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Commercial catch sampling for species proportion, sex, length, and age of jack mackerels in JMA 7 in the 2011–12 fishing year, with a summary of all available data sets

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EXECUTIVE SUMMARY

Horn, P.L.; Hulston, D.; Ó Maolagáin, C. (2013). Commercial catch sampling for species proportion, sex, length, and age of jack mackerels in JMA 7 in the 2011–12 fishing year, with a summary of all available data sets.

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This report describes the scientific observer sampling programme carried out on trawl landings of jack mackerel (*Trachurus novaezelandiae*, *T. declivis*, and *T. murphyi*) in JMA 7 during the 2011–12 fishing year, and the subsequent estimates of species proportions and sex ratios in the landings, catch-at-length, and catch-at-age for these species.

Each tow in the observer data includes (estimated) total jack mackerel catch and weights by species sampled from the tow. The sampled weights were scaled to give estimated total catch weights by species for the tow. Stratification of the data was required because the observer coverage and catch composition varies with both month and statistical area. Just over 80% of the 2011–12 landed catch was sampled, and sampling was found to be representative of the landings both temporally and spatially.

For all three species, the scaled length distributions from 2011–12 were generally similar to those from the five previous years. The age-frequency distributions for all species in 2011–12 had mean weighted c.v.s of 21% or less, which more than met the target of 30%. By species, there is clear variation in catch-at-age between years, and it is apparent that for all species this variation is largely a consequence of the progression of year classes with different relative strengths.

Estimated species proportions indicated a predominance of *T. declivis* at about 65–71% in the JMA 7 TCEPR catch throughout all statistical areas and the six years of sampling; *T. novaezelandiae* was consistently represented at 25–28% and *T. murphyi* at 3–8%.

Estimates of catch-at-age for *T. declivis* and *T. novaezelandiae* from a research survey (TAN1202) in the south Taranaki Bight in February 2012 are also presented.

1. INTRODUCTION

Commercial catches of jack mackerel are recorded as an aggregate of the three species (*Trachurus declivis*, *T. murphyi*, and *T. novaezelandiae*) under the general code JMA, so separate catch information for each is unavailable from MPI databases for the jack mackerel quota management areas (Figure 1). Estimates of proportions of the three *Trachurus* species in the catch are essential for assessment of their stocks individually. Reliable estimates of species proportions can be used to apportion the aggregated catch histories to provide individual catch histories for each species at least back to when observer sampling began, which can in turn be used to scale age samples from the various fisheries. Recently the JMA 7 fishery has been primarily a trawl fishery with a small proportion of catches made using purse seine or set net. In earlier years larger proportions of the catch came from purse seine fishing (Taylor & Julian 2008).

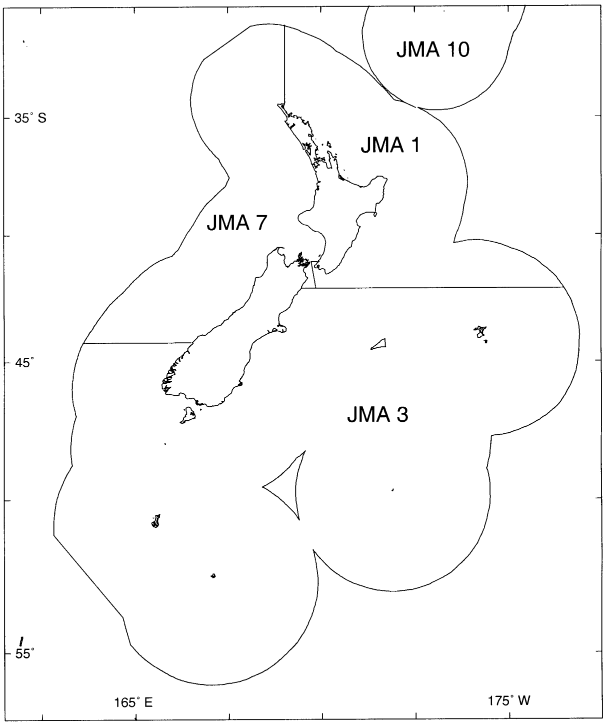

Figure 1: Jack mackerel administrative Fishstocks.

This report provides estimates of relative proportions and catch-at-age for the three *Trachurus* species in the commercial JMA 7 catch for 2011–12 using observer data. Similar data were presented by Taylor et al. (2011) for 2006–07, 2007–08 and 2008–09, Horn et al. (2012a) for 2009–10, and Horn et al. (2012b) for 2010–11. Summaries of the time series of catch-at-age estimates, sex ratios and species proportions for the JMA 7 catch are also presented. This document fulfils the reporting requirements for Objective 6 of Project MID201001C "Routine age determination of hoki and middle depth species from commercial fisheries and trawl surveys", funded by the Ministry for Primary Industries. That objective is "To determine the age and size structure of the commercial catches of jack mackerel (all three species) in the JMA 7 fishery from samples collected at sea by the Observer Programme".

