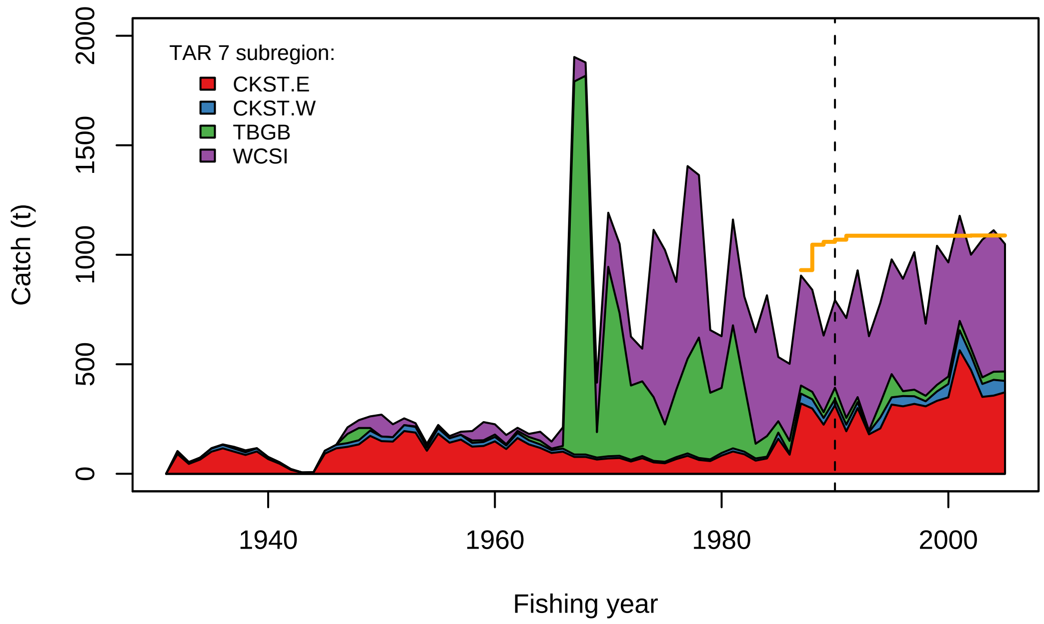


Figure 7: TAR 7 catch history (1931–32 to 2004–05) by stock subregion. TAR 7(W), the stock subregion assumed in the market sampling programme and in the quantitative stock assessment, is the union of the CKST.W, TBGB, and WCSI subregions. Derivation of the catch-history is described in full in Appendix A. The TAR 7 TACCs (1986–87 to 2004–05) are overlaid (thick solid line). The dashed line indicates the year from which modern catch-effort and landings data are available (1989–90 and beyond).

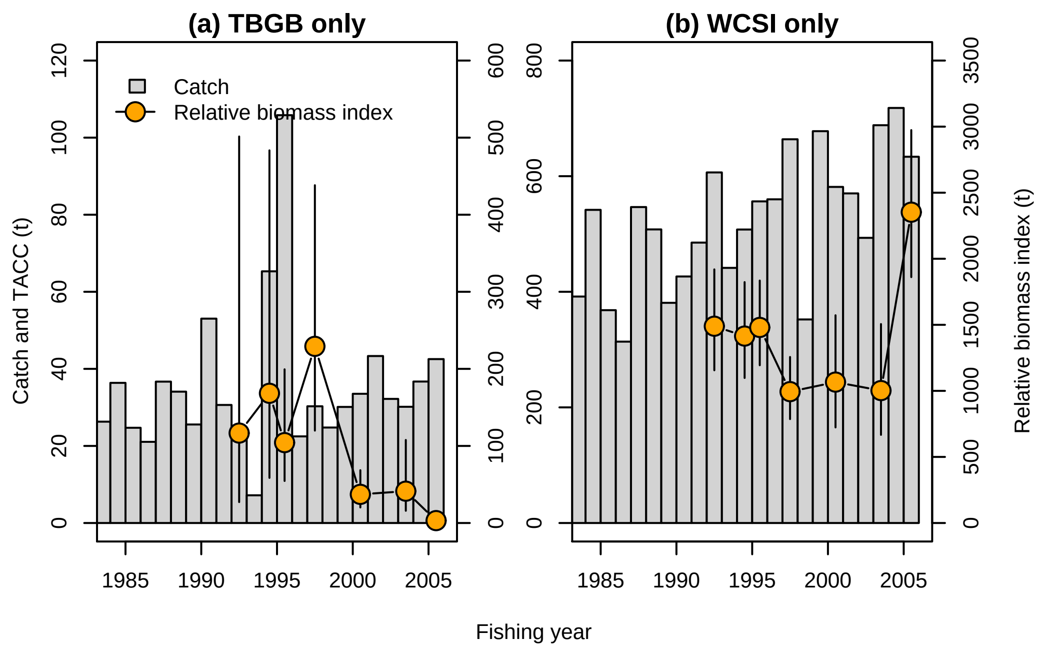


Figure 8: TAR 7(W) catches for the (a) TBGB subregion and (b) WCSI subregion with corresponding RV *Kaharoa* trawl survey relative biomass indices (1992–2005) overlaid. The error bars are 95% log-normal confidence intervals.

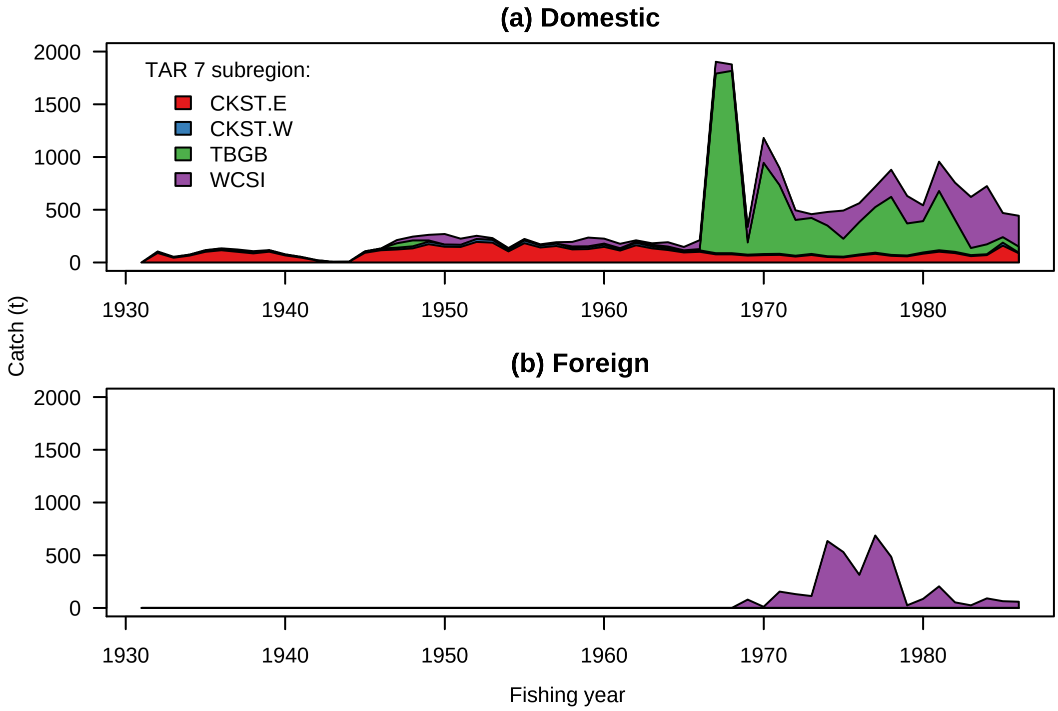


Figure 9: The TAR 7 catch history before the full implementation of the QMS (1931–32 to 1985–86) by fishing year, stock subregion (CKST.E, CKST.W, TBGB, or WCSI), and fleet sector (domestic or foreign).

Historic patterns in fishing methods

Historically, the TAR 7 fishery was overwhelmingly a trawl fishery. Although data that relate catches to fishing method and other effort variables (e.g., area) on a vessel by vessel or smaller scale are unavailable before the establishment of the New Zealand Fisheries Statistics Unit (FSU) in 1982, Vooren (1974) found that 67–100% of the total New Zealand domestic tarakihi catch over the 1936 to 1969 calendar yeas was caught by (steam or motor) trawlers. Post FSU, King et al. (1987) reported that 81% of the total domestic catch in 1983–84 was caught by "single trawl" (presumably bottom trawl) vessels compared with 83% in 1982–83 (King 1985). The method totals given by Vooren (1974) and by King (1985, 1986) and King et al. (1987) can be applied to the TAR 7 and TAR 7(W) stock areas only with some difficulty due to differences in reporting areas and the definition of the fishing year between now and then, but it seems reasonable to assume that a similar proportion of the catch in these stock areas was taken by (single, bottom) trawl vessels during this period. Finally, given the composition of the foreign fleet in New Zealand waters in the 1960s and 1970s (i.e., of mostly Japanese, Korean, and Soviet vessels), it seems very likely that the foreign tarakihi catch during this time was caught almost exclusively by trawl vessels.

3.1.2 Recent trends

The groomed and merged landed catch over the 1989–90 to 2004–05 years is plotted by month and fishing year, by statistical area and fishing year, by fishing method and fishing year, and by target species and fishing year in Figure 10. The relative importance of selected target species in each of the four subregions in the groomed and merged dataset is plotted in Figure 11. The catch is plotted by fishing year conditioning on fishing method, target species, subregion, and form type in Figure 12, and

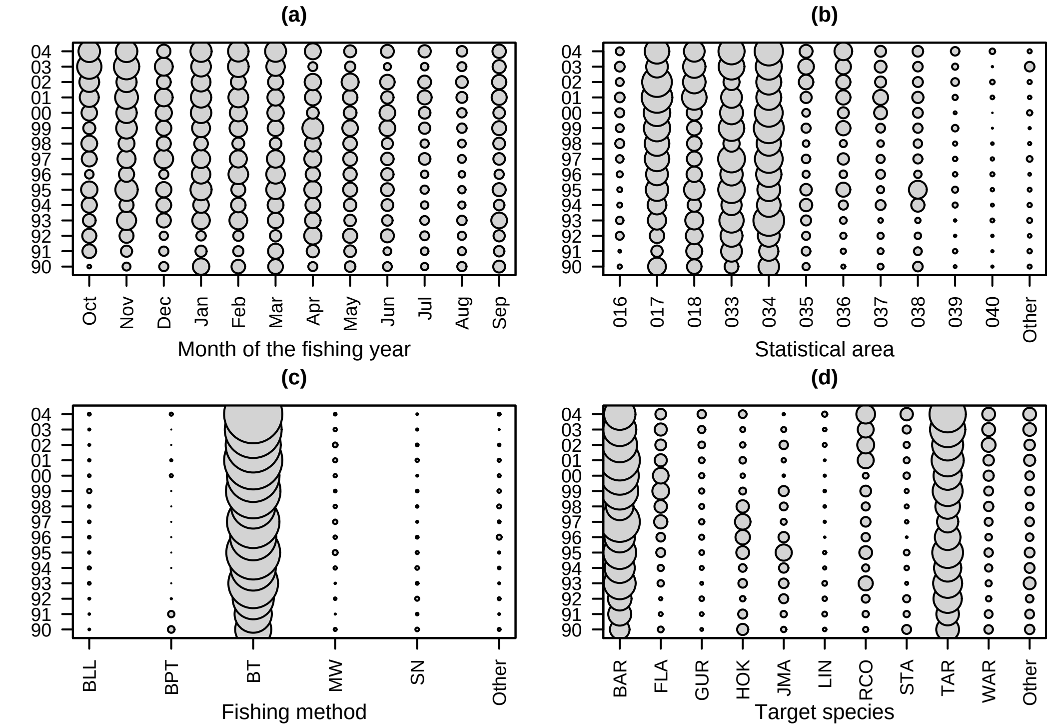


Figure 10: The groomed and merged TAR 7 catch by: (a) month and fishing year; (b) statistical area and fishing year; (c) method and fishing year; and (d) target species and fishing year. Circle areas are proportional to the amount of catch in each factor level and fishing year combination. The area of a circle 0.5 cm in diameter is 500 t.

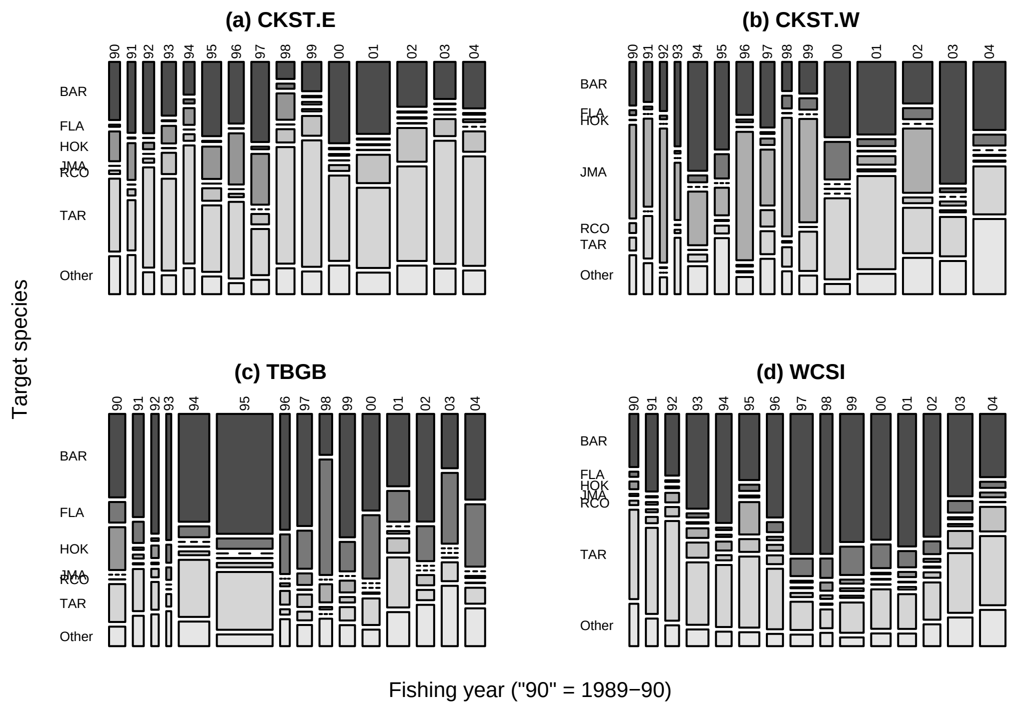


Figure 11: Mosaic plot of the relative importance of the tarakihi catch by selected target species in each of the four stock subregions by fishing year in the groomed and merged dataset. The sides of the mosaic polygons are proportional to the amount of landed catch by each target species-fishing year level in each area.

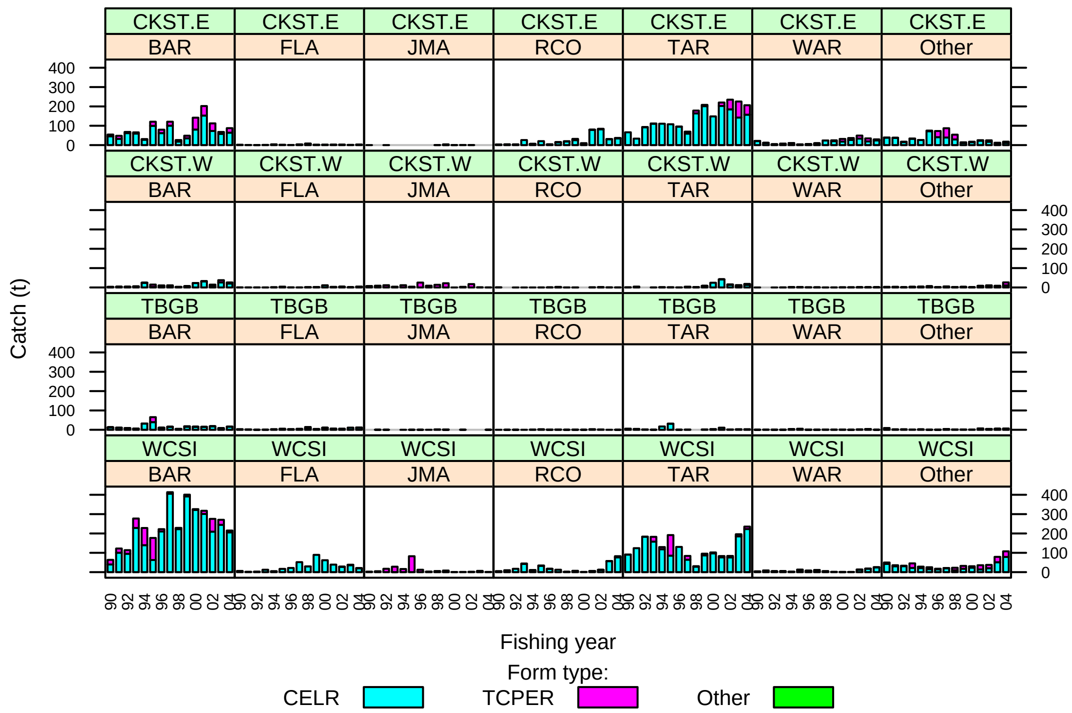


Figure 12: The groomed and merged TAR 7 catch by fishing year (1989–90 to 2003–04), target species (BAR, barracouta; FLA, flatfishes; HOK, hoki; RCO, red cod; TAR, tarakihi; all other target species), tarakihi), stock subregion (CKST.E, CKST.W, TBGB, and WCSI; defined in Section 2.2), and catch-effort and landings reporting form type (CELR, TCEPR, all other form types).

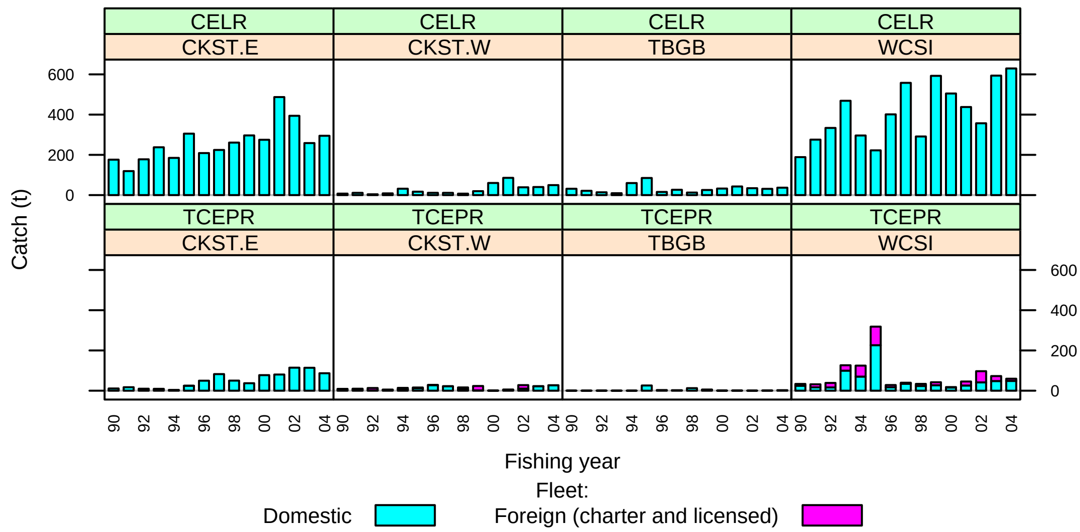


Figure 13: The groomed and merged TAR 7 catch by fishing year (1989–90 to 2003–04), fleet sector (domestic or foreign charter and licensed vessels), stock subregion (CKST.E, CKST.W, TBGB, and WCSI; defined in Section 2.2), and catch-effort and landings reporting form type (CELR, TCEPR).