Age monitoring of jack mackerels over time was carried out previously for jack mackerel species in New Zealand by Horn (1993) who tracked strong and weak age classes of *T. declivis* and *T. novaezelandiae* through time to provide a qualitative validation for ageing these two species. There was no significant difference in growth between sexes for either species although geographical differences were evident between the Bay of Plenty and the central west coast.

2. METHODS

Catch sampling for length, sex, age, and species composition was carried out by observers primarily working on board large trawl vessels targeting jack mackerels. Sampling was carried out according to instructions developed at NIWA and included in the Scientific Observers Manual. Each tow in the observer dataset includes estimated total jack mackerel catch and weights by species sampled from the tow. All observer data on jack mackerels sampled from JMA 7 in the 2011–12 fishing year were extracted for the analyses. As in previous analyses, estimated species proportions (by weight) in each sampled landing were assumed to be the same as the proportions in a randomly selected sample from the catch (Taylor et al. 2011). The observer data were examined for spatial and temporal variability, and this was compared with the spatial and temporal distribution of the entire commercial JMA 7 catch.

Commercial catch data extracted from the Ministry for Primary Industries catch-effort database "warehou" (Extract #8891) were used in these analyses. The data comprised estimated catch and associated date, position, depth, and method data from all fishing events that recorded catches of jack mackerel from JMA 7 (i.e., QMAs 7, 8, and 9) in 2011–12.

Stratification of the data is required because the observer coverage varies with both month and statistical area, the fishery is not consistent throughout the year, and the species composition varies across area and depth (Taylor et al. 2011). The derivation of the five strata used in this analysis is shown in Appendix A of Horn et al. (2012b). Each fishing event from the catch-effort dataset and the observer dataset was allocated to one of the five strata, i.e., west coast South Island, Statistical Areas 037 and 040 with two time strata, and all remaining areas stratified deeper and shallower than 124.5 m.

Proportions of the catch by species were estimated as follows. For each observed tow, the catch weight of each species was estimated based on the species weight proportions of a random sample. Each observed tow was allocated to one of the five strata. Within each stratum, the estimated landed weights of each species were summed across all observed tows. Percentages of catch by species were then calculated for each stratum. Total jack mackerel catch by stratum was obtained by summing the reported estimated landing weights of all tows (from the catch-effort dataset) in that stratum. The species percentages derived for that stratum were then applied to the total summed catch to estimate catch by species in that stratum. The estimated catch totals were then summed across strata (by species) to produce total estimated catch weight by species for the fishing year, and, consequently, total species proportions by weight.

Ageing was completed for all three *Trachurus* species (i.e., *T. declivis*, *T. novaezelandiae*, and *T. murphyi*) caught by trawl in Statistical Areas 033–048 and 801 of JMA 7 (Figure 2) in the 2011–12 fishing year, using data and otoliths collected by observers. For each of the three species, samples of otoliths (for each sex separately) from each 1 cm length class were selected approximately proportionally to their occurrence in the scaled length frequency, with the constraint that the number of otoliths in each length class (where available) was at least one. In addition, otoliths from fish in the extreme right hand tail of the scaled length frequency (constituting about 2% of that length frequency) were over-sampled. Target sample sizes were about 550 per species. Sets of five otoliths were embedded in blocks of clear epoxy resin and cured at 50°C. Once hardened, a 380μm thin transverse section was cut from each block through the primordia using a high speed saw. The thin section was washed, dried, and embedded under a cover slip on a glass microscopic slide. Thin sections were read with a bright field stereomicroscope at up to ×100 magnification. Zone counts were based on the number of complete opaque zones (i.e., opaque zones with translucent material outside them), which were counted to provide data for age estimates. Otoliths of *T. declivis* and *T. novaezelandiae* were read following the validated methods described by Horn (1993) and Lyle et al. (2000). A validated ageing method has not yet been developed for *T. murphyi* in New Zealand waters (Beentjes et al. 2013). Otoliths from this species were interpreted similarly to those of *T. declivis*. However, they are notably harder to read, with presumed annual zones often being diffuse, split, or containing considerable microstructure (Taylor et al. 2002).

The age data were used to construct age-length keys (by species and sex) which in turn were used to convert the weighted length composition of the catch to catch-at-age by sex using the NIWA catch-at-age software (Bull & Dunn 2002). This software also provides estimates of c.v.s-at-age using a bootstrap procedure. Sex ratios by species were also derived from this process.

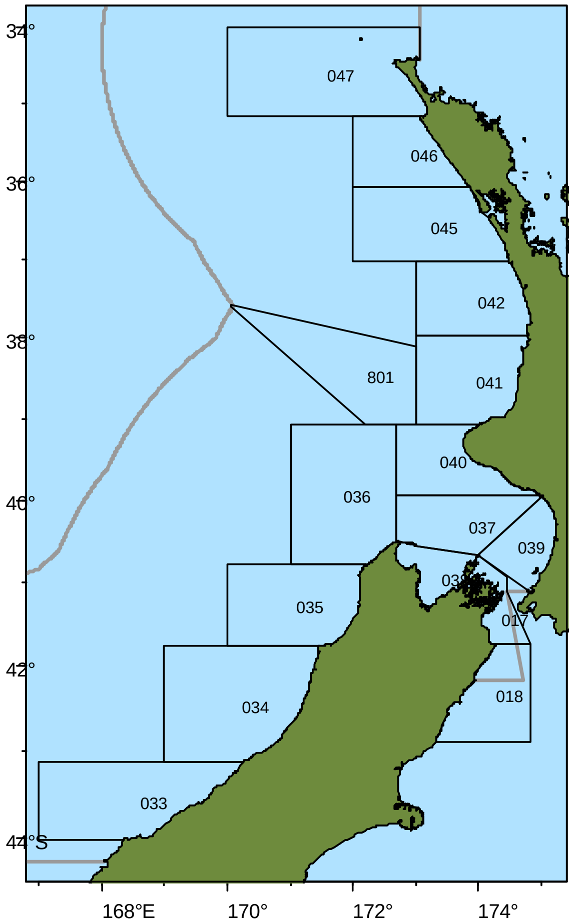

Figure 2: Statistical Areas referred to in the text.

3. RESULTS

3.1 Catch sampling

The landings distribution in 2011–12 shows that there is a fishery from October to January concentrated in Statistical Areas 037 and 040–042, followed by a secondary fishery centred around June and concentrated in the same statistical areas as well as off the northwest South Island (Areas 034–036) (Table 1). Because the two fishery peaks were quite widely separated in time it was considered desirable to split the year into two equal parts (i.e., a split between March and April), and use separate age-length keys for each part (to account for the growth of fish, particularly of the younger age classes). In each time period, the data were analysed in the five strata determined previously (Taylor et al. 2011, Horn et al. 2012b).

In 2011–12, about 82% of the landed weight was sampled by observers (Table 1). All data from one observed trip (trip 3572) were removed from the analysis as significant errors were apparent with the identification of the three mackerel species. Most of the estimated landings were derived from four

Statistical Areas (037, 040–042), and these were all well sampled (Figure 3). The percentage of the catch sampled in each month was greater than 50%, except for June (45%) and February (no sampling) (Figure 3). Clearly, the sampling of the whole fishery was satisfactory to estimate the overall catch-at-age.

Table 1: Jack mackerels — distribution of estimated total catch and sampled landings (t, rounded to the nearest tonne), by month and statistical area (Stat Area), in the 2011–12 fishing year. Values of 0 indicate landings from 1 to 499 kg; blank cells indicate zero landings or samples. %, percentage of estimated total catch that was sampled by observers, by month and statistical area.

Estimated total catch (t), 2011–12

Stat												Month	
Area	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	All
033–034	4	2	3	3	5	2	3	3	142	83	109	6	365
035	1		0	0	0	0	0		105	200	183	1	489
036	113	0	0	0	0		0	2	382	0	8	30	536
037	585	339	1 226	953	727	273	536	202	414	1	1	422	5 678
038	2	1	0	1	1	0	0	1	1	1	1	1	12
039	18	0	0	0	13	0	3	324	112	2	3	1	474
040	683	278	1 121	945	262	18	146	39	1 139	1	108	441	5 181
041	21	582	5 260	1 595	1	1	3	2	907	1	31	442	8 846
042	490	383	1 249	125		0	1		0	0	1	373	2 622
045	513	0	0	0	0	0	0			0	0	219	733
046–047	0	1	0	0	0	1	0	0	0	0	0	0	4
801			913	327	0	0			338			2	1 580
	2 430	1 586	9 773	3 951	1 008	295	693	572	3 541	289	444	1 938	26 520