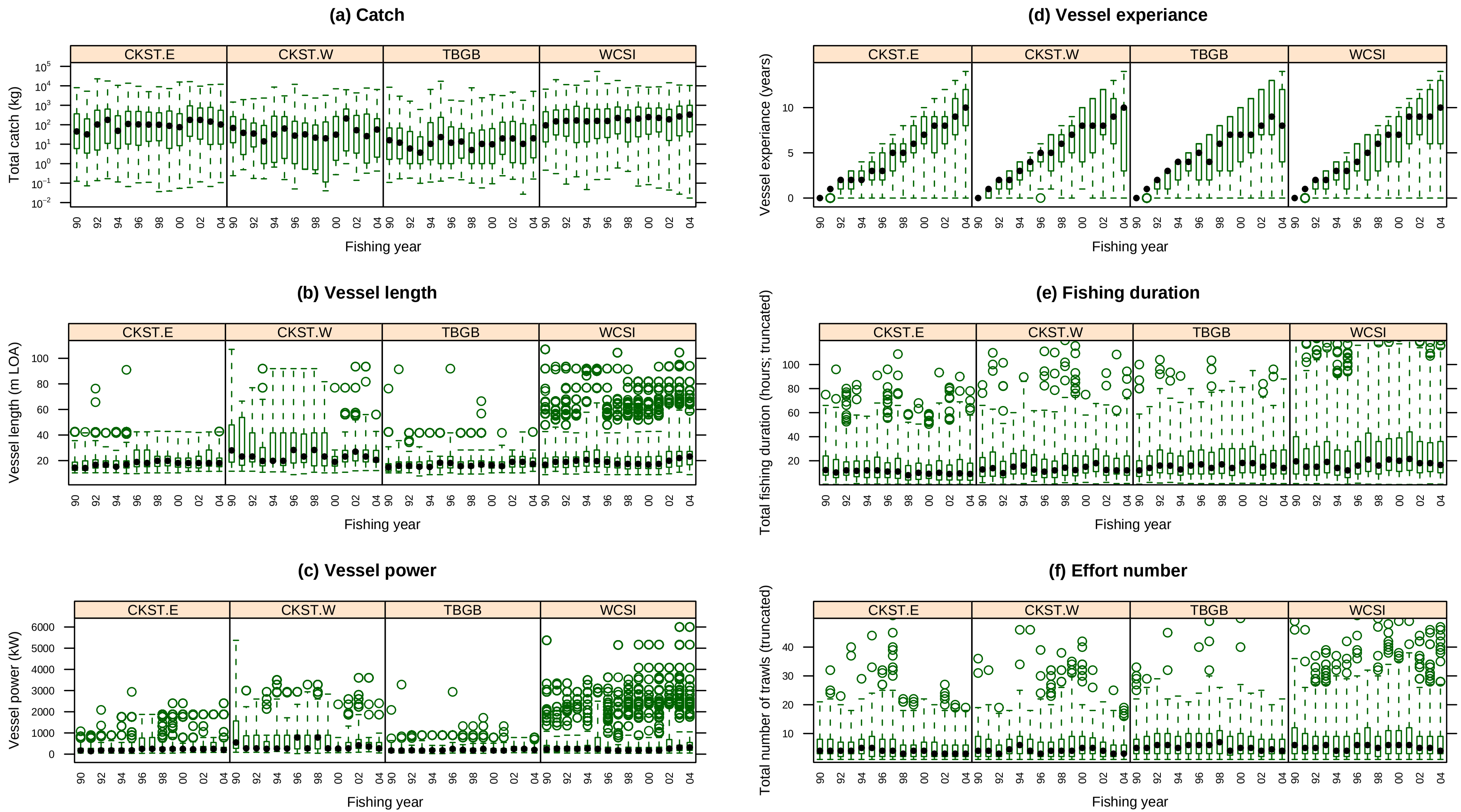
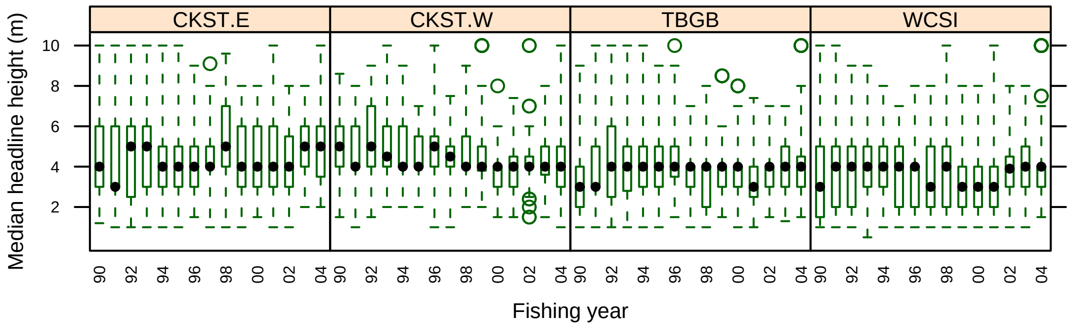


Figure 14: Box and whisker plots selected of catch and effort variables for bottom-trawl effort strata in the groomed and merged dataset by stock subregion and fishing year: (a) total catch; (b) associated vessel length; (c) associated vessel power; (d) associated vessel experience; (e) total fishing duration; (f) total number of trawls; (g) median effort (headline) height; and (h) median effort width (wingspread) per effort stratum. Box hinges are drawn at the first and third quantile of each distribution. The whiskers extend three times the interquartile range above and below the first and quantiles. Nominal outlier values are plotted singly. Note that a log *y*-axis is used on panel (a) and panels (e) and (f) are truncated.

(g) Effort height



(h) Effort width

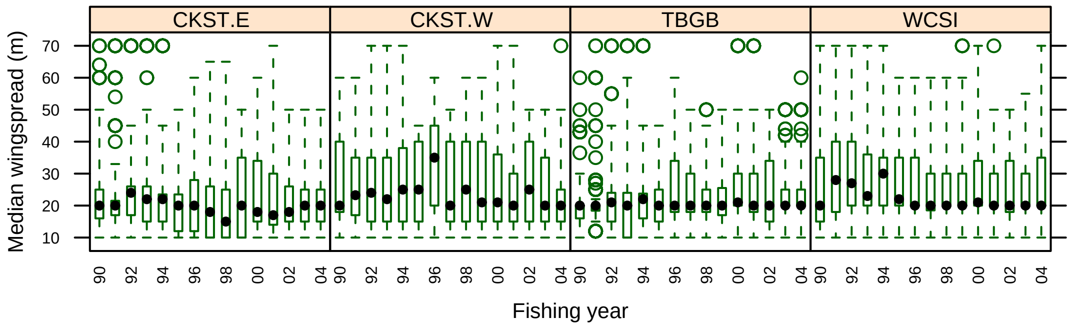


Figure 14: (continued).

by fishing year conditioning on vessel registration type (domestic or foreign chartered or licensed), subregion, and form type in Figure 13. These figures complement the plots of the groomed and merged catch by month conditioning on year and fishing method in Figure 2 and by fishing year conditioning on landing location (port) and fishing method in Figure 3. Cross-tabulations of the catch by fishing year and other covariates are provided in Appendix B. Box and whisker plots of selected catch and effort variables (catch, CPUE, selected fishing parameters, selected vessel attributes, etc.) are plotted by fishing year for bottom trawl effort strata in each of the TAR 7 subregions in the groomed and merged dataset in Figure 14. Several features are immediately apparent.

The fishery remains overwhelmingly a bottom trawl fishery

Bottom trawling continues to account for most of the catch, 98% of the total catch over the 1989–90 to 2004–05 fishing years, varying between 94% and 99% in any given fishing year. Small (i.e., less than 28 m in overall length) bottom-trawl vessels completing Catch-Effort Landing Returns (CELRs) and fishing in both eastern Cook Strait (CKST.E) and on the open west coast of the South Island (WCSI) account for the largest proportion of the catch by any sector of the fishery.

Most of the trawl catch is associated with small, domestic vessels

Trawl vessels catching tarakihi in the TAR 7 stock area tend to be relatively small (i.e., less than 28 m in overall length as suggested by the amount of catch associated with trawl fishing and reported on CELRs). In all subregions but CKST.W, the median vessel size is about 20 m or less in overall length, with few effort strata associated with vessels longer than about 43 m. This is not too surprising, as vessels longer than 43 m have been excluded from fishing within the New Zealand territorial sea (i.e., the area within 12 nautical miles of the mean low water mark) since the early 1980s, effectively excluding them from the greater part of the CKST.E and TBGB subregions. There is a minimal amount of tarakihi catch associated with vessels larger than 43 m in the CKST.W and WCSI subregions. These are typically large, foreign-registered vessels chartered by New Zealand quota owners and targeting barracouta and trachurid mackerels, but their overall importance in the catch is low, compared with the catch associated with small domestic trawl vessels. Small numbers of "new" vessels with no experience in the fishery (that is, vessels that have no previous associated effort) have continued to enter the fishery in all subregions throughout the data series.

The catch by other fishing methods in areas other than CKST.E and WCSI is minor

Contributions by other fishing methods (e.g., midwater trawling, bottom longlining, setnetting) in other areas (CKST.W, TBGB) and on other reporting form types are generally unimportant, although there is a small amount of catch (16%) by large (i.e., 28 m or more in overall length) trawl vessels completing Trawl Catch-Effort and Processing Returns (TCEPRs). There is no evidence of any temporal change in the relative importance of particular fishing methods over recent times in any of the stock subregions.

There is no evidence of a change in basic trawl fishing effort variables within the data

Basic trawl fishing effort variables appear reasonably static throughout the dataset. The total number of trawls in each effort stratum (i.e., each unique combination of statistical area, fishing method, and target species per fishing trip within the dataset) is typically low and rarely exceeds 20 per stratum, corresponding to several days fishing, although some effort strata with many more associated trawls do exist in all subregions. Median trawl wing spread (effort width) per effort stratum is typically about 20 m, but there are modes at about 40 m in some subregions corresponding to fishing effort by large vessels. Median trawl headline height (effort height) per effort stratum is typically about 4 m. These quantities appear not to have shifted greatly in any direction throughout the time series, indicating, everything else being equal, that there has been no gross change in basic trawl fishing during the time series.

This is not to say that such change has not occurred, as there have been technological changes over the time series that are likely to have changed fishing behaviour that are not well recorded or are not recorded at all by the catch-effort reporting system. The three most obvious shortcomings of the present system are: (a) the failure of the system to capture the almost universal adoption of global positioning system (GPS) receivers and modern fishing sensors (e.g., net monitors, modern sonar, etc.) by both large and small fishing vessels in the New Zealand region by the mid 1990s at the level of individual fishing events; (b) despite the relatively widespread introduction of multi-rig trawls in certain New Zealand fisheries in the late 1990s, including by some coastal trawl vessels (N. Bagley, NIWA, pers. comm.), there is no fishing method code or system of codes to clearly identify vessels using such rigs and to more accurately describe their fishing behaviour within the reporting system; and (c) although fine-scale spatial data on individual fishing events are captured by certain reporting form types such as the TCEPR, such fine-scale space use data are unavailable for vessels that report on CELRs, which make up the vast bulk of this and other coastal fisheries. Effort creep has probably occurred but its magnitude is unknown.

Statistical areas 017–018 and 033–034 are the most important

Statistical areas 017 and 018 in eastern Cook Strait and 033 and 034 on the west coast of the South Island are by far the most important, accounting for 33% (017 & 018) and 45% (033 & 034) of the total catch across all fishing years. Catches in other statistical areas are much less important, although there are minor contributions from areas 016 (2%) and 035–038 (17%). As noted, fish caught in eastern Cook Strait may be part of another biological stock unit and are not included within the TAR 7(W) stock definition assumed in both the market sampling programme and in the stock assessment. Catches in the CKST.E subregion account for 35%, in CKST.W for 5%, in TBGB for 4%, and in WCSI for 56%, and in the TAR 7(W) stock region as a whole for 65% of the total TAR 7 catch. There is no evidence of a major shift in catch by area either at the subregion or statistical area level in recent years, although the relative importance of the WCSI may have increased since the 2002–03 fishing year. As most trawl vessels catching tarakihi complete CELRs, which do not capture fine-scale spatial data, we do not know whether there has been a finer scale (i.e., within statistical area) shift in catch in the fishery.

There is some seasonality in the catch

There is some evidence of seasonality in the catch, with a little less than two-thirds (64%) of the total catch caught between the six months from October to March over all fishing years in the dataset. Although there is some variance in the distribution of catch by month from one year to the next, with as little as 43% of the total annual catch being caught in the October–March season in the 1991–92 fishing year and as much as 83% in 2002–03, the overall trend seems fairly consistent across the dataset.

Although tarakihi is caught as both a target and bycatch species, it is probably more useful to think of it as a dominant part of an outer-shelf, mixed-species trawl fishery

Tarakihi is caught both as the result of target fishing and as a bycatch of fishing effort directed at other species in all of the stock subregions (CKST.E, CKST.W, TBGB, & WCSI). Of the nominated target species other than tarakihi for which there is an associated tarakihi catch, barracouta is by far the most important. Tarakihi catches where barracouta was the nominated target species accounted for 41% of the total catch in the dataset, with the target tarakihi catch accounting for about 32%. There are lesser contributions from tarakihi caught by fishing effort directed at several other target species, in particular red cod (5%), flatfishes (4%), hoki (4%), blue warehou (4%), jack mackerels (3%), giant stargazer (1%), and red gurnard (1%), in decreasing order of importance. The declining trend in the target tarakihi catch from about 30% of the total catch to about 15% over the 1989–90 to 1994–95 fishing years noted by Field & Hanchet (2001) seems to have been arrested. Although the target tarakihi catch accounts for a disproportionally high amount of catch given the amount of associated effort strata in the dataset, the extent to which target species truly aliases for different fishing behaviour associated with optimising fishing effort to catch different target species or whether it merely reflects reporting practices (e.g., fishers perhaps recording the most common species in a particular catch as their “target” species) is unknown. Based on trends in unstandardised CPUE, Field & Hanchet (2001) hypothesised that it was the latter. We agree, and while we do not deny that true directed fishing occurs to some degree in the TAR 7 stock region, given that the spatial and depth distributions of barracouta and tarakihi and most of the other species listed above overlap (see, for example, the data presented by Anderson et al. (1998) and Hurst et al. (2000), the classification of both barracouta and tarakihi and the other target species listed within an “outer-shelf species” assemblage on the east coast of the South Island by Beentjes et al. (2002), etc.), it seems more useful to think of fishers prosecuting a mixed-species trawl fishery on the continental shelf in eastern Cook Strait and on the west coast of the South Island, within which tarakihi are naturally abundant and often tend to be caught. We refer to this a the “BT-MIX” fishery elsewhere in this report.

3.2 Market sampling results

Forty-seven landings were sampled and 1860 sagittal otolith pairs were collected from the BT-MIX fishery during the 2004–05 fishing year. Allocated and achieved sampling effort in the fishery are summarised in Table 6 and compared with the catch in Table 7. The numbers of fish measured and otoliths collected from the fishery are compared with those collected during the survey in Table 8. Of the 1860 otolith pairs collected from the fishery, 1031 were randomly selected for later preparation and analysis. As discussed, inclusion probabilities for individual otolith pairs in the preparation subsample were weighted by the corresponding total reported landed catch for each sampled landing. Although fewer landings were sampled than was planned, sampling effort is thought to be roughly proportional to the allocated sampling effort and, more importantly, is thought to be representative of the BT-MIX fishery in the TAR 7(W) stock area.

Comparisons of fishing and sampling effort are provided in Figures 15 and 16 and Table 8. Sampling extended throughout all 12 months of the fishing year and is roughly proportional to the total fleet catch in any given month (Figure 15). The sampled catch accounts for 15% by weight and 8% by number of landings by the BT-MIX fleet in the TAR 7(W) stock area over the entire fishing year (Table 7). The estimated tarakihi catch and numbers of trawls by the sampled vessels and the BT-MIX fleet are compared by statistical area and target species in Figure 16. Although there is some over- and under-representation of these variables in certain statistical areas and target species by the sampled vessels relative to the fleet as a whole, overall they are broadly comparable. And although the target of 60 landings was not met, the comparability of the estimated catch and trawl effort distributions by these factors, and the temporal extent and rough proportionality of the sampled catch to the BT-MIX fleet catch as a whole, suggest that the sampled landings are representative of the BT-MIX fishery in the TAR 7(W) stock area during the sampling period.

Although sampling staff were instructed to sample only landings from vessels that they were sure had not fished in the CKST.E subregion, after matching up the associated catch-effort and landings data to the corresponding market-sampling data for each sampled landing (exact matches were found between the two datasets for 41 of the 47 sampled landings; the remaining 6 landings needed to be matched by hand, and of these, all mismatches were due to "out-by-one" errors in the landing date recorded in either the *market* or *warehou* data), several vessels were found to have fished in CKST.E (fishing effort and estimated catch is summarised by subregion for each sampled landing in Appendix C). The sampling staff relied on information provided by the Licensed Fish Receivers (LFRs) receiving the catch at the point of sampling to identify where particular vessels had fished. Misidentification of vessels that had fished in CKST.E is thought to be due to miscommunication between the fisher and LFR or between the LFR and sampling staff.

Rather than discarding these data, landings were assigned to one of three separate analytical strata for the following scaled length and age frequency calculations based on where they had spent most (i.e., more than half) of their fishing effort (hours fished) in each sampled trip (CKST.E = 3 landings, CKST.W = 1 landing; TBGB = 7 landings; and WCSI = 36 landings). The one trip that had fished mostly in CKST.W was lumped with those that had fished mostly in WCSI, as retaining a separate CKST.W stratum based on 1 landing was thought to be a bad idea, vessels that fished mostly on the WCSI typically also reported a small amount of trawl effort and estimated tarakihi catch from CKST.W, and the union of CKST.W and WCSI subregions approximates the WCSI survey ground. All three landings of fish caught in CKST.E that were inadvertently sampled were received by LFRs in Nelson (Table 9).

Table 6: Allocated and achieved sampling effort and the total numbers of fish sampled in the coastal BT-MIX fishery in the TAR 7(W) stock area during the 2004–05 fishing year.

		Months of the fishing year						
		Oct–Nov	Dec–Jan	Feb–Mar	Apr–May	Jun–Jul	Aug–Sep	Total
Allocated effort (no. landings)	Greymouth	8	8	8	4	4	4	36
	Jackson Bay	1	1	1	1	1	1	6
	Nelson	4	3	2	1	1	1	12
	Westport	1	1	1	1	1	1	6
	Total	14	13	12	7	7	7	60
Achieved effort (no. landings)	Greymouth	3	3	5	2	5	7	25
	Jackson Bay	–	–	–	–	–	–	–
	Nelson	3	5	4	4	1	4	21
	Westport	1	–	–	–	–	–	1
	Total	7	8	9	6	6	11	47
Numbers of fish sampled	Greymouth	150	120	220	70	198	170	928
	Jackson Bay	–	–	–	–	–	–	–
	Nelson	121	231	161	180	23	166	882
	Westport	50	–	–	–	–	–	50
	Total	321	351	381	250	221	336	1860

3.3 Otolith readings

One otolith from each pair in the fishery subsample and one otolith from 260 of the 261 pairs collected during the 2005 WCSI survey was prepared and read (a total of 1290 otoliths). As in earlier studies (Tong & Vooren 1972, Vooren 1977, Annala et al. 1990, Stevenson & Horn 2004), alternating light (opaque) and dark (translucent) regions were visible in all of the prepared otolith sections and in the otoliths from small (less than 25 cm in fork length) fish that were viewed whole. Otoliths from 4 fish from the fishery sample and from 39 fish from the survey sample were read whole (43 fish in total). Translucent zone counts could be produced for all the prepared otoliths by the first reader (M.L. Stevenson). The age estimates derived from his zone counts ranged from 1.6 to 37.7 years in the fishery sample and from 0.9 to 31.9 years in the survey sample.

A simple random sample of 200 otoliths was selected from the set of 1290 prepared otoliths for the within and between-reader comparison tests. These otoliths were re-read by the first reader and read by a second reader familiar with tarakihi otoliths (P.L. Horn). Graphical comparisons of these results are given in Figure 17. The relative symmetry of the histograms in Figure 17(a), that the error bars in Figure 17(b) encompass the one-to-one line, and the relatively even distribution of plotted points about the zero line in Figure 17(c) all suggest that no gross systematic difference in interpretation exists either within- or between-readers, although there is a suggestion of some negative skewness in the between reader results, suggesting that the second reader's interpretation may be subtly different from the first reader's. Stevenson & Horn (2004) found no evidence of any between reader differences in interpretation in their results. The within-reader IAPE and mean c.v. were 1.79% and 2.52%, the between reader IAPE and mean c.v. were 4.57% and 6.46%. These results are somewhat worse than those of Stevenson & Horn (2004), who obtained a between reader IAPE and mean c.v. of 1.9% and 2.7%.

Table 7: Summary of fishing and sampling activity. The numbers of landings and reported greenweight catch (t) by all vessels that reported a TAR 7 landing during the 2004–05 fishing year ("All"), by all vessels in the BT-MIX fleet ("Fleet"), and by all sampled vessels ("Sampled") by month. P_{SF}, the sampled catch as a percentage of the fleet catch by numbers or weight.

		Landed catch (kg)				Number of landings			
Year	Month	All	Fleet	Sampled	P_{SF}	All	Fleet	Sampled	P_{SF}
2004	10	118 176	117 347	12 641	11	92	70	2	3
2004	11	105 024	103 058	25 326	25	99	72	7	10
2004	12	84 821	42 743	3 950	9	66	43	2	5
2005	1	104 196	72 834	11 903	16	86	54	4	7
2005	2	90 554	73 912	15 115	20	73	47	4	9
2005	3	116 761	74 707	10 355	14	85	47	5	11
2005	4	88 340	82 809	15 207	18	73	39	4	10
2005	5	72 034	51 089	9 124	18	68	46	2	4
2005	6	29 789	16 273	3 820	23	57	30	3	10
2005	7	38 112	34 340	3 237	9	75	38	4	11
2005	8	33 636	32 049	4 513	14	80	50	7	14
2005	9	174 220	173 859	18 602	11	109	77	3	4
	Total	1 055 661	875 021	133 791	15	963	613	47	8

Table 8: Numbers of landings sampled, numbers of fish measured, and numbers of otoliths collected from the BT-MIX fishery in TAR 7(W) during the 2004–05 fishing year. Numbers of fish measured and otoliths collected during the March–April 2005 research survey are provided for comparison.

	Origin	
	Market	Survey
Number of landings sampled	47	–
Number of fish measured	1860	1871
Number of otolith pairs collected	1860	261
Number of otoliths prepared and read	1031	260

Table 9: Cross tabulation of port of landing by subregion most fished for all landings sampled.