Sampled landings (t)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	All	%
033–034									44.8	90	74	2.98	212	58.1
035								0	63	171	187	3	426	87.0
036	120			8				2	98	0	6	11	246	45.8
037	323	174	1 054	836		260	486	160	319	1		284	3 896	68.6
038													0	0.0
039	8							186	56				250	52.7
040	553	444	1 301	901		30	174	3	656		109	457	4 628	89.3
041	5	593	5 257	1 495					212		27	289	7 878	89.1
042	119	384	1 256	125								383	2 267	86.5
045	385											164	549	74.8
046–047													0	0.0
801			877	330					151			1	1 360	86.1
	1 514	1 595	9 746	3 694	0	290	660	351	1 600	262	404	1 596	21 711	81.9
	62.3	100	99.7	93.5	0.0	98.4	95.3	61.4	45.2	90.7	90.9	82.4	81.9	

3.2 Species proportions

An examination of estimated species proportions by fishing year (Table 2) indicates that *T. declivis* (JMD) was the dominant species during the period examined, accounting for 65 to 71% of landed weight in all years. *T. novaezelandiae* (JMN) was the second most frequently caught species at 25 to 28%. By contrast, *T. murphyi* (JMM) was detected at a much lower and quite variable rate of 3 to 8%.

Table 2: Estimated species proportions (by weight) and catch weights by species in JMA 7 since 2006–07. 'Estimated catch' is the sum of all the tow-by-tow estimates of jack mackerel catch.

	Species proportions (%)			Estimated catch (t)			Landed catch (t)		
Fishing year	JMD	JMN	JMM	JMD	JMN	JMM	JMD	JMN	JMM
2006–07	69.5	26.8	3.7	21 248	8 188	1 128	22 273	8 583	1 183
2007–08	64.8	27.0	8.2	21 033	8 763	2 671	22 064	9 193	2 802
2008–09	66.4	25.3	8.3	17 943	6 826	2 236	19 154	7 287	2 387
2009–10	65.9	27.6	6.5	19 487	8 155	1 933	20 526	8 590	2 036
2010–11	70.6	26.9	2.5	18 679	7 123	650	19 897	7 587	692
2011–12	68.6	28.1	3.3	18 184	7 456	880	19 381	7 497	938

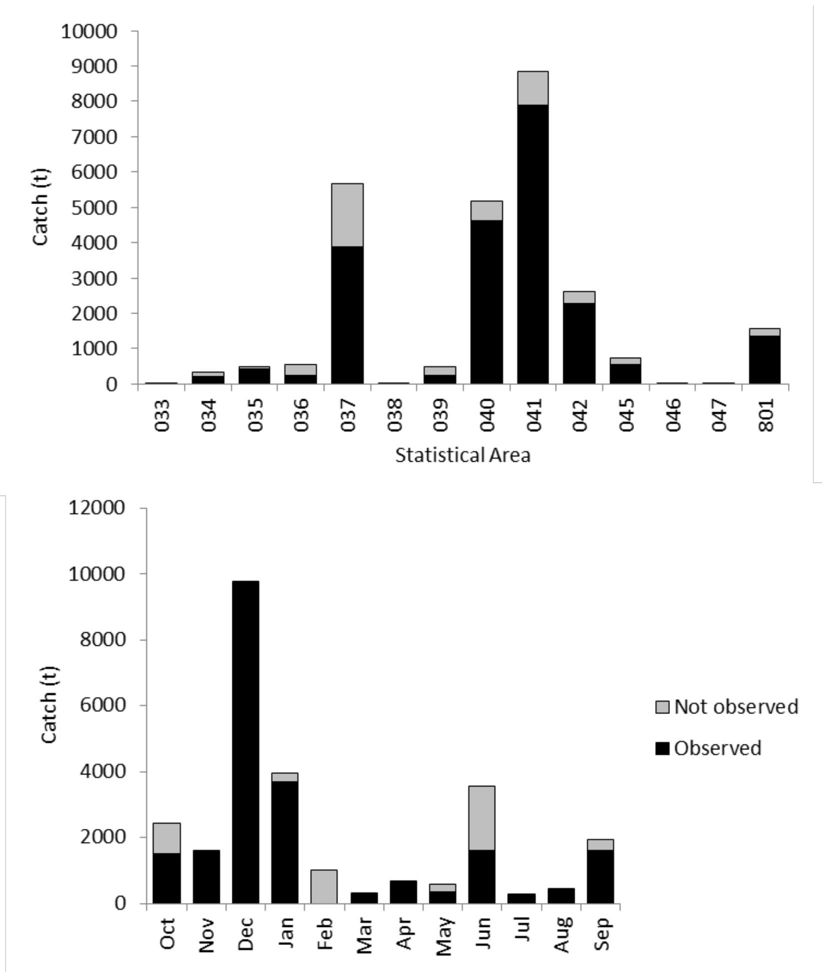

Figure 3: Observed landings and landings that were not observed, by Statistical Area and month, in 2011–12.