	Subregion most fished				
Port	CKST.E	CKST.W	TBGB	WCSI	Total
Greymouth	–	–	–	25	25
Jackson Bay	–	–	–	–	0
Nelson	3	1	5	12	21
Westport	–	–	–	1	1
Total	3	1	7	36	47

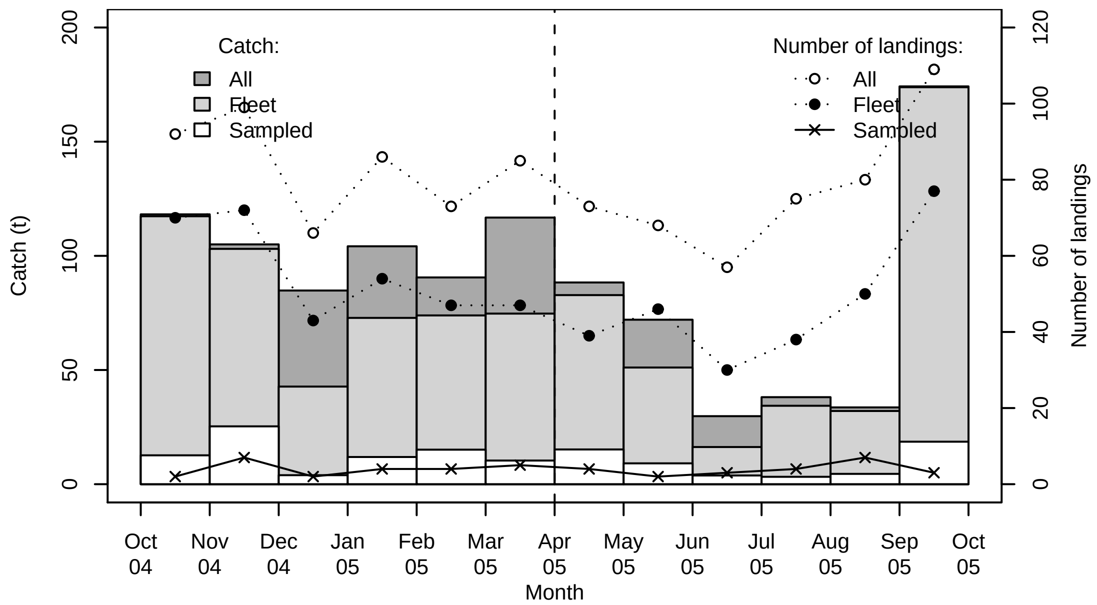


Figure 15: Summaries of fishing and sampling activity in TAR 7(W) during the 2004–05 fishing year. Histograms of the total landed catch (dark-grey bars) by all vessels, by all vessels in the BT-MIX fishery (light-grey bars), and by all sampled vessels (white bars) are overlaid. Numbers of landings by each fleet sector are also overlaid. The approximate date of the WCSI trawl survey (March–April = 1 April) is indicated by the dashed vertical line.

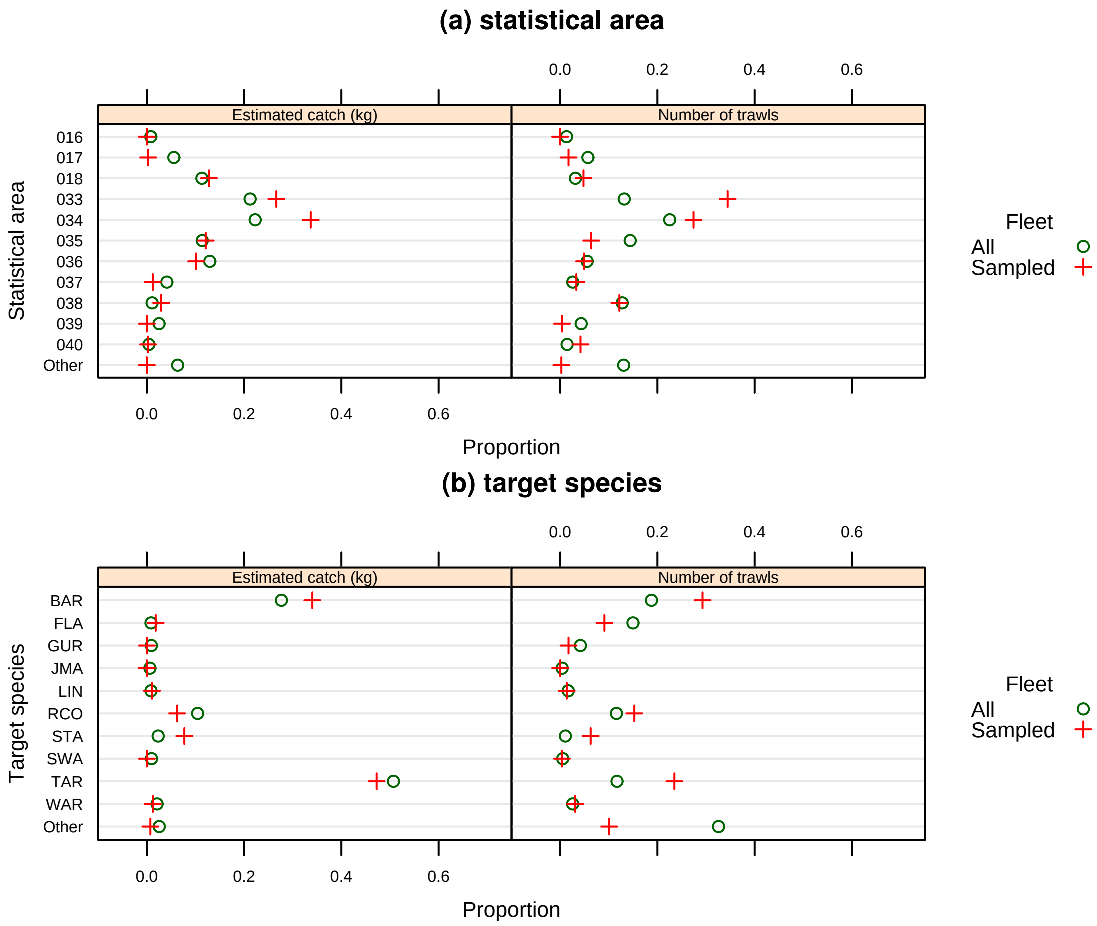


Figure 16: Comparing the sampled and fleet catch and effort by two covariates. Proportions of the estimated tarakihi catch and of the number of trawl shots by (a) statistical area and (b) target species for all vessels in the TAR 7(W) bottom-trawl fleet are compared with those for the sampled fleet.

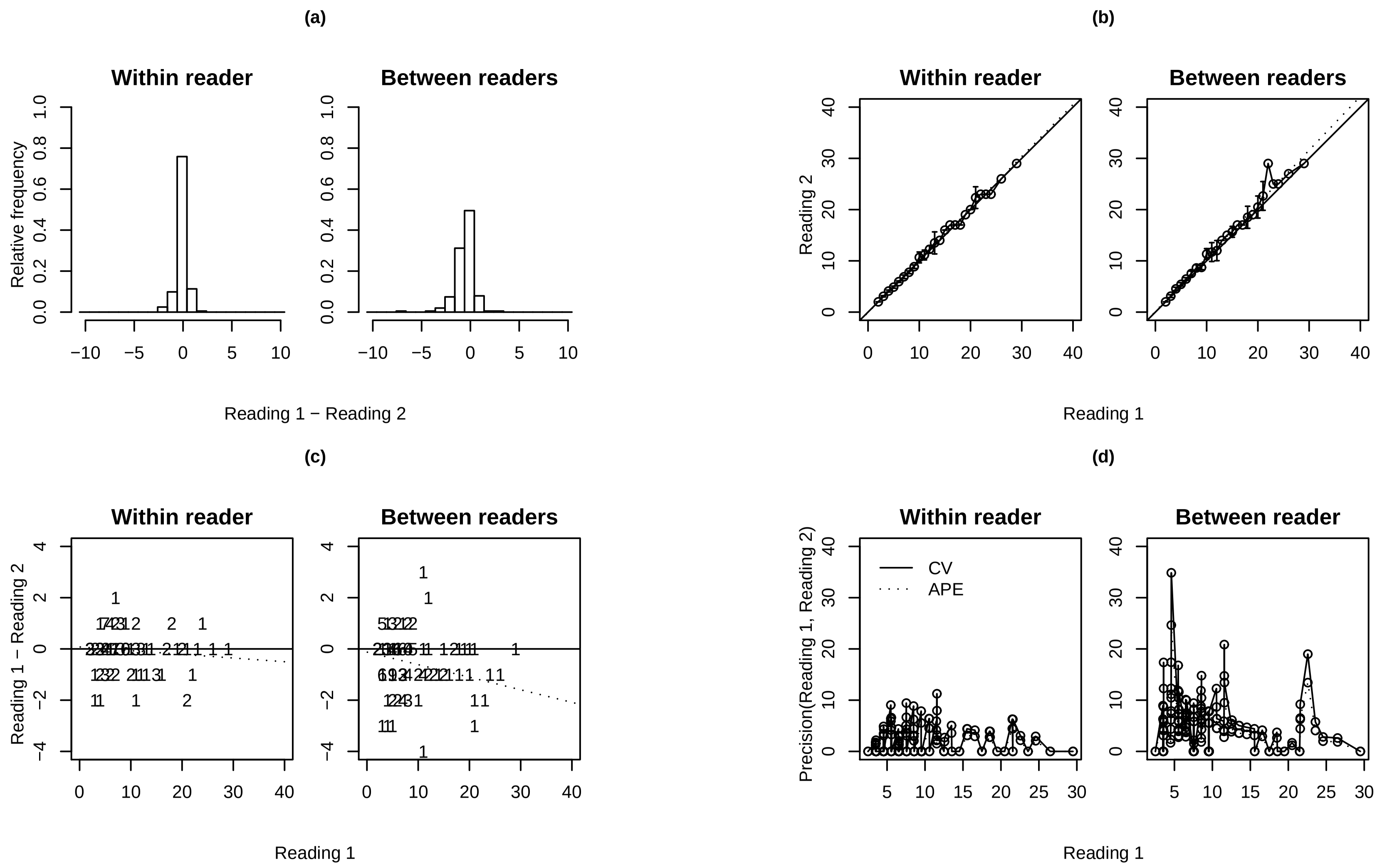


Figure 17: **Results of within- and between-reader comparison tests: (a) histogram of differences between the ages estimated during each reading of the same otolith; (b) differences between ages estimated during each reading relative to the result of the first reading; (c) bias plot; and (d) c.v. and APE profiles (precision) for a given age produced during the first reading. The expected 1:1 (solid line) and actual relationship (dashed line) between the ages estimated during the first and second readings of the same otolith are overlaid on (b) and (c). The numbers on (b) are the numbers of readings at each point. The error bars on (c) are 95% confidence intervals about the mean age produced during the second set of readings for a given age produced during the first set of readings.**

3.4 The length and age composition of the fishery and survey catch

Scaled length and age-frequency distributions were computed for the fishery and survey data using `Catchatage`. For the fishery, lengths and age estimates associated with the subsampled otolith pairs were first scaled to the greenweight catch for each landing and then to the total catch for each stratum in the analysis; i.e., (a) "CKST.E", (b) "TBGB", and (c) "CKST.W and WCSI". The total catch for each stratum was imputed by multiplying the total reported TAR 7 catch derived from monthly harvest return (MHR) data by MFish for the 2004–05 fishing year (1056 t; see Table 1) by the proportion of catch in each subregion in the groomed and merged TAR 7 catch-effort and landings dataset by bottom trawl vessels (bottom trawling = 94% of the total TAR 7 catch; bottom-trawl fishing in CKST.E = 39% , in TBGB = 7%, and in CKST.W & WCSI = 49% of the total catch). For the survey, lengths were scaled first to the catch from each station, and then using the area swept by the survey gear (the product of the corresponding trawl doorspread and tow distance at each station), to the area of each stratum in square kilometres. Data (catch, lengths) from valid biomass stations only were used in this analysis. The biomass estimates for all earlier surveys in the survey series were recomputed using the 2005 strata. The age estimates derived from the prepared and read survey otoliths were converted to a separate age-length key for each sex and applied to the corresponding length-frequency distributions to yield scaled age-frequency distributions.

The scaled length and age frequency distributions of the fishery catch are plotted separately by sex and by analytical stratum in Figure 18. The cumulative length and age frequency distributions of the fishery strata are compared in Figure 19. Mean-weighted c.v.s for the length and age distributions are tabulated by sex and stratum in Table 10. From these plots, we see that most fish in the BT-MIX fishery are between about 25 cm and about 45 cm or so in fork length. There are relatively few fish outside this size range in the catch, regardless of subregion. Median length lies between 32 and 37 cm fork length, depending on sex and subregion. The median sizes of fish in CKST.W & WCSI appear greater than for fish of the same sex in the two other subregions. There is no obvious polymodal structure in the length distributions in any of the three subregions in the analysis for either sex, although our knowledge of the length structure of the CKST.E and TBGB catches is poor, given the relatively few data that are available for these subregions compared with the WCSI. The c.v.s and mean-weighted c.v.s that were calculated from these data reflect this uncertainty. There appear to be no 0 year old fish and relatively few fish less than 3 years of age of either sex in any of the subregions. The median age of fish in CKST.E and in CKST.W & WCSI was 5 years, but was 4 years in TBGB. There also appear to be relatively few fish older than 10 years in the TBGB catch, while the age distribution tails are much longer in both CKST.E and in CKST.W & WCSI, with some fish older than 20 years present in the catch in the two latter subregions, although these are few in number; comparing the cumulative length and age distributions of the three subregions shows that the catch in TBGB contains more smaller, younger fish than either of the other two subregions. Over all the subregions, the single oldest fish observed was a 37 year old female with ripe (stage 3) gonads that measured 44 cm in fork length, caught in January 2005 on the west coast of the South Island in either statistical area 033 or 034.

The scaled length and age frequency distributions of the survey catch are plotted separately by sex but pooled across all survey strata in Figures 20 and 21, respectively. The length and age structure of the survey catch is markedly different from that of the fishery. There is more structure in the survey catch by length, with distinct modes centred at about 12–13 cm, at about 20–25 cm, and at about 35 cm in most surveys. The smaller modes correspond to distinct year classes. Stevenson & Horn (2004) found that over the 1995–2003 surveys, 0 year old fish were between 10–15 cm in fork length, 1 year olds were 15–24 cm, and 2 year olds ranged between 20 and 31 cm in fork length, matching the length modes well. The larger length mode centred at about 35 cm is composed of older fish from all other age classes present in the catch. Interestingly, in 2005, both of the smaller length modes at about 12 and at about 20 cm are absent from the catch. The survey age distributions are characterised by a single mode, peaking at about 2–3 years, with a long declining tail. Relatively large numbers of 0 and

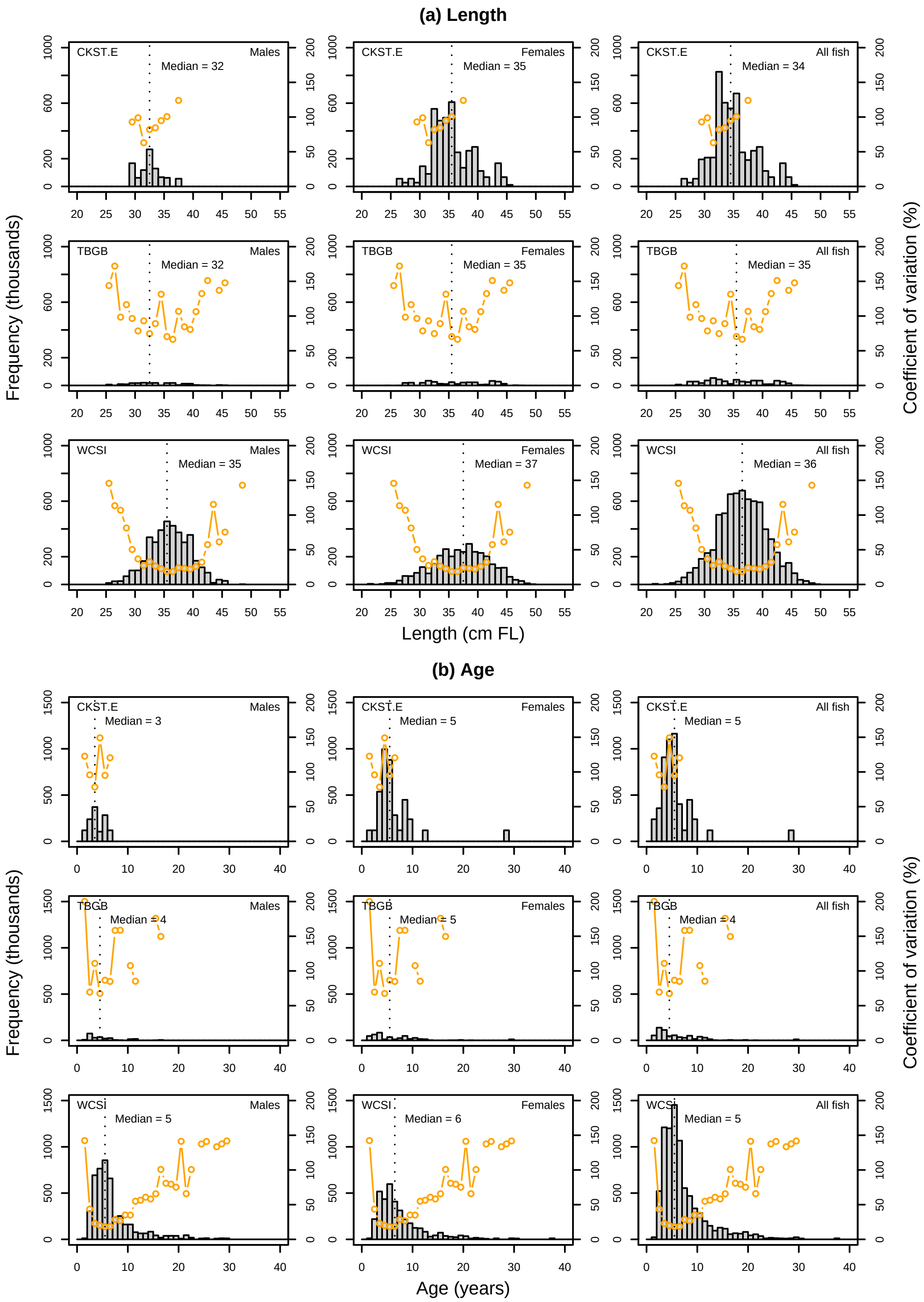


Figure 18: The (a) length and (b) age composition of the fishery catch during the 2004–05 fishing year. The length and age frequency distributions for males, females, and all fish are plotted separately for each stratum (CKST.E, TBGB, and WCSI) in the analysis. Boot-strapped coefficients of variation for each length and age class are overlaid (orange lines). Fish median lengths and ages (by sex and stratum) are noted on each panel.

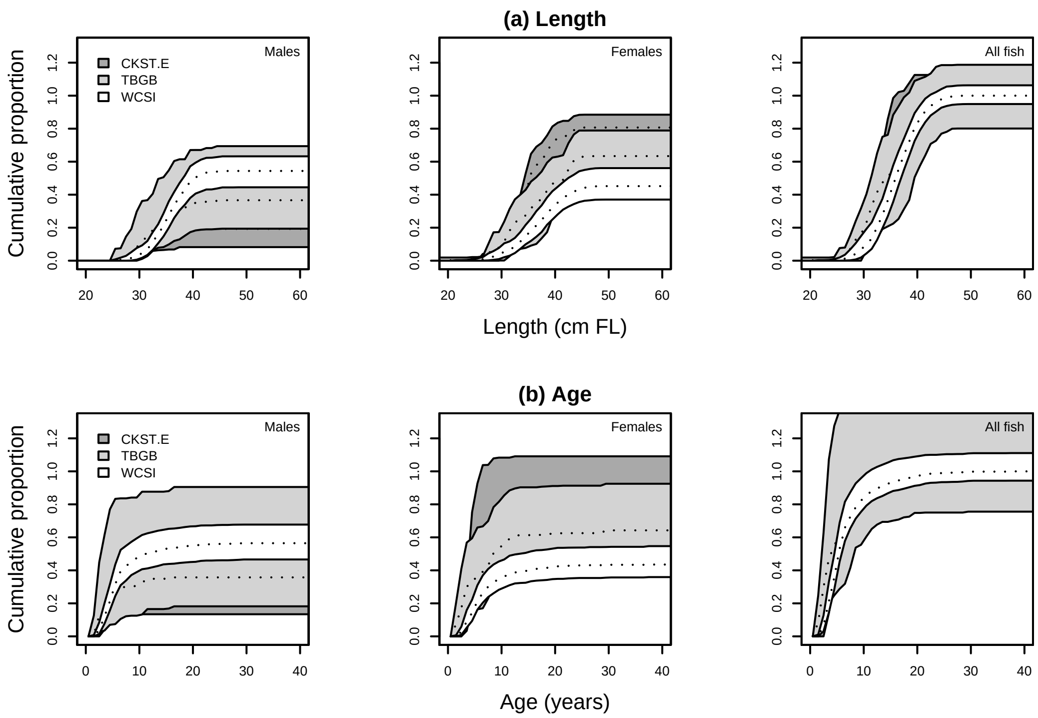


Figure 19: Cumulative proportions at (a) length and at (b) age by sex and stratum for the BT-MIX fishery. The dotted lines are the cumulative proportions-at-length or at age. The surrounding regions are bootstrapped 95 % confidence intervals about the cumulative proportion at length or at age. The proportions at length and at age for all fish in each stratum have been scaled to sum to one.

1 year old fish are present in all surveys but 2005, suggesting that the 2003 and 2004 year classes may be somewhat weak. The median ages of the 2003 and 2005 surveys (5 years) appear to be several years older than the median ages of the earlier surveys. The weak 2003 and 2004 year classes are obvious when the survey age distributions are plotted as year classes on the same panel (Figure 22).