3.3 Sex ratios

Sex ratios by fishing year since 2006–07 are shown in Table 3. Generally, ratios are around 50% for *T. declivis* and *T. novaezelandiae*, although *T. novaezelandiae* consistently comprises more females than males. The sex ratios for *T. murphyi* indicate a population quite strongly biased towards males (i.e., 54–62%).

Table 3: Estimated sex ratios (%) in the JMA 7 catch by species and fishing year.

	JMD		JMN		JMM	
Fishing year	Males	Females	Males	Females	Males	Females
2006–07	51.6	48.4	49.5	50.5	54.8	45.2
2007–08	51.7	48.3	43.0	57.0	60.7	39.3
2008–09	52.5	47.5	45.7	54.3	56.9	43.1
2009–10	51.5	48.5	49.1	50.9	54.3	45.7
2010–11	46.8	53.2	43.4	56.6	56.9	43.1
2011–12	48.4	51.6	47.9	52.1	62.1	37.9

3.4 Catch-at-length

The estimated catch-at-length distributions, by species, for trawl-caught jack mackerel from JMA 7 in 2011–12 are plotted in Figure 4. For *T. novaezelandiae* there are two length modes (i.e., 16–22 cm, and 27–32 cm). For *T. declivis* there are strong length modes at 20–23 cm and 40–46 cm, and a secondary mode at about 28–30 cm. The length range of *T. murphyi* is very narrow, with most fish being from 49 to 55 cm. For all species, there is little between-sex difference in the length distributions.

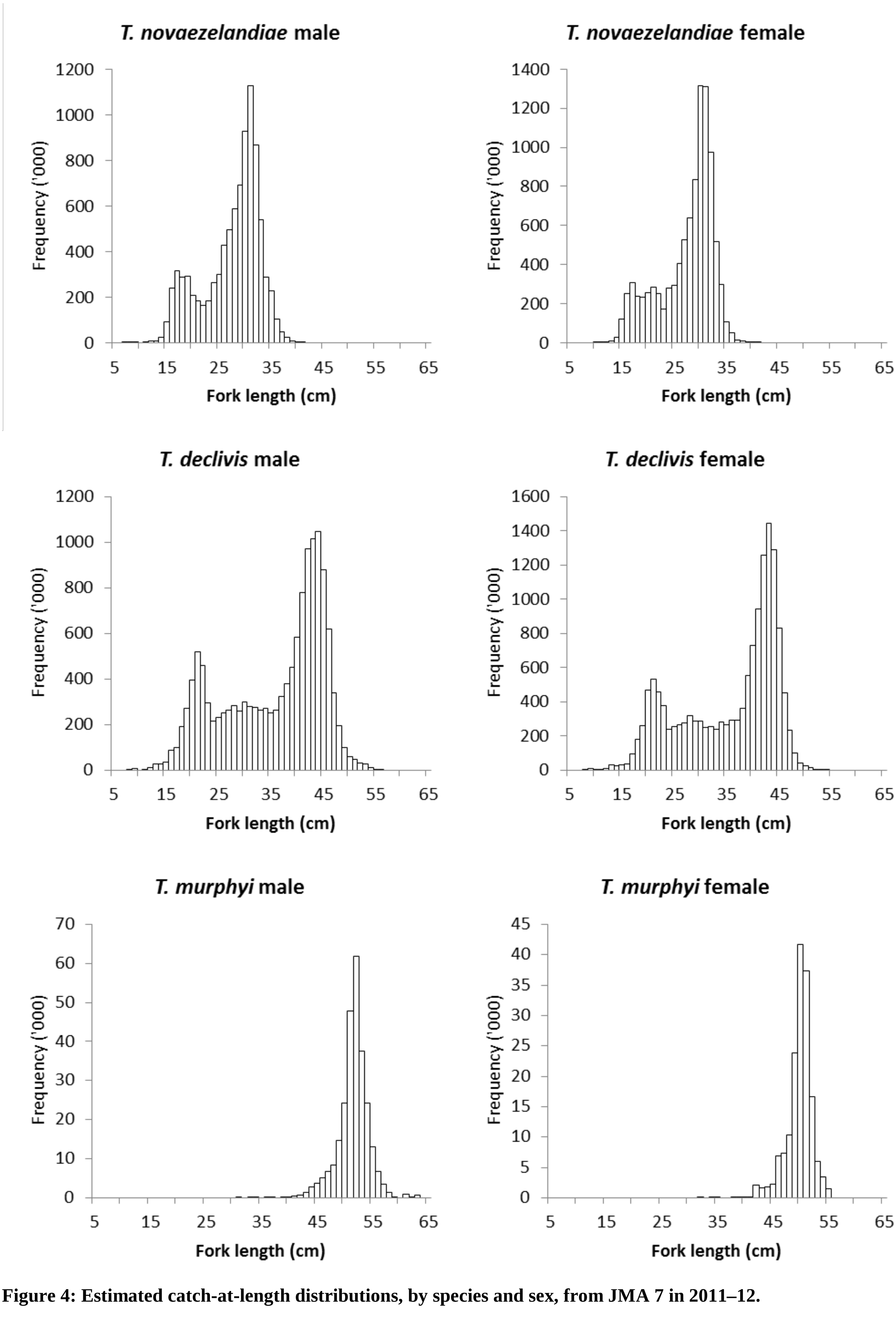

Figure 4: Estimated catch-at-length distributions, by species and sex, from JMA 7 in 2011–12.

3.5 Catch-at-age

The details of the estimated catch-at-age distributions for trawl-caught jack mackerel from JMA 7 in 2011–12 are presented for *T. novaezelandiae* in Table 4, *T. declivis* in Table 5, and *T. murphyi* in Table 6. The mean weighted c.v.s for *T. novaezelandiae* (17%), *T. declivis* (17%), and *T. murphyi* (21%) were all well below the target value of 30%. The estimated distributions are plotted in Figure 5. The catch of *T. novaezelandiae* is dominated by 2–6 year old fish, with very few fish older than 12 years. The catch of *T. declivis* has abundant fish aged 1–11 years old, with few fish older than 14 years. The catch of *T. murphyi* is dominated by 15–20 year old fish, with very few fish younger than 14 or older than 25 years.

Table 4: Calculated numbers-at-age, separately by sex, with c.v.s, for *Trachurus novaezelandiae* caught during commercial trawl operations in JMA 7 during the 2011–12 fishing year. Summary statistics for the sample are also presented.

Age	Male	c.v.	Female	c.v.	Total	c.v.
0	0	–	0	–	0	–
1	251 796	0.583	96 990	0.662	348 786	0.487
2	1 016 419	0.256	1 103 331	0.223	2 119 750	0.209
3	653 622	0.257	829 564	0.280	1 483 187	0.219
4	1 176 254	0.161	1 361 027	0.131	2 537 281	0.109
5	1 450 437	0.138	1 665 585	0.129	3 116 022	0.097
6	667 593	0.215	909 983	0.177	1 577 577	0.133
7	645 999	0.220	552 428	0.258	1 198 427	0.176
8	395 545	0.280	465 379	0.252	860 925	0.187
9	577 350	0.210	621 192	0.219	1 198 542	0.157
10	251 090	0.343	269 901	0.363	520 990	0.252
11	548 216	0.204	644 889	0.207	1 193 105	0.145
12	533 077	0.221	494 602	0.232	1 027 678	0.166
13	215 557	0.300	258 781	0.309	474 338	0.222
14	172 631	0.371	165 793	0.374	338 425	0.272
15	164 487	0.369	61 588	0.544	226 075	0.305
16	39 185	0.455	170 092	0.361	209 278	0.311
17	133 542	0.425	55 670	0.719	189 211	0.374
18	39 992	0.629	4 643	0.997	44 635	0.565
No. measured		17 585		20 735		38 320
No. aged		263		266		535
No. of tows sampled						549
Mean weighted c.v.		23.4		21.8		17.1

Table 5: Calculated numbers-at-age, separately by sex, with c.v.s, for *Trachurus declivis* caught during commercial trawl operations in JMA 7 during the 2011–12 fishing year. Summary statistics for the sample are also presented.