The survey length and age distributions are plotted by survey subregion in Figures 23 and 24, respectively, where the TBGB subregion is the pool of survey strata 17–19 and WCSI is the pool of strata 1–2, 5–9, & 11–16. The trend noted in the fishery analysis for fish in the TBGB subregion to be smaller and younger than fish elsewhere is even more marked in the survey catch. When the survey length and age-frequency distributions for each stratum are aggregated by subregion, we see that the TBGB survey catch contains very few fish over 30 cm, and the WCSI survey catch typically contains very few fish under 25 cm across the survey series. Fish median lengths in the TBGB catch range between 19 and 22 cm fork length and range between 31 and 37 cm in fork length in the WCSI. The age distributions for each subregion suggest a similar picture, with very few fish older than 3–4 years typically present in the TBGB catch with a typical median age of 1 year, and with few 0–2 year old fish typically present in the WCSI catch. The median age of fish in the WCSI strata ranges between 3 and 7 years over the survey series. The differences in the size and age composition of the catch in each of the survey subregions is very obvious in the plots of the corresponding cumulative length and age frequency distributions (Figure 25). But as with the fishery, comparatively few data were collected from the TBGB subregion and these plots also illustrate the resulting imprecision in our estimates of the length and age of fish in the TBGB strata compared with those on the WCSI. Interestingly, as the survey series has progressed, the catch at length and at age in the TBGB survey region has all but disappeared, with a corresponding drop in the associated relative biomass indices (see Figure 8). Mean- weighted c.v.s for each survey stratum and region and pooled across all strata are also given in

Table 10: Mean-weighted coefficients of variation (%) for the length- and age-frequency distributions in the BT-MIX fishery and WCSI survey (KAH0503) catches during the 2004–05 fishing year by stratum and sex. Mean-weighted c.v.s for the TBGB (strata 17–19) and WCSI (strata 1–2, 5–9, & 11–16) survey regions are also provided.

			Sex			
Sector	Distribution	Stratum	Males	Females	Unsexed	All fish
Fishery	Length	CKST.E	86.2	48.2	–	46.5
		TBGB	89.5	74.3	–	60.2
		WCSI	28.5	31.7	139.9	22.2
		Pooled	32.2	29.9	139.9	22.8
	Age	CKST.E	99.3	63.7	–	57.6
		TBGB	87.3	75.2	–	63.5
		WCSI	30.8	33.9	–	23.3
		Pooled	37.3	40.0	–	28.9
Survey	Length	1	–	–	–	–
		2	62.7	50.1	–	49.4
		5	128.9	102.3	–	113.0
		6	86.8	66.5	–	69.8
		7	89.3	90.1	–	89.8
		8	84.8	56.4	–	56.5
		9	37.7	70.7	–	35.1
		11	105.8	98.1	–	93.8
		12	84.8	41.0	145.2	41.5
		13	66.9	78.4	–	61.1
		14	130.1	78.7	–	78.6
		15	87.2	61.6	–	57.1
		16	94.1	89.1	–	67.0
		17	88.0	94.3	111.2	85.1
		18	74.8	125.5	–	82.4
		19	120.3	102.6	–	97.6
		TBGB	85.4	103.2	91.0	86.3
		WCSI	40.4	31.3	140.6	29.8
		Pooled	40.9	31.6	136.3	30.1
	Age	1	–	–	–	–
		2	64.2	54.1	–	51.3
		5	111.9	112.1	–	89.0
		6	88.0	63.8	–	68.0
		7	136.9	114.1	–	85.6
		8	76.3	61.7	–	60.0
		9	58.3	77.2	–	50.9
		11	94.7	88.5	–	81.8
		12	60.6	47.6	–	44.2
		13	81.8	78.1	–	73.7
		14	183.7	91.7	–	91.1
		15	69.2	54.4	–	50.6
		16	84.7	93.5	–	68.0
		17	81.4	89.8	–	81.7
		18	69.4	173.2	–	64.4
		19	132.8	71.4	–	74.3
		TBGB	64.7	79.4	–	62.3
		WCSI	47.8	43.8	–	37.7
		Pooled	48.2	43.8	–	37.9

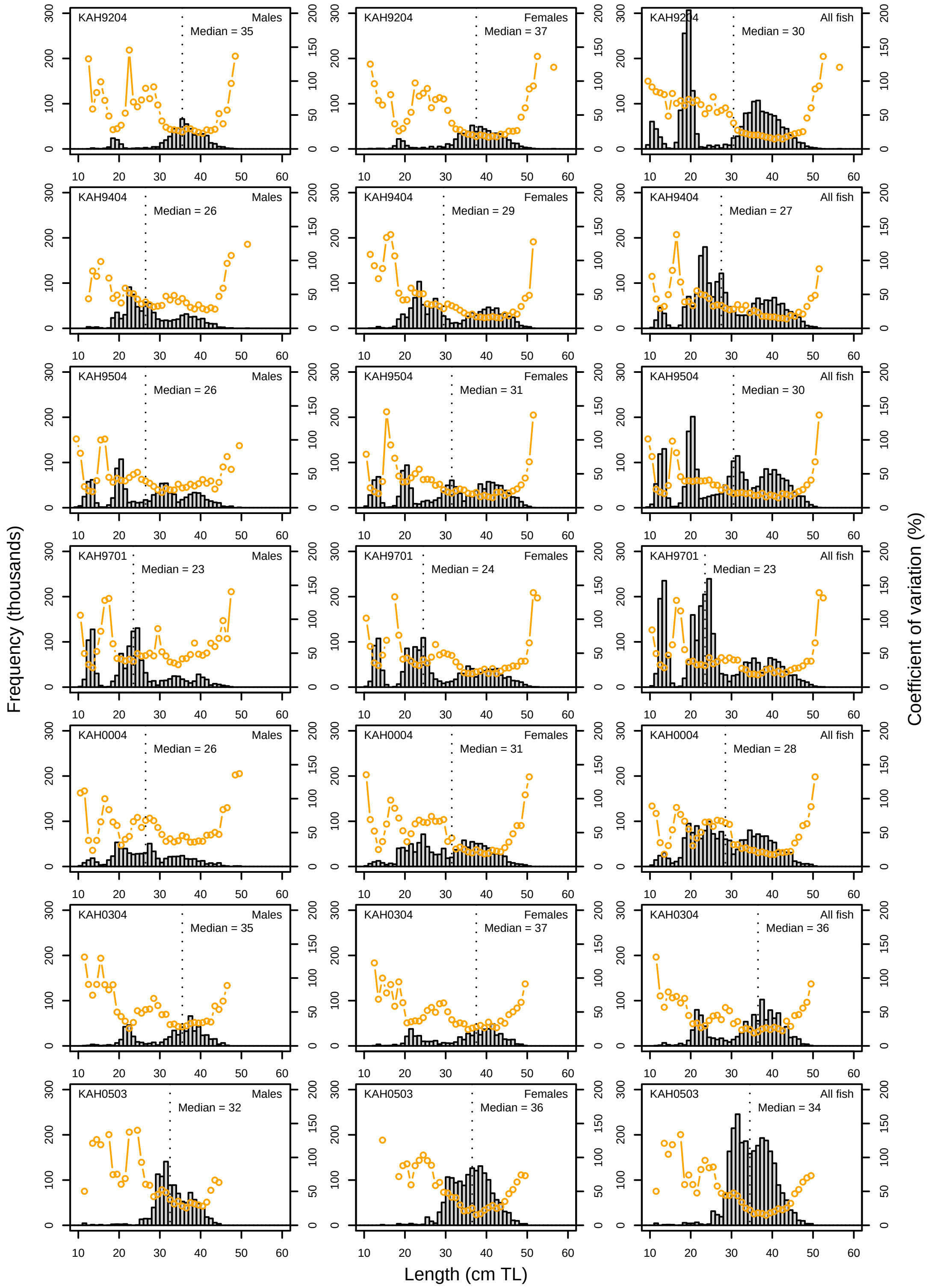


Figure 20: Length-frequency distributions for the WCSI survey series (1992–2005) by sex (males, females, and all fish) and survey pooled across all survey strata. Boot-strapped coefficients of variation for each length class are overlaid (orange lines). Fish median lengths (by sex and survey) are noted on each panel.

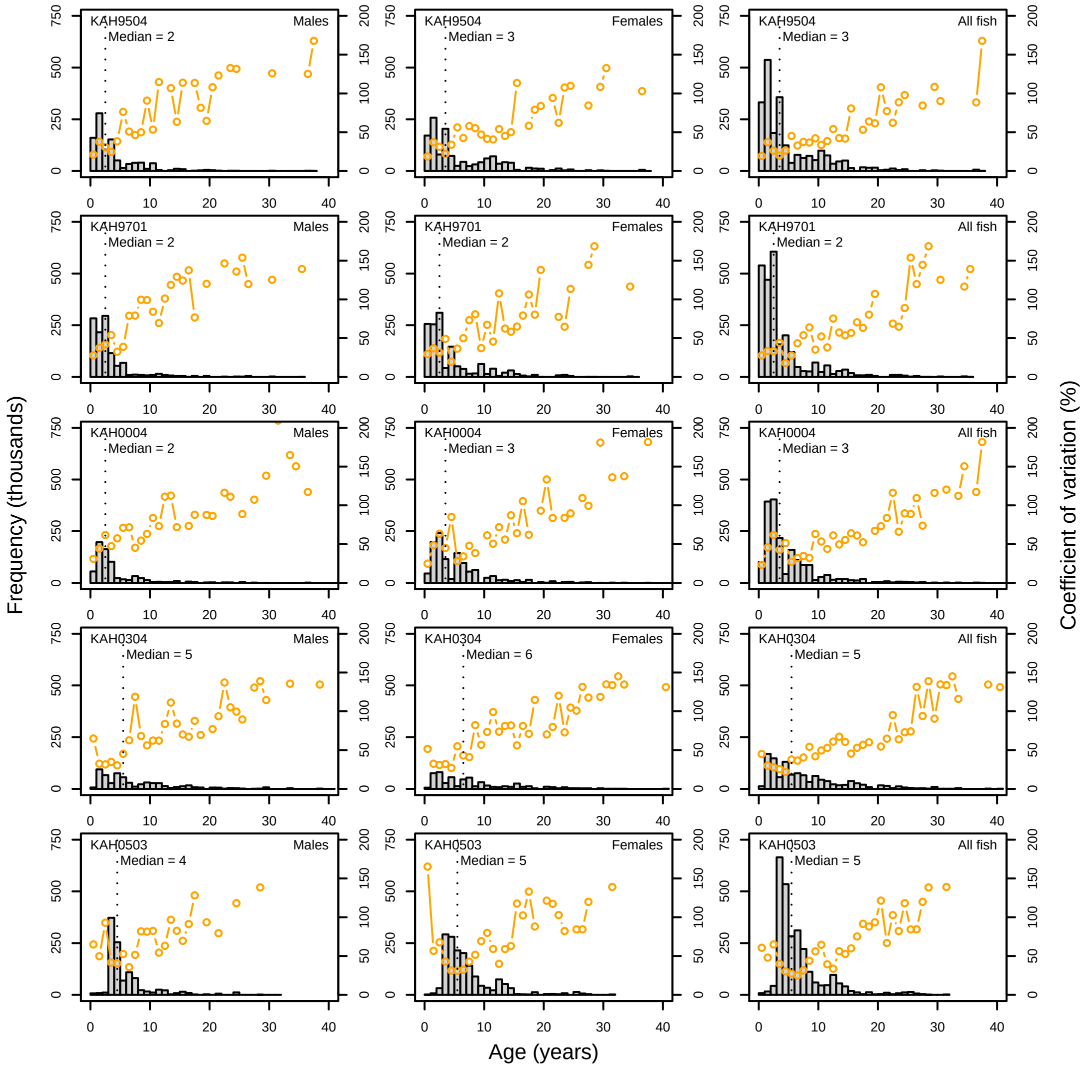


Figure 21: Age-frequency distributions for the WCSI survey series (1995–2005) by sex (males, females, and all fish). Boot-strapped coefficients of variation for each length class are overlaid (orange lines). Fish median ages (by sex and survey) are noted on each panel.

Table 10. Changes in reference quantiles of the length and age frequency distributions for male sand females pooled across all survey strata are plotted in Figure 26.

Although the definitions of the WCSI subregion in the fishery and survey analyses are similar but not exactly equivalent, the cumulative length and age frequency distributions of the TBGB and WCSI areas in the two analyses are compared in Figure 27, showing that the length and age distributions of the nominal WCSI subregion in each analysis are nonetheless similar. The TBGB subregion is almost exactly equivalent in both analyses (survey strata 17–19 encompasses most of Tasman and Golden Bays, which is recorded as a separate statistical area, area 038, for fisheries reporting), but the survey catch contains markedly more smaller, younger fish than the fishery in the same area. Male to female sex ratios throughout the survey series and in the fishery are tabulated in Table 11. Sex rations across the survey series are consistently skewed in favour of female fish, with more females than males being caught on average (1.32 females for every male across the survey series). This trend was also found in the fishery in 2004–05, but is slightly more skewed, with 1.49 females being caught for every male in the fishery. The numbers at age from the fishery in 2004–05 and the survey series over 1992–2005 are tabulated in Appendix D.

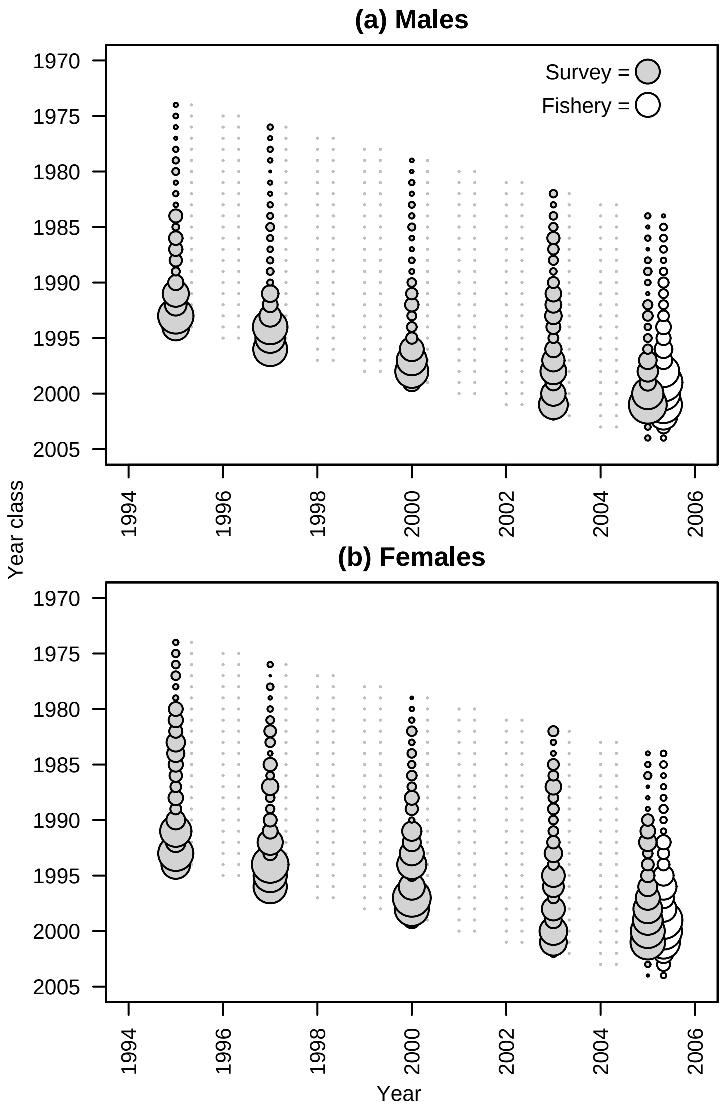


Figure 22: Visualising and comparing year-class progression. The age-frequency distributions of males and females in the fishery and WCSI survey catch are plotted by calendar year as year classes. Ages range from 0 to 20 years with 20 years being a plus-group containing all fish estimated to be 20 years of age or older. The areas of each circle are proportional to each age-frequency (year class). Dashes represent year classes for which no fish were observed during a particular survey.

4. DISCUSSION

4.1 On the performance of the market sampling programme

The success of any sampling programme is best measured by whether its aim has been met or not. More specifically (and assuming that such things have been written into the aim), this can depend on whether an assigned variance target (however this has been defined) has been met. More important, however, is whether the sample data collected are representative of the sampling frame or study population, and thus whether the conclusions drawn from the sample data can be extrapolated to the study population. This, of course, is the point of sampling any population. Here we evaluate our performance during 2004–05 against this criterion and make suggestions for future catch sampling in light of our performance.

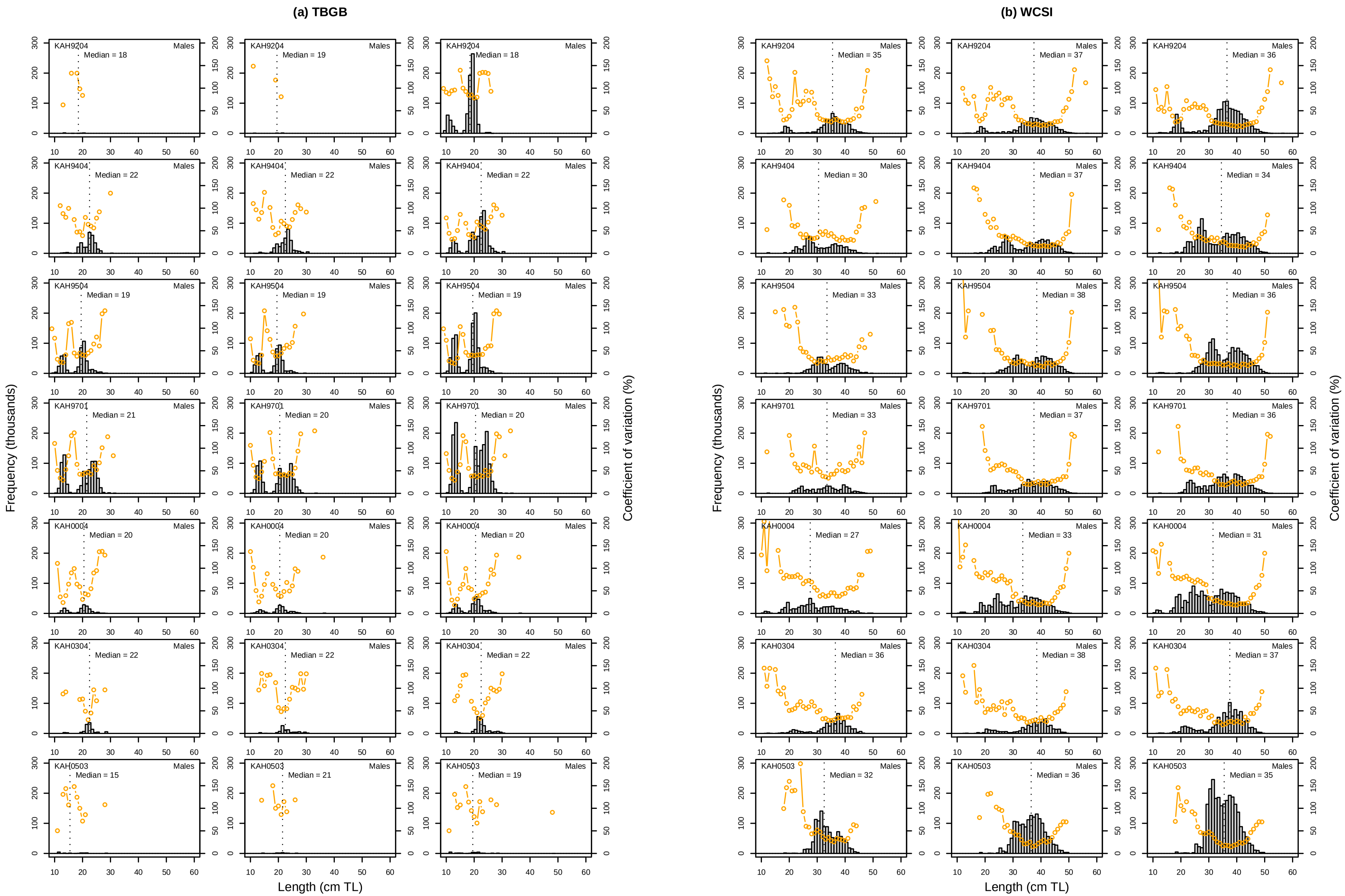


Figure 23: Length-frequency distributions for the WCSI survey series (1992–2005) by sex (males, females, and all fish) plotted separately for (a) TBGB and (b) WCSI survey strata. Bootstrapped coefficients of variation for each length class are overlaid (orange lines). Fish median lengths (by sex and survey) are noted on each panel.

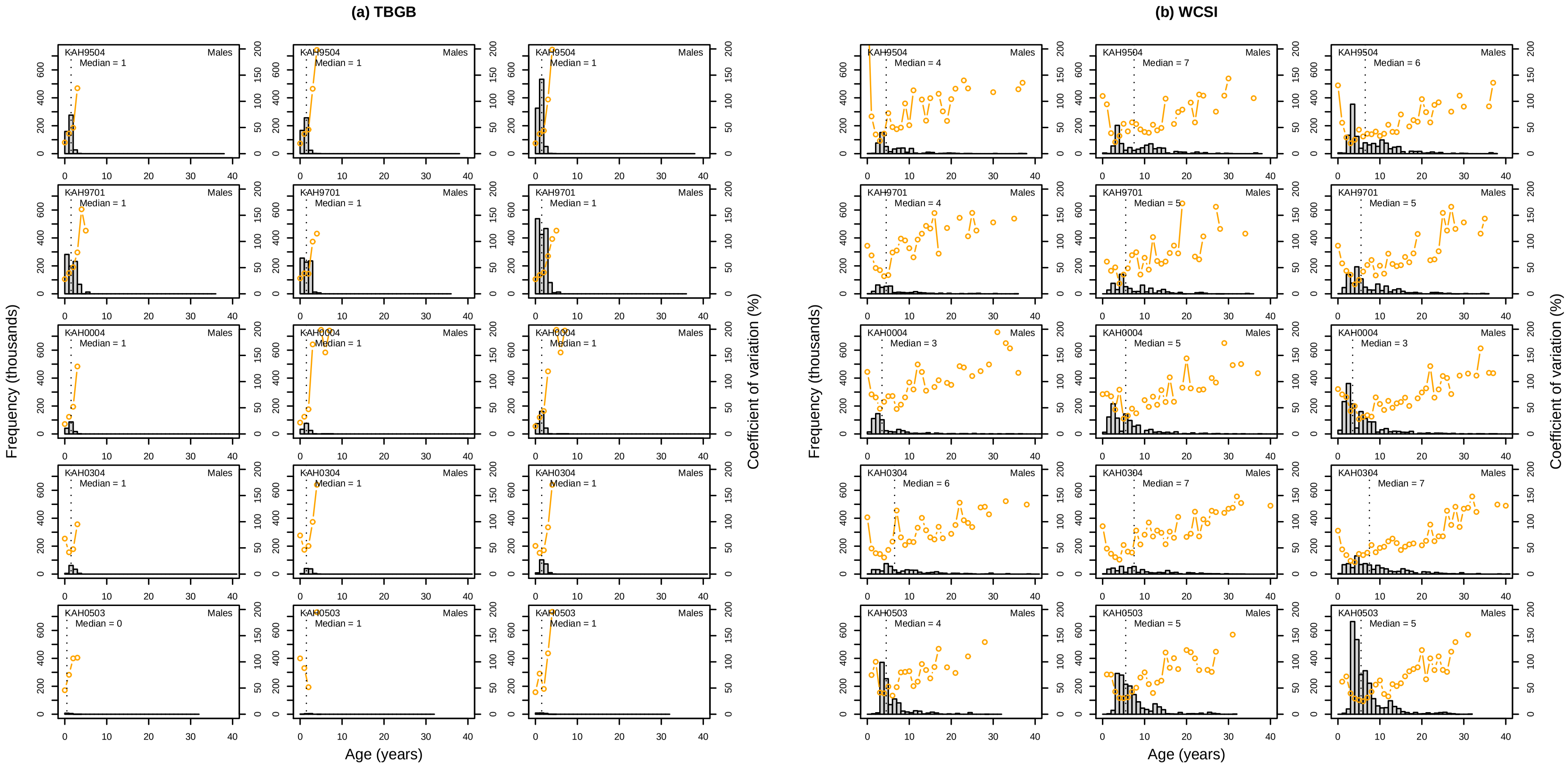


Figure 24: Age-frequency distributions for the WCSI survey series (1992–2005) by sex (males, females, and all fish) plotted separately for (a) TBGB and (b) WCSI survey strata. Bootstrapped coefficients of variation for each age class are overlaid (orange lines). Fish median ages (by sex and survey) are noted on each panel.

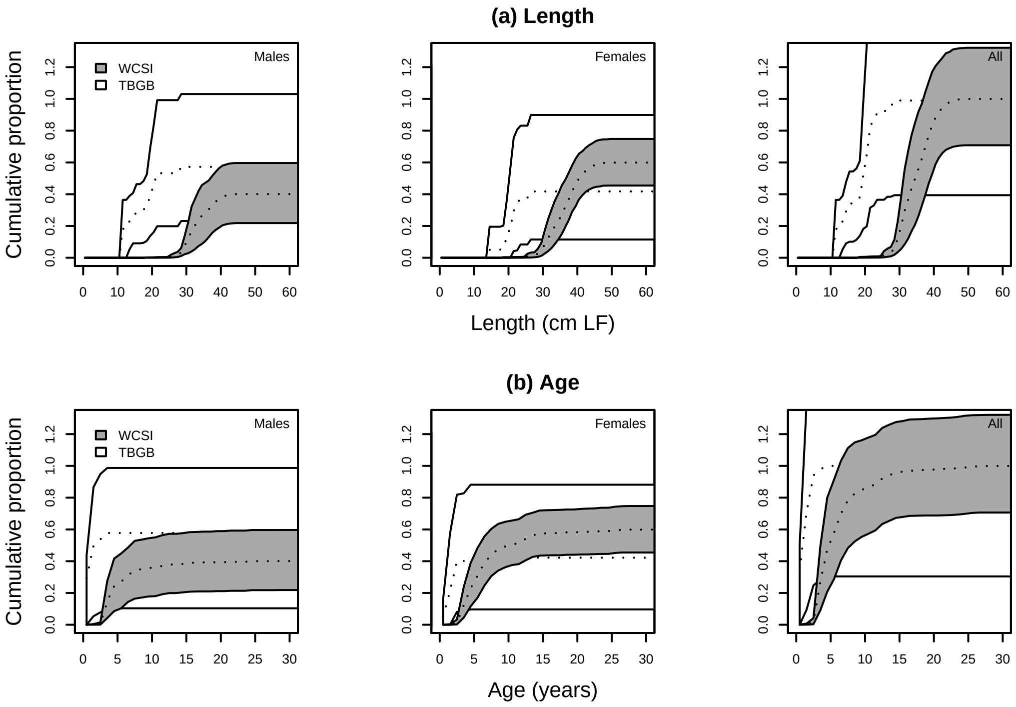


Figure 25: Cumulative proportions at (a) length and at (b) age by sex and by survey region ("TBGB" = strata 17–19, "WCSI" = strata 1–2, 5–9, & 11–16) for the 2005 WCSI survey (KAH0503). The dotted lines are the cumulative proportions-at-length or at age. The surrounding regions are bootstrapped 95% confidence intervals about the cumulative proportion at length or at age. The proportions at length and at age for all fish in each region have been scaled to sum to one.

Our aim in this programme is to sample the tarakihi catch in the mixed-species bottom-trawl fishery by trawl vessels (usually small, New Zealand flagged vessels completing CELR reporting forms) in the TAR 7(W) subregion of the TAR 7 QMA over the 2004–05 to 2006–07 fishing years. A target mean-weighted c.v. of 30% was set for the proportions-at-age distribution over all age classes. Because the fishery extends throughout all 12 months of the fishing year, a "direct age" sampling design was used, where individual sagittal otolith pairs were sampled from the catch randomly by fish length, and are then scaled up to stratum totals in the analysis directly without the use of an intermediate age-length key. Even though only 47 out of the target of 60 landings were sampled, we were able to beat the variance target, achieving a mean-weighted c.v. of 28.9% across both sexes and all age classes in all three of the strata assumed in our calculations. We have also shown that the sample data we collected are also probably representative of the fishery. From these results, we conclude that sampling during 2004–05 was a success. However, we feel that there are at least two issues to consider further.

The first is what to do with sample data collected from the CKST.E subregion inadvertently in subsequent fishing years. Despite not intending to sample any catch from this area, three of the 47 landings sampled in 2004–05 were actually found to be of fish caught mostly in CKST.E. Rather than dropping these data, as CKST.E is outside the TAR 7(W) stock area, we elected to retain them in our analysis, but to treat them as a separate analytical stratum, as this may have offered an opportunity to learn something about the length and age composition of the tarakihi catch in this area. However, extrapolating from data collected from only three sampled landings is tenuous at best, and given this, and that our results for the CKST.E subregion are very uncertain (a mean-weighted c.v. of 57.6% was obtained for the catch-at-age in the CKST.E stratum), we suggest that similar amounts of such data collected in subsequent fishing years be simply dropped.

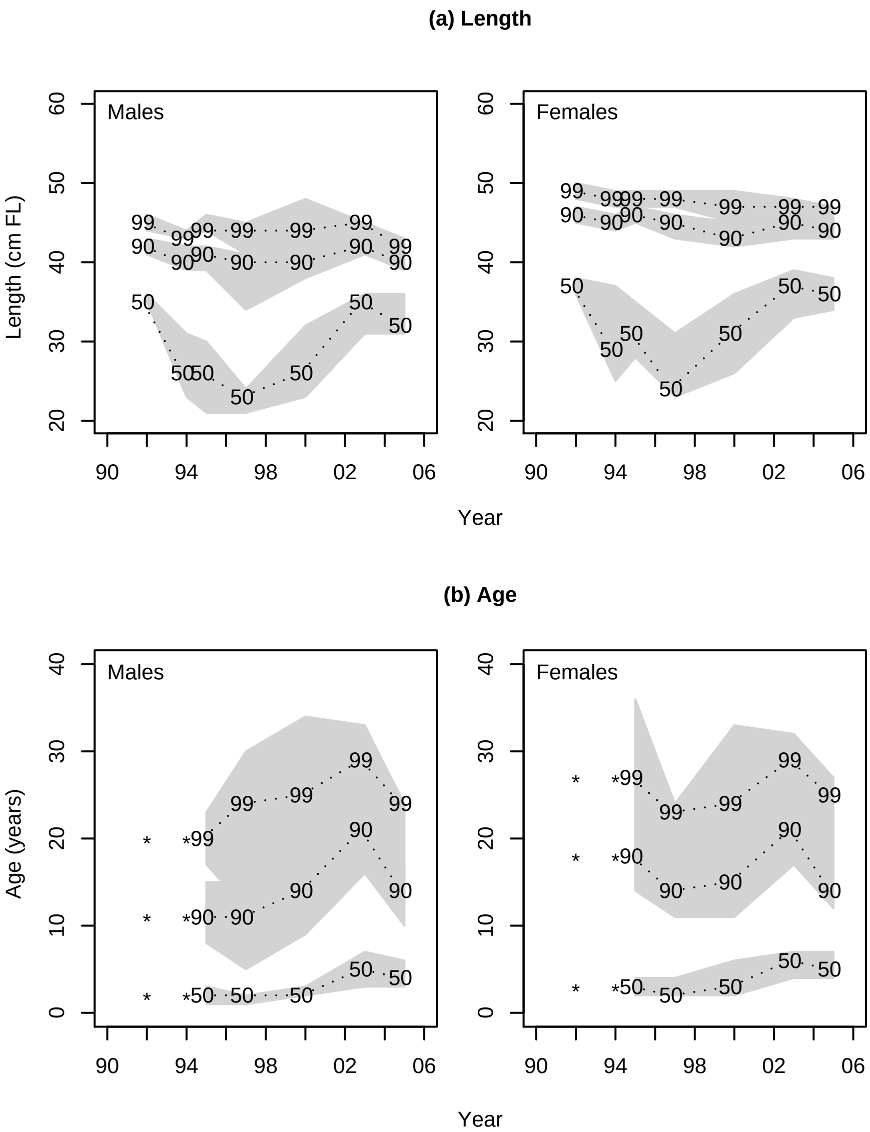


Figure 26: Changes in selected reference quantiles (the 50, 90, and 95th percentiles) of the scaled (a) length and (b) age frequency distributions by sex over the survey series. The shaded region is a bootstrapped 95% confidence region about each quantile. Age frequencies are not available for the 1992 and 1994 surveys (indicated by asterisks).

The second issue to consider is whether the existing sampling design should be modified for the two remaining years in the sampling programme. That we were able to sample the fishery representatively and precisely despite achieving 78% of the assigned sampling effort (73% if the three CKST.E landings are dropped) suggests that we may be able to reduce sampling effort by some amount to achieve the same outcomes. However, this assumes that fishing conditions, fish behaviour, and all other factors likely to affect the outcomes are the same (or at least similar), and this may not be the case in the two remaining years. We suggest that a quantitative consideration of the optimum sample size and composition for this fishery be carried out once all three years of data under the present design have been collected. We suggest that only then will we have adequate data to carry out such an optimisation. We recommend that the same overall sampling design (direct-age sampling of otoliths) with the same level and allocation of sampling effort be used until then.

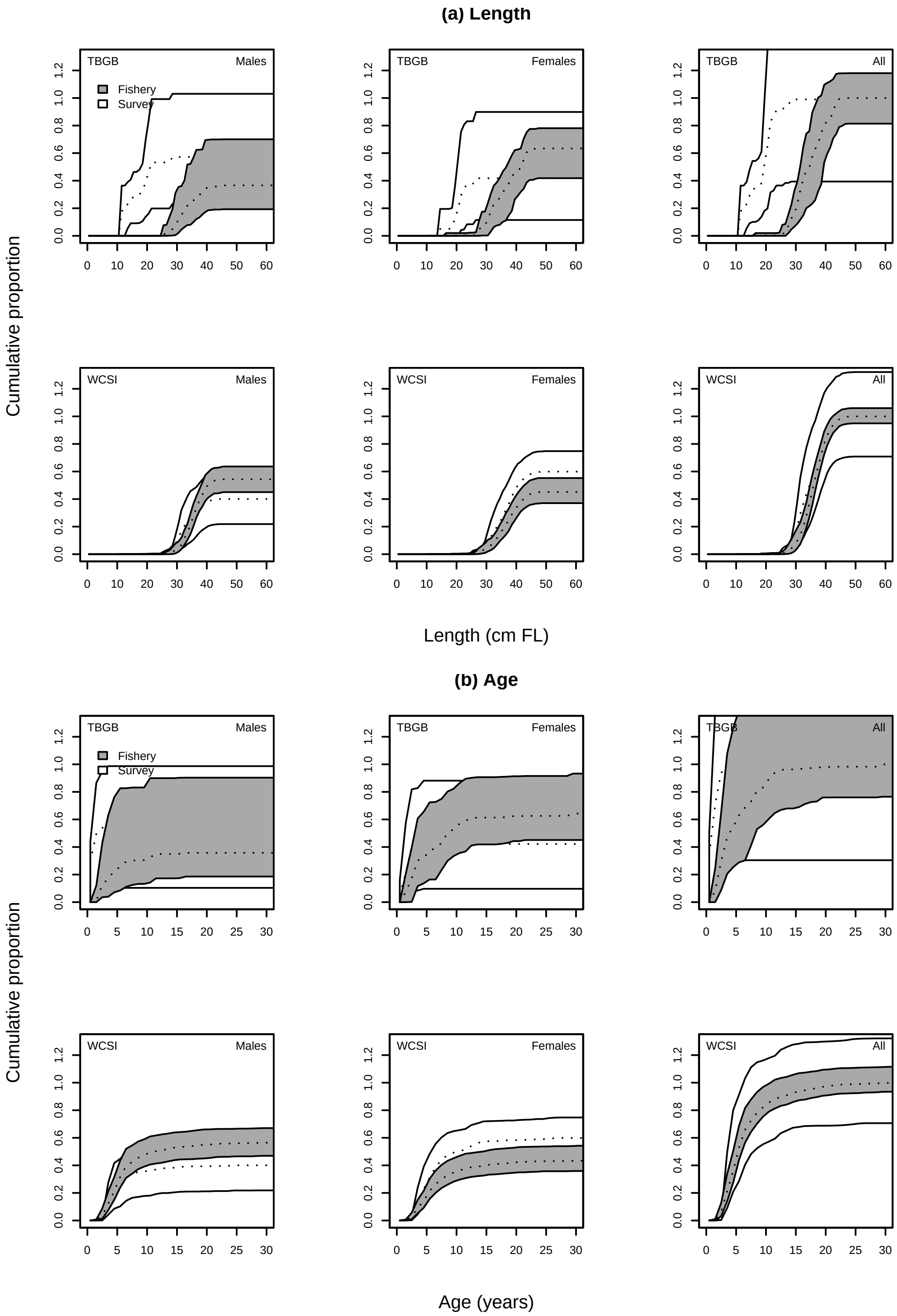


Figure 27: Comparing cumulative proportions at length and at age for the TBGB and WCSI regions for the fishery and WCSI survey during the 2004–05 fishing year. For the survey, the TBGB and WCSI regions are defined by union of strata 17–19 and strata 1–2, 5–9, & 11–16, respectively. The definitions of the same regions for the fishery are given in Section 2.2. The dotted lines are the cumulative proportions-at-length or at age. The surrounding regions are bootstrapped 95 % confidence intervals about the cumulative proportion at length or at age. The proportions at length and at age for all fish in each region have been scaled to sum to one.

Table 11: Male to female sex-ratios in the WCSI survey series (1992–2005). These are calculated from the corresponding scaled length-frequency distributions (total numbers of fish) by sex for each survey and are expressed as the number of males for each female fish. The sex ratio from the BT-MIX fishery in TAR 7(W) in 2004–05 is provided for comparison.

	Sex			Sex	
Survey	M	F	Survey	M	F
WCSI fishery	0.6725	1			
KAH9204	0.8812	1	KAH0004	0.6124	1
KAH9404	0.7582	1	KAH0304	1.0426	1
KAH9504	0.7549	1	KAH0503	0.6731	1
KAH9701	0.8353	1	Over all surveys	0.7632	1

4.2 On trends in the fishery and survey age compositions and their implications

Stevenson & Horn (2004) presented growth curves and proportions-at-age distributions for the six WCSI surveys carried out over 1992–2003. We consider the conclusions they reached about the age and length composition of tarakihi in TAR 7 in light of the results from the 2004–05 fishery and survey that we have presented. As they noted, the survey catch is generally composed of a moderately large age range of fish. Although the tail is long, with fish exceeding 30 years of age observed in all seven of the 1992–2005 WCSI and TBGB surveys, nearly all fish in most surveys are between 0 to 20 years of age, with most (95%) fish 15 years of age or less. Median age is somewhat variable, ranging between 2 and 5 years across both sexes and all strata in each survey over the survey series. The variation in median age is due to the numbers of very young (0–3 years) fish that are observed in the catch in a given survey.

Stevenson & Horn (2004) also noted the movement of several particularly weak year classes that could be tracked through the survey series. They found that the 1989 year class (5 years old in 1995) could be tracked through most of the subsequent surveys (as 7 year olds in 1997 and as 10 year olds in 2000). They also noted that the 1999 year class (0 year old in 2000) could be tracked into the 2003 surveys (as 3 year olds in 2003). It can also be tracked into the 2005 survey (as 5 year olds, although this is more obvious for males than for females). The 2005 survey age distribution suggests that the 2003 and 2004 year classes (0 and 1 year olds in 2005) may also be particularly weak. Fish in these age classes have been relatively abundant in previous surveys. While their absence has no immediate implications for the fishery, as the fishery clearly exploits a number of successful year classes and is certainly not reliant on one or a few hyper-abundant year classes, it does have implications for future yields in the medium term. Speculation about what this effect might be is best carried out within the context of the quantitative stock assessment and is left for that analysis. Ongoing monitoring of year class strenghs, in the survey catch in particular, may be useful in future years when no updated quantitiative stock assessment is planned or underway.

Although the fishery and survey catches are generally similar, there are some notable differences. These differences, namely the tendency for the survey to catch smaller, younger fish in general and in the TBGB survey region in particular, are thought to be mainly due to one factor, namely different trawl codend mesh sizes selectivities. The minimum trawl codend mesh size specified by MFish on the west coast of the South Island is 100 mm (inside mesh)[1], whereas the survey gear codend mesh size is 60 mm

[1] New Zealand (Commercial Fishing) Regulations 2001 Section 71

(inside mesh) (Stevenson 2006). The fishery and survey gears with their different codend mesh sizes almost certainly have different selectivity effects, retaining fish within their codends differently. However, the contrast between the fishery and survey proportions at age and at length will allow selectivity ogives (at age or length) to be estimated for each gear type within the stock assessment model fits. There is also a minimum legal size of 25 cm fork length for tarakihi caught by commercial fishers that may bias what fish can be observed in the commercial catch, but the nature and extent of this bias (or if it exists at all) is not known.

The prevailing hypothesis to explain the distribution of generally smaller, younger fish in Tasman and Golden Bays and generally larger, older fish on the open west coast was first suggested by Vooren (1975) with more recent support from Annala (1987). Vooren suggested that larvae from fish spawned on the west coast of the South Island between Jackson Head and Cape Foulwind settle into Tasman and Golden Bays, a nursery ground, when they are between about 7–12 months of age after their long post-larval, pelagic phase (Vooren 1972). Based on seasonal length and age composition data from Tasman and Golden Bays, he suggested that fish begin moving gradually into deeper water off the nursery ground during their fourth and fifth years (i.e., when 3–4 years of age) and migrate from there onto adult habitat between the ages of 4 and 6 years. Tong & Vooren (1972) found that New Zealand tarakihi attain full sexual maturity between 6 and 7 years of age. In an update of these calculations using data from the WCSI survey series, Manning (unpublished results) found that 50% of WCSI male tarakihi are sexually mature by the time they are 4 years of age and 95% are mature by 7 years, and that 50% and 95% of females are sexually mature by the time they are 5 and 9 years, respectively. The hypothesised dispersal of young fish out of the TBGB nursery ground might therefore be associated with the onset of sexual maturity.