Age	Male	c.v.	Female	c.v.	Total	c.v.
0	0	–	0	–	0	–
1	1 589 118	0.244	1 601 167	0.348	3 190 285	0.267
2	1 118 625	0.246	652 384	0.351	1 771 010	0.229
3	1 480 474	0.209	1 860 193	0.197	3 340 667	0.162
4	822 411	0.250	1 321 205	0.225	2 143 615	0.182
5	1 616 458	0.145	1 138 577	0.171	2 755 035	0.115
6	974 850	0.181	1 406 860	0.148	2 381 710	0.114
7	906 310	0.179	1 215 927	0.155	2 122 236	0.117
8	821 843	0.190	762 293	0.205	1 584 136	0.140
9	837 593	0.189	1 146 671	0.169	1 984 264	0.124
10	566 252	0.232	1 021 582	0.167	1 587 835	0.137
11	1 031 919	0.167	793 492	0.210	1 825 411	0.127
12	827 058	0.191	479 469	0.250	1 306 527	0.158
13	433 594	0.284	326 777	0.297	760 371	0.208
14	160 652	0.444	614 275	0.207	774 927	0.183
15	232 611	0.409	80 446	0.687	313 057	0.339
16	95 716	0.605	75 816	0.782	171 533	0.472
17	128 532	0.497	34 127	0.771	162 660	0.438
18	8 568	0.948	8 289	0.925	16 857	0.690
No. measured		25 654		27 096		52 750
No. aged		279		288		567
No. of tows sampled						674
Mean weighted c.v.		21.6		22.2		16.7

Table 6: Calculated numbers-at-age, separately by sex, with c.v.s, for *Trachurus murphyi* caught during commercial trawl operations in JMA 7 during the 2011–12 fishing year. Summary statistics for the sample are also presented.

Age	Male	c.v.	Female	c.v.	Total	c.v.
4	485	1.114	209	1.773	693	1.047
5	595	0.745	177	1.826	772	0.747
6	3 148	0.662	4 673	0.508	7 821	0.420
7	1 835	1.093	0	–	1 835	1.093
8	2 028	0.891	0	–	2 028	0.891
9	2 723	0.875	4 883	0.786	7 606	0.596
10	1 394	1.225	0	–	1 394	1.225
11	1 394	1.119	0	–	1 394	1.119
12	895	1.043	0	–	895	1.043
13	1 403	0.934	3 934	0.612	5 338	0.511
14	10 915	0.357	2 952	0.677	13 868	0.322
15	44 831	0.151	29 151	0.204	73 981	0.119
16	62 889	0.133	32 465	0.164	95 354	0.102
17	40 170	0.148	25 854	0.195	66 024	0.119
18	26 581	0.225	16 815	0.232	43 395	0.165
19	16 956	0.236	10 344	0.311	27 300	0.182
20	13 737	0.256	8 076	0.355	21 813	0.198
21	7 117	0.325	7 584	0.351	14 700	0.231
22	6 335	0.341	5 855	0.415	12 190	0.267
23	8 442	0.365	3 230	0.515	11 672	0.298
24	1 270	0.831	0	–	1 270	0.831
25	4 237	0.461	3 452	0.457	7 688	0.336
26	1 755	0.788	0	–	1 755	0.788
27	1 269	0.916	822	1.078	2 091	0.673
28	271	1.301	0	–	271	1.301
29	1 991	0.780	0	–	1 991	0.780
30	1 194	1.041	1 615	0.819	2 808	0.645
31	895	0.952	822	1.047	1 717	0.693
No. measured		1 243		850		2 093
No. aged		280		177		457
No. of tows sampled						381
Mean weighted c.v.		26.4		30.1		20.6