4.3 Is the definition of the unit stock assumed in this study and in the stock assessment sensible?

Vooren's (1975) hypothesised relationship between the Jackson Bay spawning site, the Tasman and Golden Bay nursery ground, and adult habitat on the west coast has not yet been tested directly. Indeed, tarakihi stock structure in general is not well understood and the true number of biological stock units and their boundaries within the New Zealand EEZ are unknown. However, the Plenary Report (Sullivan et al. 2005) states that due to the long post-larval planktonic stage, juvenile tarakihi could be widely dispersed throughout the New Zealand region. Vooren (1975) recognised this, stating that it was very likely that juveniles off the Manuwatu coast on the west coast of the North Island were a mixture of locally spawned fish and fish spawned on the west coast of the South Island. But the Plenary Report goes further, and states that based on mark-recapture data, all tarakihi around mainland New Zealand should be considered a single biological stock unit, but fish at the Chatham Islands should be considered to be a separate biological stock unit because of the large distance between the mainland and the Chatham Islands and the deeper water separating them than is normally occupied by adult tarakihi.

But the hypothesis stated in the plenary report is an inappropriately conclusive interpretation of the available scientific evidence. In truth, no experiment has yet been carried out that has provided an adequate test of tarakihi stock structure in the New Zealand EEZ. Tag releases in the 1950s and 1960s were confined to the east coast of the North Island around East Cape (Crossland 1982), and although Crossland (1982) and Annala (1987) stated that over 7000 tarakihi were tagged and released at several different sites around the North and South Island (the Bay of Plenty and Pegasus and Tasman Bays) in the late 1960s and 1970s, all fish were trawl caught, the return rate was very low (< 0.5%), and the data themselves appear never to have been published. The low rate and patchy and incomplete distribution of the returns do not allow the strong conclusions advanced in the plenary report to be drawn. An analysis of the parasite fauna of tarakihi from East Cape, Tasman Bay, and the Chatham Islands suggested some level of stock differentiation within New Zealand tarakihi (Vooren & Tracey 1976), but an early otolith microchemical study (Gauldie & Nathan 1977) and genetic studies using protein electrophoresis (Gauldie & Johnston 1980) and mtDNA (Burridge & Smolenski 2003) were inconclusive and did not provide adequate hypothesis tests, although genetic methods were able to show the existence of a second *Nemadactylus* species within the New Zealand catch (Smith et al. 1996), and a fairly recent otolith microchemistry study has shown stock-level differentiation within Australian tarakihi (Thresher et al. 1994). The recent pre-recruit tagging experiment carried out in Tasman and Golden Bays at the end of the March–April 2007 inshore trawl survey may be able to quantify dispersal of fish out of Tasman and Golden Bays (S.M. Hanchet NIWA, unpublished results), but it cannot provide any evidence about the source populations of fish that have settled into Tasman and Golden Bays, although larvae from other known tarakihi spawning sites such as eastern Cook Strait, would need to swim against the prevailing Westland and D'Urville currents to settle in Tasman and Golden Bays.

Hanchet & Field (2001) reviewed the tarakihi stock structure literature, including the sources referred to above, as well as the location of the known spawning and nursery grounds, the distribution of adults and their fisheries, and possible recruitment and settlement mechanisms, before (rightly!) concluding that tarakihi stock structure is complex and poorly understood. No new evidence has become available since their study. But based on the circumstantial evidence presented by Vooren (1975), as well as evidence presented by Stevenson & Hanchet (2000) on how strong and weak year classes observed in Tasman and Golden Bays as pre-recruits could be seen on the west coast as adults in the west coast survey series data over the 1992–2000 surveys, and given the prevailing currents around the west coast and Tasman and Golden Bays and the degree to which these are likely to affect larval dispersal, the unit stock assumption, TAR 7(W), made in the market sampling programme and in the stock assessment seems reasonable at least until an adequate test of tarakihi stock structure can be carried out and evidence is presented that suggests the unit stock definition should be revised.

4.4 Is the tarakihi otolith collection protocol used during the WCSI survey adequate?

As noted, tarakihi otoliths are collected during the WCSI survey voyages using a "fixed allocation" sampling scheme. This involves collecting otoliths non-randomly from the random sample of fish selected for length-frequency measurements at each survey station. Typically, the sagittal otolith pair from up to five fish per sex per 1 cm size class are collected from the catch. Once the quota of fish per sex per size class is filled, no more otolith pairs of fish of that size are collected. The implications for this are that fish encountered early during the survey voyage will dominate the otolith collection. If, as we suspect may be the case with tarakihi, there is some non-random size or age based distribution or movement of fish on the survey ground, then the otolith collection may not represent all size and age groups found on the survey ground adequately, although the number and distribution of otoliths by size class and sex might appear adequate to define (a single) age-length key used to convert the scaled length-frequency distributions by sex and stratum to age-frequency distributions. We suggest that further consideration of this issue is required and a revision of the otolith collection protocol may be necessary.

5. ACKNOWLEDGMENTS

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Appendix A: A catch history for TAR 7 by stock subregions

A.1 Data sources

A catch history for the TAR 7(W) stock area that was assumed in the market sampling programme and in the preliminary stock assessment (i.e., the TAR 7 subregions CKST.W, TBGB, and WCSI, but not CKST.E) for the 1931–32 to 2004–05 fishing years was derived as follows. Total catches for the TAR 7 stock area for the 1983–84 to 2004–05 fishing years were obtained from Fisheries Statistics Unit (FSU; 1982–1983 to 1985–86) and Quota Management System (QMS;: 1986–87 to 2004–05) data given by Sullivan et al. (2005). Landings data for the 1931–32 to 1981–82 fishing years were derived from the port landing statistics given by Annala (1988), who compiled and updated previously published summaries of the tarakihi catch in the New Zealand region by earlier authors, notably the Fisheries Statistics Unit (FSU) reports by King et al. (1987) and King (1985, 1986), and earlier compilations by McKoy (1985) and Vooren (1974).

A.1.1 The 1931–32 to 1981–82 fishing years ("pre-FSU data")

The total TAR 7 catch for the 1931–32 to 1981–82 fishing years was estimated as the sum of published reported domestic and foreign landings for this period. Domestic landings data by fishing regions ("East Northland", "Hauraki Gulf", "Bay of Plenty", "East coast and Hawke Bay", "Cook Strait", "Canterbury Bight", "Southland", "West Coast of the South Island", and "Tasman Bay) are available for 1931–1982, but these data are given by calendar year and are three months out of phase with the contemporary fishing year and the model year assumed in the assessment, nor do the fishing regions match contemporary FMA or QMA definitions exactly, but these problems were ignored. Foreign landings data are available for 1968 and later, but again, these data are reported by calendar year, two different reporting area definitions are used in the data, and they are composed of mostly Japanese catch data. The catch in Japanese reporting area D7 was used for 1968–1977 and in EEZ reporting area H for 1978–1982. The tarakihi catch by Korean and Soviet-flagged vessels over this period was assumed to be zero. Although this assumption is very likely to be incorrect, as these vessels almost certainly caught some tarakihi in the stock area at this time, its effect is thought to be minimal as these vessels tended to fish in deeper water on the continental slope, and their tarakihi catches are therefore thought to be low (N. Bagley, NIWA, pers. comm.). Japanese vessels, on the other hand, tended to fish in shallower water, closer to shore (N. Bagley, NIWA, pers. comm.). The earlier, pre-FSU data appear to be unavailable for re-tabulation and partitioning by variables of interest (e.g., fishing method, stock subregion).

The domestic catch in the TAR 7 stock area over 1931–32 to 1981–82 was assumed to be the sum of reported catches in the "Cook Strait", "West Coast of the South Island", and "Tasman Bay" fishing regions. The approximate extent of these regions was illustrated by McKoy (1985). The TBGB subregion catch was assumed to be equal to the "Tasman Bay" catch and the WCSI subregion catch to the "West Coast of the South Island" catch. The Cook Strait catch was partitioned into "CKST.E" and "CKST.W" and "OUTSIDE" (i.e., outside TAR 7) parts using proportions of catch by statistical area calculated from the landings data reported by King et al. (1987) and King (1985, 1986) for the 1982–83 to 1985–86 fishing years aggregated across all fishing years in these data. In the FSU data, the Cook Strait fishing region was assumed to be statistical areas 016–019, 037, & 039–040. The catch in areas 018 and 019 was assumed to be outside the TAR 7 stock area (OUTSIDE), areas 016 & 017 to be in the CKST.E subregion as described elsewhere in this report, and areas 037 and 039–040 in the CKST.W subregion. The estimated catch in the CKST.E and CKST.W subregions was retained in the catch history and that estimated to be OUTSIDE was dropped. Although these proportions are unlikely to be a precise estimate of the true level of catch in that part of Cook Strait in the TAR 7 stock area, they are thought to be closer to the truth than calculating similar proportions from post-QMS data. All of the domestic catch was assumed to be by trawling. King et al. (1987), King (1985, 1986), and Vooren (1974) show that trawling dominates the west coast catch at this time.

All of the foreign catch was assumed to be from the west coast of the South Island (i.e., from the WCSI TAR 7 subregion). There was assumed to be no foreign catch from the other (CKST.E, CKST.W, or TBGB) TAR 7 subregions. All of the foreign catch was assumed to be by bottom trawling.

A.1.2 The 1982–83 to 1985–86 fishing years ("FSU data")

The FSU data were partitioned as follows. Domestic catches by statistical area for each of the 1983–84 to 1985–86 fishing years were published by McKoy (1985) and by King (1986, 1987). The catches by statistical area for each of these fishing years were mapped to the CKST.E, CKST.W, TBGB, and WCSI subregions using the definitions in Section 2.2 to yield the domestic catch by subregion for each year. The 1982–83 catch was partitioned using the total catch by statistical area across all of the 1983–84 to 1985–86 fishing years, as the catch by statistical area is unavailable for this year. As with the pre-FSU fishing years, all the foreign catch was assumed to be from the WCSI, and all of both the foreign and domestic catch was assumed to be by bottom trawling. Although bottom trawling dominated the catch in the WCSI subregion, other fishing methods are more important in the other regions, in particular setnet fishing in CKST.E, but as the CKST.E subregion is outside the TAR 7(W) stock area, this was ignored. Nevertheless, the raw FSU data are available for re-tabulation by variables of interest (Fisher & Sanders 2007), and a confrontation with the raw data may be useful when the catch history is re-examined for the revised stock assessment in 2008.

A.1.3 The 1986–87 and later fishing years ("QMS data")

Tarakihi landings and associated catch-effort data from the 1989–90 to 2004–05 fishing years were extracted from the MFish catch-effort and landings database, *warehou* (Duckworth 2002).The catch-effort data were then restratified and the landed catch allocated to the catch-effort strata using the algorithm described by Manning et al. (2004). The proportion of the total merged catch by fishing year and model time step (T1, October–April; T3, May–September) was calculated for bottom-trawl (BT) and all other vessels (OTH) by area (CKST.E, CKST.W, TBGB, and WCSI) in the merged dataset. These proportions were then applied to the total catches for the 1989–90 to 2004–05 fishing years to yield estimated catches in the stock area for bottom trawl vessels in each model time step for these fishing years. The proportions were then recalculated across all fishing years in the dataset and applied to the total catches for the 1986–87 to 1988–89 fishing years to yield estimated catches in the stock area for trawl vessels for each of these fishing years. The proportion of trawl catch by model time step across all fishing years in the merged dataset was then applied to the sum of the estimated domestic and foreign catches for the pre- and post-FSU data to partition these by time step, yielding the catch history.

A.2 Results

The catch estimates for all fishing years are given in Table A1. As there are no quantitative data available on the level of customary, recreational, or illegal catch of tarakihi in TAR 7, catches by these sectors were ignored. The catches are given by the time steps assumed in the assessment model. They are plotted by region in Figure 5

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Table A1: **A catch history for the TAR 7(W) stock by model time step (T1 = October to April; T3 = May to September). CS, total catch source (1 = QMS; 2 = FSU; 3 = pre-FSU); CKST.E, eastern Cook Strait; CKST.W, western Cook Strait; TBGB, Tasman and Golden Bays; WCSI, west coast of the South Island. Catches in the shaded region were calculated from year and time-step specific proportions in the *warehou* data extract.**

			T1				T3			
Fishing year	CS	TACC	CKST.E	CKST.W	TBGB	WCSI	CKST.E	CKST.W	TBGB	WCSI
1932	3	–	1	0	0	1	0	0	0	0
1933	3	–	1	0	0	1	0	0	0	0
1934	3	–	0	0	0	0	0	0	0	0
1935	3	–	1	0	0	1	0	0	0	0
1936	3	–	1	0	0	1	0	0	0	0
1937	3	–	2	0	0	3	1	0	0	1
1938	3	–	2	0	0	4	1	0	0	1
1939	3	–	0	0	0	0	0	0	0	0
1940	3	–	0	0	0	0	0	0	0	0
1941	3	–	0	0	0	0	0	0	0	0
1942	3	–	1	0	0	1	0	0	0	0
1943	3	–	0	0	0	0	0	0	0	0
1944	3	–	0	0	0	0	0	0	0	0
1945	3	–	0	0	0	0	0	0	0	0
1946	3	–	0	0	0	0	0	0	0	0
1947	3	–	20	2	2	29	6	1	1	11
1948	3	–	25	3	3	37	7	2	1	14
1949	3	–	18	2	2	26	5	1	1	10
1950	3	–	28	3	3	40	8	2	1	15
1951	3	–	16	2	2	24	5	1	1	9
1952	3	–	9	1	1	13	2	1	0	5
1953	3	–	5	1	0	7	1	0	0	3
1954	3	–	5	1	0	7	1	0	0	3
1955	3	–	4	0	0	6	1	0	0	2
1956	3	–	3	0	0	4	1	0	0	2
1957	3	–	4	0	0	6	1	0	0	2
1958	3	–	15	2	1	22	4	1	1	8
1959	3	–	25	3	2	37	7	2	1	14
1960	3	–	16	2	2	23	5	1	1	9
1961	3	–	13	2	1	19	4	1	1	7
1962	3	–	7	1	1	10	2	0	0	4
1963	3	–	8	1	1	12	2	1	0	4
1964	3	–	16	2	2	23	5	1	1	9
1965	3	–	11	1	1	16	3	1	1	6
1966	3	–	27	3	3	39	8	2	1	15
1967	3	–	499	58	50	733	145	32	24	275
1968	3	–	492	57	49	723	143	31	24	271
1969	3	–	94	11	9	138	27	6	5	52
1970	3	–	306	36	30	449	89	19	15	168
1971	3	–	266	31	27	391	77	17	13	147
1972	3	–	155	18	15	227	45	10	7	85
1973	3	–	135	16	13	198	39	9	6	74
1974	3	–	290	34	29	426	84	18	14	160
1975	3	–	266	31	26	390	77	17	13	146
1976	3	–	220	26	22	323	64	14	11	121
1977	3	–	361	42	36	530	104	23	17	199
1978	3	–	355	41	35	522	103	23	17	196
1979	3	–	155	18	15	228	45	10	7	86
1980	3	–	147	17	15	215	42	9	7	81
1981	3	–	231	27	23	339	67	15	11	127
1982	3	–	195	23	19	286	56	12	9	107
1983	3	–	178	21	18	262	52	11	9	98
1984	2	–	247	29	25	362	71	16	12	136
1985	2	–	168	19	17	246	49	11	8	92
1986	2	–	143	17	14	210	41	9	7	79
1987	1	930	249	29	25	365	72	16	12	137
1988	1	1046	231	27	23	339	67	15	11	127
1989	1	1059	173	20	17	254	50	11	8	95
1990	1	1069	230	13	36	244	84	14	17	156

Table A1: (continued)

Fishing year	CS	TACC	T1 CKST.E	T1 CKST.W	T1 TBGB	T1 WCSI	T3 CKST.E	T3 CKST.W	T3 TBGB	T3 WCSI
1991	1	1087	154	14	26	302	40	16	5	153
1992	1	1087	202	11	21	348	97	16	2	231
1993	1	1087	146	8	6	303	35	3	2	127
1994	1	1087	151	44	40	353	56	6	25	105
1995	1	1087	240	23	82	414	76	10	24	109
1996	1	1087	238	34	15	394	70	13	8	119
1997	1	1087	242	20	24	480	77	15	6	148
1998	1	1087	227	15	23	221	81	8	2	109
1999	1	1087	245	17	16	451	88	26	14	184
2000	1	1087	287	30	12	372	62	31	22	149
2001	1	1087	446	59	21	339	118	32	22	140
2002	1	1088	334	41	24	272	140	25	9	155
2003	1	1088	306	51	22	537	45	8	8	92
2004	1	1088	312	51	18	487	45	21	18	159
2005	1	1088	0	0	0	0	0	0	0	0

Appendix B: Some cross-tabulations of the groomed and merged landed catch

Table B1: The groomed and merged TAR 7 landed catch by fishing year and month. The catch for each month in each fishing year is given as a proportion of the total landed catch for that fishing year retained in the dataset. Zero values indicate cells that have rounded to zero at the second decimal place; an en-dash ("–") indicates cells where no catch was recorded.

	Month (proportion of total catch retained in the dataset for each fishing year)											
Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1989–90	0.01	0.05	0.06	0.19	0.13	0.16	0.06	0.08	0.06	0.04	0.06	0.10
1990–91	0.13	0.09	0.06	0.09	0.07	0.16	0.10	0.10	0.04	0.04	0.05	0.08
1991–92	0.11	0.11	0.04	0.05	0.06	0.07	0.17	0.12	0.10	0.05	0.04	0.07
1992–93	0.07	0.15	0.08	0.12	0.13	0.10	0.10	0.05	0.04	0.03	0.04	0.10
1993–94	0.11	0.10	0.10	0.12	0.10	0.12	0.10	0.07	0.07	0.03	0.03	0.05
1994–95	0.09	0.17	0.08	0.15	0.07	0.12	0.10	0.07	0.06	0.02	0.02	0.06
1995–96	0.03	0.11	0.04	0.16	0.18	0.16	0.09	0.08	0.07	0.03	0.02	0.04
1996–97	0.08	0.12	0.12	0.12	0.10	0.11	0.10	0.07	0.06	0.05	0.02	0.05
1997–98	0.12	0.13	0.10	0.09	0.07	0.07	0.13	0.09	0.06	0.03	0.03	0.07
1998–99	0.05	0.14	0.08	0.11	0.10	0.08	0.14	0.08	0.08	0.04	0.03	0.06
1999–00	0.09	0.15	0.09	0.15	0.10	0.10	0.05	0.06	0.09	0.05	0.03	0.05
2000–01	0.11	0.15	0.09	0.12	0.11	0.08	0.07	0.06	0.04	0.06	0.03	0.07
2001–02	0.13	0.13	0.06	0.12	0.07	0.07	0.09	0.09	0.07	0.05	0.05	0.07
2002–03	0.18	0.20	0.10	0.12	0.13	0.10	0.02	0.03	0.02	0.02	0.02	0.05
2003–04	0.14	0.14	0.05	0.13	0.12	0.13	0.08	0.04	0.05	0.04	0.03	0.05
Total	0.10	0.14	0.08	0.12	0.10	0.10	0.09	0.07	0.06	0.04	0.03	0.06

Table B2: The groomed and merged TAR 7 landed catch by fishing year and statistical area. The catch for each month in each fishing year is given as a proportion of the total landed catch for that fishing year retained in the dataset. Zero values indicate cells that have rounded to zero at the second decimal place; an en-dash ("–") indicates cells where no catch was recorded.

	Statistical area (proportion of total catch retained in the dataset for each fishing year)											
Fishing year	016	017	018	033	034	035	036	037	038	039	040	Other
1989–90	0.01	0.23	0.15	0.14	0.31	0.04	0.01	0.02	0.07	0.01	0.00	0.01
1990–91	0.01	0.09	0.18	0.30	0.25	0.05	0.02	0.02	0.04	0.01	0.00	0.01
1991–92	0.04	0.12	0.16	0.28	0.28	0.04	0.02	0.02	0.02	0.00	0.00	0.01
1992–93	0.02	0.13	0.13	0.24	0.38	0.04	0.02	0.01	0.01	0.00	0.01	0.01
1993–94	0.01	0.17	0.08	0.20	0.27	0.07	0.04	0.05	0.08	0.01	0.00	0.01
1994–95	0.01	0.17	0.14	0.24	0.18	0.05	0.07	0.02	0.11	0.01	0.00	0.01
1995–96	0.02	0.22	0.11	0.23	0.29	0.02	0.03	0.04	0.03	0.01	0.01	0.00
1996–97	0.02	0.22	0.08	0.26	0.28	0.03	0.05	0.02	0.03	0.01	0.00	0.01
1997–98	0.04	0.30	0.11	0.13	0.30	0.02	0.03	0.02	0.04	0.01	0.00	0.00
1998–99	0.02	0.23	0.07	0.22	0.30	0.03	0.07	0.03	0.03	0.01	0.00	0.00
1999–00	0.03	0.25	0.08	0.19	0.28	0.02	0.04	0.06	0.03	0.00	0.00	0.01
2000–01	0.03	0.27	0.18	0.13	0.18	0.04	0.06	0.07	0.04	0.01	0.00	0.00
2001–02	0.02	0.29	0.17	0.08	0.20	0.07	0.07	0.04	0.03	0.02	0.01	0.01
2002–03	0.03	0.14	0.15	0.20	0.21	0.08	0.07	0.04	0.03	0.01	0.00	0.03
2003–04	0.02	0.18	0.13	0.20	0.24	0.05	0.09	0.04	0.03	0.02	0.01	0.00
Total	0.02	0.21	0.13	0.20	0.26	0.04	0.05	0.03	0.04	0.01	0.00	0.01

Table B3: The groomed and merged TAR 7 landed catch by fishing year and fishing method. The catch for each month in each fishing year is given as a proportion of the total landed catch for that fishing year retained in the dataset. BLL, bottom longline; BPT, bottom paired trawl; BT, bottom trawl; MW, midwater trawl; SN, setnet; Other, all other fishing methods. Zero values indicate cells that have rounded to zero at the second decimal place; an en-dash ("–") indicates cells where no catch was recorded.

	Fishing method					
Fishing year	BLL	BPT	BT	MW	SN	Other
1989–90	0.00	0.03	0.94	0.01	0.01	0.01
1990–91	0.00	0.03	0.96	0.00	0.00	0.00
1991–92	0.00	0.00	0.98	0.00	0.01	0.01
1992–93	0.00	–	0.99	0.00	0.00	0.00
1993–94	0.00	–	0.98	0.01	0.01	0.00
1994–95	0.00	–	0.98	0.01	0.00	0.00
1995–96	0.00	–	0.98	0.01	0.00	0.01
1996–97	0.00	–	0.99	0.01	0.00	0.00
1997–98	0.00	–	0.98	0.01	0.00	0.01
1998–99	0.01	–	0.99	0.00	0.00	0.00
1999–00	0.00	0.00	0.99	0.00	0.00	0.00
2000–01	0.00	0.00	0.99	0.01	0.00	0.00
2001–02	0.00	0.00	0.99	0.01	0.00	0.00
2002–03	0.00	–	0.99	0.00	0.00	0.00
2003–04	0.00	0.00	0.99	0.00	0.00	0.00
Total	0.00	0.00	0.98	0.00	0.00	0.00

Table B4: The groomed and merged catch by fishing year and recorded target species. The catch for each method in each fishing year is given as a percentage of the total catch for that fishing year. Zero values indicate cells that have rounded to zero at the second decimal place; an en-dash ("–") indicates cells where no catch was recorded.

	Target species										
Fishing year	BAR	FLA	GUR	HOK	JMA	LIN	RCO	STA	TAR	WAR	Other
1989–90	0.28	0.02	0.01	0.09	0.02	0.01	0.02	0.06	0.38	0.05	0.06
1990–91	0.37	0.01	0.01	0.06	0.03	0.02	0.03	0.03	0.36	0.04	0.06
1991–92	0.32	0.01	0.01	0.02	0.05	0.01	0.04	0.03	0.47	0.02	0.03
1992–93	0.41	0.02	0.00	0.03	0.04	0.01	0.08	0.00	0.34	0.02	0.06
1993–94	0.43	0.02	0.01	0.03	0.04	0.00	0.03	0.01	0.36	0.03	0.05
1994–95	0.37	0.03	0.01	0.06	0.09	0.00	0.06	0.01	0.32	0.02	0.03
1995–96	0.42	0.03	0.01	0.10	0.05	0.00	0.03	0.00	0.30	0.02	0.03
1996–97	0.58	0.06	0.01	0.09	0.01	0.00	0.03	0.00	0.16	0.02	0.03
1997–98	0.38	0.08	0.01	0.08	0.03	0.00	0.03	0.01	0.30	0.04	0.03
1998–99	0.45	0.09	0.01	0.02	0.03	0.00	0.04	0.01	0.30	0.03	0.03
1999–00	0.52	0.09	0.01	0.01	0.00	0.00	0.01	0.01	0.28	0.04	0.03
2000–01	0.47	0.04	0.01	0.01	0.01	0.00	0.07	0.01	0.30	0.03	0.04
2001–02	0.39	0.04	0.01	0.01	0.02	0.00	0.09	0.01	0.31	0.06	0.04
2002–03	0.34	0.05	0.02	0.01	0.01	0.00	0.08	0.02	0.38	0.05	0.05
2003–04	0.29	0.03	0.02	0.02	0.00	0.01	0.10	0.05	0.39	0.05	0.05
Total	0.41	0.04	0.01	0.04	0.03	0.00	0.05	0.02	0.32	0.04	0.04

Appendix C: Summary of areas actually fished for each sampled landing

Table C1: Summary of fishing duration, number of trawls, and total estimated tarakihi catch by subregion for each sampled landing. The total landed greenweight catch for each fishing trip is also provided. The analytical stratum assigned to each sampled landing is noted. The total estimated catch for a given landing does not necessarily equal the total landed greenweight catch. Zeros are indicated by an en-dash (“–”).

		Fishing duration (hours)				Number of trawls				Estimated catch (kg)					
Landing number	Port	CKST.E	CKST.W	TBGB	WCSI	CKST.E	CKST.W	TBGB	WCSI	CKST.E	CKST.W	TBGB	WCSI	Landed catch (kg)	Stratum assigned
20041101	Greymouth	–	–	–	103	–	–	–	23	–	–	–	5220	5930	CKST.W & WCSI
20041102	Greymouth	–	–	–	116	–	–	–	26	–	–	–	2550	2209	CKST.W & WCSI
20041103	Greymouth	–	–	–	73	–	–	–	18	–	–	–	1176	1640	CKST.W & WCSI
20041104	Greymouth	–	–	–	51	–	–	–	12	–	–	–	660	811	CKST.W & WCSI
20041105	Westport	–	–	–	98	–	–	–	23	–	–	–	5820	5966	CKST.W & WCSI
20041171	Nelson	–	–	–	73	–	–	–	18	–	–	–	6000	6253	CKST.W & WCSI
20041172	Nelson	–	10	–	94	–	2	–	21	–	250	–	5070	6387	CKST.W & WCSI
20041173	Nelson	–	–	63	–	–	–	15	–	–	–	1958	–	2465	TBGB
20041174	Nelson	–	10	–	78	–	3	–	21	–	400	–	7200	6305	CKST.W & WCSI
20041175	Nelson	–	38	–	58	–	10	–	12	–	540	–	2850	3858	CKST.W & WCSI
20041176	Nelson	–	–	32	–	–	–	8	–	–	–	–	–	91	TBGB
20051101	Greymouth	–	–	–	32	–	–	–	22	–	–	–	1780	2672	CKST.W & WCSI
20051102	Greymouth	–	–	–	84	–	–	–	21	–	–	–	1204	2021	CKST.W & WCSI
20051103	Greymouth	–	–	–	102	–	–	–	20	–	–	–	9720	8254	CKST.W & WCSI
20051104	Greymouth	–	–	–	78	–	–	–	17	–	–	–	3800	3681	CKST.W & WCSI
20051105	Greymouth	–	–	–	35	–	–	–	12	–	–	–	2910	2847	CKST.W & WCSI
20051106	Greymouth	–	–	–	16	–	–	–	13	–	–	–	2580	2676	CKST.W & WCSI
20051107	Greymouth	–	–	–	50	–	–	–	10	–	–	–	800	775	CKST.W & WCSI
20051108	Greymouth	–	–	–	28	–	–	–	15	–	–	–	2580	3502	CKST.W & WCSI
20051109	Greymouth	–	–	4	37	–	–	4	19	–	–	–	360	287	CKST.W & WCSI
20051110	Greymouth	–	–	–	20	–	–	–	11	–	–	–	1550	1682	CKST.W & WCSI
20051111	Greymouth	–	–	–	44	–	–	–	13	–	–	–	2050	1741	CKST.W & WCSI
20051112	Greymouth	–	–	–	42	–	–	–	21	–	–	–	200	396	CKST.W & WCSI
20051113	Greymouth	–	–	–	65	–	–	–	11	–	–	–	1240	1385	CKST.W & WCSI
20051114	Greymouth	–	–	–	71	–	–	–	14	–	–	–	330	409	CKST.W & WCSI
20051115	Greymouth	–	–	–	36	–	–	–	11	–	–	–	510	623	CKST.W & WCSI
20051116	Greymouth	–	–	–	30	–	–	–	7	–	–	–	120	671	CKST.W & WCSI
20051117	Greymouth	–	–	–	47	–	–	–	11	–	–	–	840	948	CKST.W & WCSI
20051118	Greymouth	–	–	–	15	–	–	–	4	–	–	–	180	227	CKST.W & WCSI
20051119	Greymouth	–	–	–	16	–	–	–	11	–	–	–	410	621	CKST.W & WCSI
20051120	Greymouth	–	–	–	80	–	–	–	21	–	–	–	2550	2005	CKST.W & WCSI
20051171	Nelson	34	25	–	–	10	6	–	–	4290	–	–	–	6919	CKST.E
20051172	Nelson	–	31	42	–	–	7	10	–	–	–	–	–	320	TBGB
20051173	Nelson	55	36	5	–	18	8	1	–	2556	–	–	–	2843	CKST.E
20051174	Nelson	–	52	35	–	–	11	8	–	–	180	60	–	416	CKST.W & WCSI
20051175	Nelson	–	37	48	–	–	8	10	–	–	–	–	–	170	TBGB

Table C1: (continued)

		Fishing duration (hours)				Number of trawls				Estimated catch (kg)					
Landing number	Port	CKST.E	CKST.W	TBGB	WCSI	CKST.E	CKST.W	TBGB	WCSI	CKST.E	CKST.W	TBGB	WCSI	Landed catch (kg)	Stratum assigned
20051176	Nelson	–	–	–	86	–	–	–	19	–	–	–	3480	3887	CKST.W & WCSI
20051177	Nelson	–	–	–	78	–	–	–	18	–	–	–	4890	5163	CKST.W & WCSI
20051178	Nelson	–	–	–	65	–	–	–	16	–	–	–	2040	1903	CKST.W & WCSI
20051179	Nelson	–	5	–	89	–	1	–	21	–	120	–	3840	4639	CKST.W & WCSI
20051180	Nelson	48	–	6	–	16	–	2	–	9250	–	–	–	8837	CKST.E
20051181	Greymouth	–	–	–	66	–	–	–	15	–	–	–	1110	1114	CKST.W & WCSI
20051182	Nelson	26	16	8	–	9	6	6	–	–	103	175	–	328	TBGB
20051183	Nelson	–	–	88	–	–	–	19	–	–	–	700	–	617	TBGB
20051184	Nelson	–	–	59	–	–	–	16	–	–	–	735	–	804	TBGB
20051185	Nelson	–	–	–	116	–	–	–	31	–	–	–	7200	8737	CKST.W & WCSI
20051186	Nelson	–	10	–	94	–	2	–	19	–	200	–	7100	7860	CKST.W & WCSI

Appendix D: Numbers-at-age for the BT-MIX fishery (2004–05 fishing year) and the WCSI survey series (1992–2005)

Table D1: Estimated scaled numbers at age (years) by stratum (CKST.E, TBGB, CKST.W & WCSI, and pooled across all strata) and by sex for the BT-MIX fishery sampled during the 2004–05 fishing year.

	CKST.E						TBGB						CKST.W and WCSI					
	Males		Females		All		Males		Females		All		Males		Females		All	
Age	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.
0	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
1	11949	1.2629	11949	1.2482	23899	1.0197	647	1.6486	4684	0.8098	5331	0.7075	1151	1.4138	1107	1.4219	2257	1.0087
2	23899	1.0086	11949	1.2275	35848	0.9024	7401	0.6518	6314	0.6550	13714	0.4000	30268	0.4680	21905	0.4262	52173	0.3556
3	37121	0.7864	53677	0.4732	90798	0.4444	2881	1.0558	8352	0.5735	11233	0.6433	69293	0.2399	51761	0.2846	121054	0.2095
4	10487	1.3770	99604	0.4975	110090	0.4292	3511	0.6779	1113	1.2332	4624	0.6886	76460	0.1970	43501	0.2619	119960	0.1422
5	28316	0.9167	88062	0.3494	116378	0.3258	1978	0.9068	3496	0.6139	5475	0.5345	85516	0.1947	59757	0.1883	145273	0.1279
6	11949	1.1793	28316	0.9192	40265	0.6440	2405	0.9040	1090	1.2995	3495	0.8554	65857	0.1889	40824	0.2240	106681	0.1344
7	0	–	11949	1.2398	11949	1.2398	428	1.6033	2375	0.7971	2803	0.8117	24161	0.2924	31255	0.2426	55417	0.1926
8	0	–	44872	0.5747	44872	0.5747	228	1.6518	4783	0.5428	5012	0.5086	25207	0.2512	21699	0.2761	46905	0.1719
9	0	–	23899	0.9683	23899	0.9683	0	–	1543	0.7971	1543	0.7971	16040	0.3403	17425	0.3187	33465	0.2355
10	0	–	0	–	0	–	1324	1.0579	2637	0.7613	3961	0.5049	16088	0.3702	12386	0.3534	28474	0.2621
11	0	–	0	–	0	–	1518	0.8631	1414	0.8972	2932	0.6199	7708	0.5353	11966	0.4118	19673	0.3173
12	0	–	11949	1.1696	11949	1.1696	0	–	1225	0.9743	1225	0.9743	6439	0.5798	8193	0.4661	14632	0.3540
13	0	–	0	–	0	–	0	–	228	1.8030	228	1.8030	6454	0.6381	2971	0.6848	9424	0.4697
14	0	–	0	–	0	–	0	–	0	–	0	–	8314	0.5433	4328	0.6291	12642	0.3866
15	0	–	0	–	0	–	113	2.1349	0	–	113	2.1349	4330	0.6915	7220	0.5412	11550	0.3942
16	0	–	0	–	0	–	428	1.5607	0	–	428	1.5607	1876	0.9977	3697	0.9184	5573	0.6871
17	0	–	0	–	0	–	0	–	113	1.9030	113	1.9030	3811	0.7600	2832	0.7624	6643	0.5020
18	0	–	0	–	0	–	0	–	113	2.0426	113	2.0426	3827	0.7786	2344	0.7847	6171	0.5375
19	0	–	0	–	0	–	0	–	428	1.5076	428	1.5076	3783	0.7583	4247	0.6394	8030	0.4923
20	0	–	0	–	0	–	0	–	0	–	0	–	817	1.3843	3472	0.9073	4290	0.7626
21	0	–	0	–	0	–	0	–	108	1.8733	108	1.8733	4494	0.6525	983	1.2393	5477	0.6127
22	0	–	0	–	0	–	0	–	0	–	0	–	1847	0.9623	1687	0.9755	3534	0.7496
23	0	–	0	–	0	–	0	–	0	–	0	–	0	–	1107	1.3781	1107	1.3781
24	0	–	0	–	0	–	0	–	0	–	0	–	1018	1.4008	642	1.4454	1660	1.0109
25	0	–	0	–	0	–	0	–	0	–	0	–	1284	1.3446	0	–	1284	1.3446
26	0	–	0	–	0	–	0	–	0	–	0	–	0	–	1079	1.3181	1079	1.3181
27	0	–	0	–	0	–	0	–	0	–	0	–	858	1.3881	0	–	858	1.3881
28	0	–	11949	1.2157	11949	1.2157	0	–	0	–	0	–	1180	1.3184	0	–	1180	1.3184
29	0	–	0	–	0	–	0	–	1090	1.2649	1090	1.2649	1079	1.3637	1180	1.3498	2259	0.9472
30	0	–	0	–	0	–	0	–	0	–	0	–	0	–	970	1.2927	970	1.2927
31	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
32	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
33	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
34	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
35	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
36	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
37	0	–	0	–	0	–	0	–	0	–	0	–	0	–	1128	1.3913	1128	1.3913
38	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
39	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
40	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–

Table D1: (continued)

	Pooled					
	Males		Females		All	
Age	NAL	c.v.	NAL	c.v.	NAL	c.v.
0	0	–	0	–	0	–
1	13747	1.0573	17740	0.8791	31487	0.7760
2	61568	0.4474	40168	0.4322	101735	0.3625
3	109295	0.3571	113791	0.2710	223086	0.2310
4	90457	0.2755	144218	0.3677	234675	0.2369
5	115810	0.3167	151316	0.2198	267126	0.1652
6	80211	0.2289	70230	0.4752	150441	0.2264
7	24590	0.2886	45580	0.3376	70169	0.2472
8	25435	0.2487	71354	0.3836	96789	0.2950
9	16040	0.3403	42867	0.5236	58907	0.3862
10	17412	0.3496	15023	0.3244	32435	0.2361
11	9226	0.4727	13379	0.3827	22605	0.2894
12	6439	0.5798	21367	0.6506	27806	0.5124
13	6454	0.6381	3199	0.6424	9653	0.4572
14	8314	0.5433	4328	0.6291	12642	0.3866
15	4442	0.6745	7220	0.5412	11662	0.3900
16	2305	0.8554	3697	0.9184	6002	0.6418
17	3811	0.7600	2945	0.7326	6756	0.4932
18	3827	0.7786	2457	0.7521	6283	0.5287
19	3783	0.7583	4675	0.5871	8458	0.4676
20	817	1.3843	3472	0.9073	4290	0.7626
21	4494	0.6525	1092	1.0901	5586	0.5962
22	1847	0.9623	1687	0.9755	3534	0.7496
23	0	–	1107	1.3781	1107	1.3781
24	1018	1.4008	642	1.4454	1660	1.0109
25	1284	1.3446	0	–	1284	1.3446
26	0	–	1079	1.3181	1079	1.3181
27	858	1.3881	0	–	858	1.3881
28	1180	1.3184	11949	1.2157	13130	1.1081
29	1079	1.3637	2270	0.9435	3349	0.7727
30	0	–	970	1.2927	970	1.2927
31	0	–	0	–	0	–
32	0	–	0	–	0	–
33	0	–	0	–	0	–
34	0	–	0	–	0	–
35	0	–	0	–	0	–
36	0	–	0	–	0	–
37	0	–	1128	1.3913	1128	1.3913
38	0	–	0	–	0	–
39	0	–	0	–	0	–
40	0	–	0	–	0	–

Table D2: Estimated scaled numbers at age (years) by survey region (WCSI strata, TBGB strata, and pooled across all survey strata) and by sex for KAH9504.

	WCSI						TBGB						Pooled					
	Males		Females		All		Males		Females		All		Males		Females		All	
Age	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.
0	1071	3.2715	4916	1.1016	5987	1.3044	159260	0.2140	166772	0.1953	326032	0.1987	160331	0.2117	171688	0.1877	332019	0.1933
1	2898	0.7121	867	0.9429	3764	0.5911	276286	0.3837	256871	0.3762	533157	0.3773	279184	0.3770	257737	0.3702	536921	0.3709
2	76437	0.3676	55531	0.3917	131968	0.3098	27122	0.4951	24423	0.4603	51546	0.4391	103560	0.3078	79954	0.3121	183514	0.2624
3	151569	0.2456	202841	0.2212	354410	0.1992	1188	1.2504	1138	1.2396	2326	1.0352	152757	0.2447	203980	0.2205	356737	0.1984
4	51282	0.3826	72683	0.3393	123965	0.2652	0	–	216	1.9808	216	1.9874	51282	0.3830	72899	0.3386	124181	0.2650
5	14418	0.7727	24749	0.5704	39167	0.4579	0	–	0	–	0	–	14418	0.7618	24749	0.5625	39167	0.4515
6	33844	0.5079	44181	0.4264	78026	0.3286	0	–	0	–	0	–	33844	0.5086	44181	0.4252	78026	0.3283
7	39475	0.4683	23593	0.5980	63068	0.3811	0	–	0	–	0	–	39475	0.4636	23593	0.5787	63068	0.3741
8	40794	0.4985	32145	0.5654	72939	0.3714	0	–	0	–	0	–	40794	0.4994	32145	0.5522	72939	0.3679
9	10324	0.9589	42238	0.4645	52562	0.4224	0	–	0	–	0	–	10324	0.9078	42238	0.4701	52562	0.4218
10	37523	0.5443	60988	0.4142	98512	0.3385	0	–	0	–	0	–	37523	0.5337	60988	0.4140	98512	0.3359
11	4607	1.2100	70995	0.3999	75603	0.3810	0	–	0	–	0	–	4607	1.1464	70995	0.4070	75603	0.3860
12	0	–	35468	0.5528	35468	0.5528	0	–	0	–	0	–	0	–	35468	0.5404	35468	0.5404
13	3924	1.0341	42528	0.4458	46452	0.4169	0	–	0	–	0	–	3924	1.0678	42528	0.4524	46452	0.4237
14	10839	0.6312	39976	0.4918	50815	0.4121	0	–	0	–	0	–	10839	0.6340	39976	0.5004	50815	0.4182
15	8815	1.0599	5532	1.0507	14347	0.7492	0	–	0	–	0	–	8815	1.1382	5532	1.1346	14347	0.8063
16	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
17	2120	1.1436	15785	0.5677	17905	0.5202	0	–	0	–	0	–	2120	1.1350	15785	0.5826	17905	0.5316
18	3329	0.8088	12340	0.7939	15669	0.6411	0	–	0	–	0	–	3329	0.8154	12340	0.7886	15669	0.6388
19	5205	0.6261	11304	0.8414	16509	0.6104	0	–	0	–	0	–	5205	0.6463	11304	0.8378	16509	0.6146
20	3924	1.0419	0	–	3924	1.0419	0	–	0	–	0	–	3924	1.0798	0	–	3924	1.0798
21	2120	1.2409	4205	0.9756	6325	0.7931	0	–	0	–	0	–	2120	1.2315	4205	0.9413	6325	0.7724
22	0	–	12276	0.5973	12276	0.5973	0	–	0	–	0	–	0	–	12276	0.6213	12276	0.6213
23	1067	1.3988	3315	1.1297	4382	0.9307	0	–	0	–	0	–	1067	1.3273	3315	1.0764	4382	0.8859
24	1067	1.2467	7618	1.1081	8686	0.9811	0	–	0	–	0	–	1067	1.3164	7618	1.0974	8686	0.9791
25	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
26	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
27	0	–	3724	0.8030	3724	0.8030	0	–	0	–	0	–	0	–	3724	0.8445	3724	0.8445
28	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
29	0	–	3315	1.1086	3315	1.1086	0	–	0	–	0	–	0	–	3315	1.0845	3315	1.0845
30	1209	1.1745	890	1.4361	2099	0.8985	0	–	0	–	0	–	1209	1.2589	890	1.3265	2099	0.9018
31	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
32	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
33	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
34	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
35	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
36	1209	1.2299	5532	1.0600	6741	0.9036	0	–	0	–	0	–	1209	1.2517	5532	1.0298	6741	0.8852
37	389	1.3549	0	–	389	1.3549	0	–	0	–	0	–	389	1.6782	0	–	389	1.6782
38	0	–	0	–	0		0	–	0	–	0	–	0	–	0	–	0	–
39	0	–	0	–	0		0	–	0	–	0	–	0	–	0	–	0	–
40	0	–	0	–	0		0	–	0	–	0	–	0	–	0	–	0	–

Table D3: Estimated scaled numbers at age (years) by survey region (WCSI strata, TBGB strata, and pooled across all survey strata) and by sex for KAH9701.

	WCSI						TBGB						Pooled					
	Males		Females		All		Males		Females		All		Males		Females		All	
Age	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.
0	1197	0.9173	0	–	1197	0.9190	282143	0.2801	255779	0.2964	537922	0.2788	283340	0.2784	255779	0.2940	539119	0.2768
1	17564	0.7332	27159	0.6148	44723	0.5811	198311	0.3968	227104	0.3903	425415	0.3579	215875	0.3747	254263	0.3691	470138	0.3343
2	63339	0.4927	75192	0.4408	138531	0.4386	231899	0.5079	235563	0.3836	467461	0.4081	295238	0.4185	310754	0.3147	605992	0.3306
3	46646	0.4523	30190	0.5049	76836	0.3645	68134	0.7913	12504	0.9969	80639	0.7198	114780	0.5390	42694	0.4911	157474	0.4406
4	53490	0.3363	140006	0.1960	193496	0.1809	909	1.6139	6706	1.1497	7615	1.0475	54400	0.3250	146712	0.1963	201112	0.1787
5	55692	0.3581	51383	0.3662	107075	0.2649	12747	1.2066	0	–	12747	1.2065	68439	0.3887	51383	0.3662	119822	0.2769
6	8921	0.7890	38754	0.4870	47675	0.4253	0	–	0	–	0	–	8921	0.7894	38754	0.4996	47675	0.4342
7	11644	0.8278	16120	0.7382	27764	0.5504	0	–	0	–	0	–	11644	0.7917	16120	0.7314	27764	0.5371
8	9792	1.0538	16962	0.7938	26755	0.6456	0	–	0	–	0	–	9792	0.9960	16962	0.8071	26755	0.6387
9	7577	1.0190	62363	0.3688	69940	0.3517	0	–	0	–	0	–	7577	0.9911	62363	0.3712	69940	0.3526
10	9432	0.8706	14087	0.6882	23519	0.5369	0	–	0	–	0	–	9432	0.8411	14087	0.6730	23519	0.5225
11	15490	0.6973	40311	0.4618	55801	0.3851	0	–	0	–	0	–	15490	0.6950	40311	0.4561	55801	0.3813
12	8979	1.0357	5027	1.0829	14006	0.7665	0	–	0	–	0	–	8979	1.0112	5027	1.0772	14006	0.7533
13	7053	1.1486	21088	0.6266	28141	0.5699	0	–	0	–	0	–	7053	1.1871	21088	0.6242	28141	0.5729
14	4222	1.2974	31623	0.5733	35845	0.5282	0	–	0	–	0	–	4222	1.2924	31623	0.5839	35845	0.5365
15	4316	1.2473	13930	0.6167	18247	0.5468	0	–	0	–	0	–	4316	1.2429	13930	0.6504	18247	0.5689
16	894	1.5418	7006	0.7789	7900	0.7034	0	–	0	–	0	–	894	1.3746	7006	0.7924	7900	0.7044
17	4874	0.7678	2723	0.9211	7596	0.6025	0	–	0	–	0	–	4874	0.7674	2723	1.0625	7596	0.6324
18	0	–	10328	0.7724	10328	0.7724	0	–	0	–	0	–	0	–	10328	0.8030	10328	0.8030
19	4316	1.2569	508	1.7259	4825	1.1429	0	–	0	–	0	–	4316	1.2008	508	1.3798	4825	1.0699
20	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
21	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
22	1926	1.4507	7793	0.7109	9719	0.6413	0	–	0	–	0	–	1926	1.4644	7793	0.7749	9719	0.6882
23	0	–	10037	0.6577	10037	0.6577	0	–	0	–	0	–	0	–	10037	0.6482	10037	0.6482
24	2134	1.0987	4562	1.0961	6697	0.8131	0	–	0	–	0	–	2134	1.3592	4562	1.1354	6697	0.8884
25	1926	1.5451	0	–	1926	1.5451	0	–	0	–	0	–	1926	1.5380	0	–	1926	1.5380
26	4222	1.2088	0	–	4222	1.2088	0	–	0	–	0	–	4222	1.1969	0	–	4222	1.1969
27	0	–	508	1.6621	508	1.6621	0	–	0	–	0	–	0	–	508	1.4450	508	1.4450
28	0	–	367	1.2396	367	1.2396	0	–	0	–	0	–	0	–	367	1.6847	367	1.6847
29	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
30	2384	1.3636	0	–	2384	1.3636	0	–	0	–	0	–	2384	1.2523	0	–	2384	1.2523
31	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
32	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
33	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
34	0	–	2737	1.1496	2737	1.1496	0	–	0	–	0	–	0	–	2737	1.1655	2737	1.1655
35	894	1.4365	0	–	894	1.4365	0	–	0	–	0	–	894	1.3915	0	–	894	1.3915
36	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
37	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
38	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
39	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
40	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–

Table D4: Estimated scaled numbers at age (years) by survey region (WCSI strata, TBGB strata, and pooled across all survey strata) and by sex for KAH0004.

	WCSI						TBGB						Pooled					
	Males		Females		All		Males		Females		All		Males		Females		All	
Age	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.
0	14448	1.1851	12260	0.7586	26707	0.8570	40859	0.1890	33296	0.2170	74155	0.1467	55306	0.3104	45555	0.2482	100862	0.2336
1	110388	0.7567	121425	0.7687	231812	0.7546	85993	0.3270	75776	0.3290	161769	0.3164	196381	0.4427	197201	0.4857	393581	0.4572
2	145328	0.6970	216011	0.7187	361339	0.7021	17175	0.5194	25022	0.4715	42198	0.4377	162504	0.6173	241033	0.6345	403537	0.6196
3	101756	0.4833	113404	0.4639	215160	0.4383	912	1.2886	847	1.7101	1759	1.1952	102668	0.4737	114251	0.4506	216919	0.4270
4	23088	0.6145	19481	0.8450	42569	0.5311	0	–	0	–	0	–	23088	0.5743	19481	0.8512	42569	0.5133
5	17044	0.7199	143112	0.2910	160156	0.2832	0	–	260	1.9879	260	1.9879	17044	0.7113	143373	0.2795	160416	0.2728
6	14211	0.7241	96601	0.3485	110812	0.3252	0	–	521	1.5564	521	1.5564	14211	0.7167	97122	0.3416	111333	0.3192
7	32461	0.4768	54502	0.4835	86964	0.3570	0	–	260	1.9736	260	1.9736	32461	0.4537	54763	0.4788	87224	0.3485
8	23385	0.5602	62941	0.3949	86326	0.3310	0	–	0	–	0	–	23385	0.5456	62941	0.3847	86326	0.3224
9	13469	0.6985	0	–	13469	0.6985	0	–	0	–	0	–	13469	0.6313	0	–	13469	0.6313
10	4352	0.9843	25286	0.6463	29638	0.5723	0	–	0	–	0	–	4352	0.8369	25286	0.6129	29638	0.5337
11	5911	0.8506	32485	0.5180	38396	0.4583	0	–	0	–	0	–	5911	0.7315	32485	0.5059	38396	0.4385
12	3136	1.3275	12443	0.7123	15579	0.6317	0	–	0	–	0	–	3136	1.1123	12443	0.7183	15579	0.6120
13	4087	1.1835	15686	0.5573	19773	0.4997	0	–	0	–	0	–	4087	1.1257	15686	0.5587	19773	0.4955
14	9013	0.8265	8934	0.8368	17947	0.5842	0	–	0	–	0	–	9013	0.7192	8934	0.8716	17947	0.5537
15	0	–	12487	0.6106	12487	0.6106	0	–	0	–	0	–	0	–	12487	0.6401	12487	0.6401
16	6428	0.8965	5252	1.0808	11680	0.6927	0	–	0	–	0	–	6428	0.7338	5252	1.0540	11680	0.6111
17	3292	1.0260	15421	0.6153	18712	0.5348	0	–	0	–	0	–	3292	0.8790	15421	0.6212	18712	0.5235
18	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
19	2106	0.9750	3233	0.8845	5339	0.6807	0	–	0	–	0	–	2106	0.8762	3233	0.9313	5339	0.6713
20	2579	0.9376	1251	1.4432	3830	0.7924	0	–	0	–	0	–	2579	0.8640	1251	1.3334	3830	0.7308
21	0	–	7557	0.8708	7557	0.8708	0	–	0	–	0	–	0	–	7557	0.8368	7557	0.8368
22	2302	1.2943	0	–	2302	1.2943	0	–	0	–	0	–	2302	1.1626	0	–	2302	1.1626
23	2223	1.2697	3983	0.8403	6206	0.6945	0	–	0	–	0	–	2223	1.1106	3983	0.8388	6206	0.6599
24	0	–	5755	0.8504	5755	0.8504	0	–	0	–	0	–	0	–	5755	0.8966	5755	0.8966
25	3866	1.1059	0	–	3866	1.1059	0	–	0	–	0	–	3866	0.8883	0	–	3866	0.8883
26	0	–	2000	1.0680	2000	1.0680	0	–	0	–	0	–	0	–	2000	1.0939	2000	1.0939
27	1542	1.1994	2880	0.9814	4421	0.7623	0	–	0	–	0	–	1542	1.0733	2880	0.9941	4421	0.7382
28	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
29	789	1.3271	879	1.7355	1668	1.1143	0	–	0	–	0	–	789	1.3828	879	1.8094	1668	1.1614
30	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
31	332	1.9435	1426	1.3143	1757	1.1533	0	–	0	–	0	–	332	2.0933	1426	1.3608	1757	1.2029
32	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
33	457	1.7336	1251	1.3353	1708	1.1144	0	–	0	–	0	–	457	1.6483	1251	1.3752	1708	1.1227
34	457	1.6347	0	–	457	1.6347	0	–	0	–	0	–	457	1.5032	0	–	457	1.5032
35	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
36	1542	1.1673	0	–	1542	1.1673	0	–	0	–	0	–	1542	1.1726	0	–	1542	1.1726
37	0	–	995	1.1605	995	1.1605	0	–	0	–	0	–	0	–	995	1.8164	995	1.8164
38	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
39	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
40	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
41	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
42	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
43	0	–	1426	1.2257	1426	1.2257	0	–	0	–	0	–	0	–	1426	1.3264	1426	1.3264

Table D5: Estimated scaled umbers at age (years) by survey region (WCSI strata, TBGB strata, and pooled across all survey strata) and by sex for KAH0304.

	WCSI						TBGB						Pooled					
	Males		Females		All		Males		Females		All		Males		Females		All	
Age	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.
0	1501	1.0839	2150	0.9142	3651	0.8288	5088	0.6776	3650	0.7375	8738	0.5384	6589	0.6489	5800	0.5154	12389	0.4495
1	31986	0.4887	35454	0.4862	67440	0.4714	61975	0.4164	40070	0.4638	102045	0.4040	93961	0.3240	75524	0.3237	169485	0.2999
2	31851	0.3982	42869	0.3885	74721	0.3630	34824	0.4760	37670	0.5364	72494	0.4549	66676	0.3149	80539	0.3083	147215	0.2767
3	22425	0.3834	24026	0.3231	46451	0.2532	5523	0.9509	4511	0.9968	10034	0.8929	27948	0.3482	28537	0.3195	56485	0.2554
4	74932	0.3171	55544	0.2757	130476	0.2261	0	–	552	1.7050	552	1.7050	74932	0.3031	56096	0.2697	131028	0.2180
5	55733	0.4619	12968	0.5553	68701	0.3851	0	–	0	–	0	–	55733	0.4526	12968	0.5483	68701	0.3780
6	29615	0.6207	45523	0.4293	75138	0.3627	0	–	0	–	0	–	29615	0.6264	45523	0.4304	75138	0.3646
7	10994	1.2139	54374	0.4112	65369	0.4081	0	–	0	–	0	–	10994	1.1872	54374	0.4086	65369	0.4045
8	21852	0.7019	12176	0.8307	34029	0.5545	0	–	0	–	0	–	21852	0.6813	12176	0.8224	34029	0.5420
9	30798	0.5549	32108	0.5668	62906	0.4170	0	–	0	–	0	–	30798	0.5596	32108	0.5679	62906	0.4191
10	28175	0.6222	16178	0.7523	44353	0.4991	0	–	0	–	0	–	28175	0.6226	16178	0.7345	44353	0.4949
11	27689	0.6119	10000	0.9846	37689	0.5222	0	–	0	–	0	–	27689	0.6212	10000	0.9898	37689	0.5287
12	13677	0.8856	7989	0.7184	21666	0.6259	0	–	0	–	0	–	13677	0.8366	7989	0.7372	21666	0.6091
13	4808	1.0739	12330	0.8310	17138	0.6777	0	–	0	–	0	–	4808	1.1125	12330	0.8110	17138	0.6723
14	9477	0.8374	10152	0.7880	19629	0.5922	0	–	0	–	0	–	9477	0.8413	10152	0.8173	19629	0.6047
15	12423	0.7013	25684	0.5708	38107	0.4604	0	–	0	–	0	–	12423	0.7009	25684	0.5597	38107	0.4542
16	16697	0.6619	10152	0.8104	26849	0.5242	0	–	0	–	0	–	16697	0.6724	10152	0.8115	26849	0.5296
17	7810	0.9023	12496	0.6935	20306	0.5671	0	–	0	–	0	–	7810	0.8770	12496	0.7098	20306	0.5688
18	6407	0.6839	2482	1.0913	8888	0.5859	0	–	0	–	0	–	6407	0.6949	2482	1.1470	8888	0.6009
19	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
20	6259	0.7689	10567	0.7098	16826	0.5489	0	–	0	–	0	–	6259	0.7708	10567	0.7012	16826	0.5452
21	6085	0.9372	8568	0.7716	14654	0.6349	0	–	0	–	0	–	6085	0.9354	8568	0.7984	14654	0.6471
22	1298	1.3632	2707	1.1918	4005	0.9455	0	–	0	–	0	–	1298	1.3714	2707	1.2009	4005	0.9522
23	4381	1.0285	7533	0.7202	11913	0.6287	0	–	0	–	0	–	4381	1.0508	7533	0.7280	11913	0.6380
24	3404	0.9762	3190	1.0453	6594	0.7212	0	–	0	–	0	–	3404	0.9958	3190	1.0478	6594	0.7295
25	1476	0.8980	3190	0.9691	4666	0.7214	0	–	0	–	0	–	1476	0.8946	3190	1.0088	4666	0.7404
26	0	–	2344	1.2090	2344	1.2090	0	–	0	–	0	–	0	–	2344	1.3150	2344	1.3150
27	738	1.2733	2482	1.1834	3220	0.9389	0	–	0	–	0	–	738	1.3058	2482	1.1762	3220	0.9399
28	1298	1.2853	0	–	1298	1.2853	0	–	0	–	0	–	1298	1.3885	0	–	1298	1.3885
29	7082	1.1410	2707	1.1687	9789	0.8995	0	–	0	–	0	–	7082	1.1450	2707	1.1860	9789	0.9055
30	0	–	734	1.2477	734	1.2477	0	–	0	–	0	–	0	–	734	1.3464	734	1.3464
31	0	–	734	1.2664	734	1.2664	0	–	0	–	0	–	0	–	734	1.3376	734	1.3376
32	0	–	734	1.4820	734	1.4820	0	–	0	–	0	–	0	–	734	1.4501	734	1.4501
33	3083	1.3920	734	1.3573	3817	1.1869	0	–	0	–	0	–	3083	1.3562	734	1.3450	3817	1.1601
34	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
35	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
36	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
37	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
38	1298	1.3279	0	–	1298	1.3279	0	–	0	–	0	–	1298	1.3446	0	–	1298	1.3446
39	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
40	0	–	846	1.3055	846	1.3055	0	–	0	–	0	–	0	–	846	1.3111	846	1.3111

Table D6: Estimated scaled numbers at age (years) by survey region (WCSI strata, TBGB strata, and pooled across all survey strata) and by sex for KAH0503.

	WCSI						TBGB						Pooled					
	Males		Females		All		Males		Females		All		Males		Females		All	
Age	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.	NAL	c.v.
0	0	–	0	–	0	–	7205	0.4581	1232	1.0660	8437	0.4206	7205	0.6499	1232	1.6526	8437	0.6064
1	3770	0.7478	3372	0.7595	7142	0.6221	4932	0.7523	3986	0.8803	8919	0.7751	8702	0.4976	7358	0.5674	16061	0.4799
2	9983	1.0012	27787	0.7569	37769	0.7212	1001	1.0663	4579	0.5162	5580	0.4835	10984	0.9297	32366	0.6762	43350	0.6496
3	371546	0.4136	292078	0.4306	663624	0.3983	977	1.0792	0	–	977	1.1628	372523	0.4161	292078	0.4289	664601	0.3990
4	254367	0.3996	280253	0.3104	534619	0.3003	0	–	511	1.9479	511	1.9554	254367	0.4045	280763	0.3121	535130	0.3029
5	68850	0.5283	214629	0.3049	283478	0.2708	0	–	0	–	0	–	68850	0.5256	214629	0.3097	283478	0.2737
6	109314	0.3550	202233	0.3229	311547	0.2470	0	–	0	–	0	–	109314	0.3575	202233	0.3232	311547	0.2477
7	81106	0.5169	140862	0.4293	221968	0.3163	0	–	0	–	0	–	81106	0.5149	140862	0.4273	221968	0.3150
8	22822	0.7988	88636	0.5055	111458	0.4302	0	–	0	–	0	–	22822	0.8184	88636	0.5158	111458	0.4394
9	16091	0.8077	43652	0.7008	59743	0.5647	0	–	0	–	0	–	16091	0.8142	43652	0.6917	59743	0.5605
10	11047	0.8215	34262	0.7994	45308	0.6452	0	–	0	–	0	–	11047	0.8240	34262	0.7984	45308	0.6451
11	24849	0.5371	22023	0.5751	46873	0.3862	0	–	0	–	0	–	24849	0.5438	22023	0.5917	46873	0.3939
12	21844	0.6225	74622	0.4054	96466	0.3394	0	–	0	–	0	–	21844	0.6318	74622	0.3995	96466	0.3367
13	2699	0.9586	52611	0.6025	55310	0.5736	0	–	0	–	0	–	2699	0.9675	52611	0.5902	55310	0.5627
14	8384	0.8440	32439	0.6406	40822	0.5372	0	–	0	–	0	–	8384	0.8253	32439	0.6288	40822	0.5269
15	14810	0.6847	3954	1.1779	18765	0.5913	0	–	0	–	0	–	14810	0.6960	3954	1.1760	18765	0.5987
16	9154	0.9016	2729	0.8868	11884	0.7230	0	–	0	–	0	–	9154	0.9117	2729	1.0234	11884	0.7525
17	1882	1.2495	1612	1.0701	3494	0.8202	0	–	0	–	0	–	1882	1.2823	1612	1.3306	3494	0.9155
18	0	–	12735	0.8620	12735	0.8620	0	–	0	–	0	–	0	–	12735	0.8805	12735	0.8805
19	2699	0.8957	0	–	2699	0.8957	0	–	0	–	0	–	2699	0.9348	0	–	2699	0.9348
20	0	–	3954	1.2249	3954	1.2249	0	–	0	–	0	–	0	–	3954	1.2145	3954	1.2145
21	5656	0.7878	4339	1.1834	9996	0.6674	0	–	0	–	0	–	5656	0.7942	4339	1.1731	9996	0.6679
22	0	–	3281	1.0664	3281	1.0664	0	–	0	–	0	–	0	–	3281	1.0275	3281	1.0275
23	0	–	7908	0.8431	7908	0.8431	0	–	0	–	0	–	0	–	7908	0.8220	7908	0.8220
24	11719	1.1041	0	–	11719	1.1041	0	–	0	–	0	–	11719	1.1816	0	–	11719	1.1816
25	0	–	13932	0.8462	13932	0.8462	0	–	0	–	0	–	0	–	13932	0.8436	13932	0.8436
26	0	–	6407	0.8088	6407	0.8088	0	–	0	–	0	–	0	–	6407	0.8451	6407	0.8451
27	0	–	3649	1.1937	3649	1.1937	0	–	0	–	0	–	0	–	3649	1.1986	3649	1.1986
28	817	1.3776	0	–	817	1.3776	0	–	0	–	0	–	817	1.3846	0	–	817	1.3846
29	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
30	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
31	0	–	1640	1.5199	1640	1.5199	0	–	0	–	0	–	0	–	1640	1.3905	1640	1.3905
32	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
33	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
34	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
35	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
36	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
37	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
38	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
39	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–
40	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–	0	–