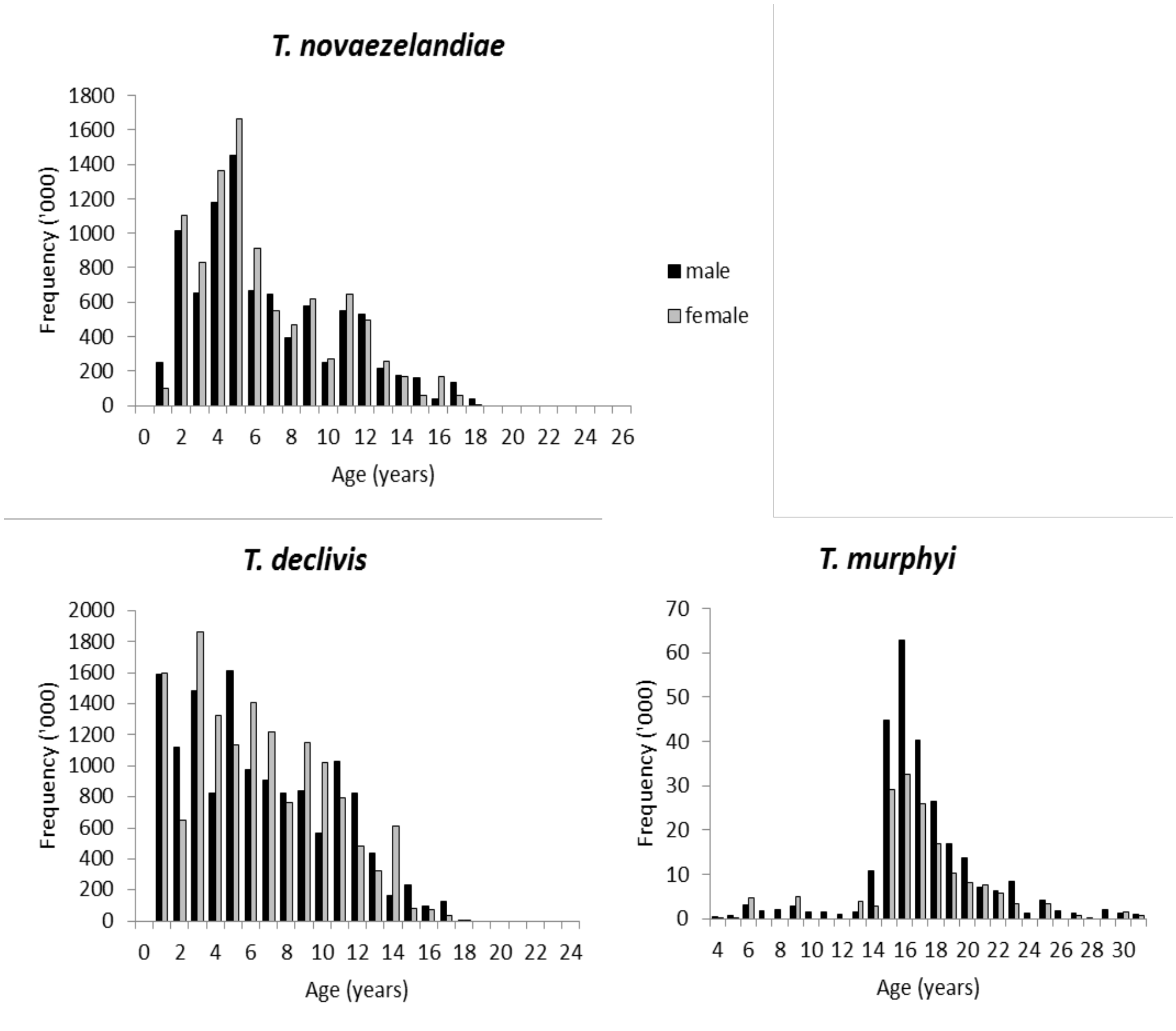

Figure 5: Estimated commercial catch-at-age distributions, by species and sex, from JMA 7 in 2011–12.

3.6 Data summaries

Catch-at-length and catch-at-age data from the JMA 7 fishery are now available from six consecutive years since 2006–07. Mean weighted c.v.s for the length and age distributions, by sex and year, are listed for each species in Table 7. The c.v.s for the total age distributions met or exceeded the target of 30% for all species in all years, except for *Trachurus murphyi* in 2006–07.

Total (i.e., sexes combined) scaled length and age distributions, by species and fishing year are shown in Figures 6–8. The data used to produce these catch-at-age distributions are listed in Appendix A.

Table 7: Mean weighted c.v.s (mwCV) for catch-at-age and catch-at-length distributions, by species, sex, and fishing year.

		Catch-at-age mwCV (%)			Catch-at-length mwCV (%)		
Species	Fishing year	Males	Females	Total	Males	Females	Total
T. declivis	2006–07	31	38	25	12	12	9
	2007–08	26	34	24	13	13	12
	2008–09	34	40	27	11	10	9
	2009–10	25	28	20	13	12	10
	2010–11	25	23	18	12	11	9
	2011–12	22	22	17	15	15	13
T. novaezelandiae	2006–07	26	24	19	17	16	14
	2007–08	27	25	22	17	12	13
	2008–09	39	39	30	14	11	11
	2009–10	32	27	23	16	15	12
	2010–11	28	24	20	20	16	15
	2011–12	23	22	17	17	16	14
T. murphyi	2006–07	41	57	38	37	37	31
	2007–08	34	48	30	17	21	14
	2008–09	35	48	30	20	21	15
	2009–10	35	47	30	27	28	23
	2010–11	31	36	23	28	28	21
	2011–12	26	30	21	20	22	16

Trachurus novaezelandiae

Scaled length-frequencies by fishing year for *T. novaezelandiae* are shown in Figure 6. There are modes at about 28–31 cm in all distributions. The distributions are all generally similar, except for a dominant second mode at 24 cm in 2009–10. Scaled age-frequencies for *T. novaezelandiae*, by fishing year, are quite variable between years (Figure 6). However, some possible year class progressions can be postulated. The 1+ year class is strong in 2007–08, and maintains a relatively high abundance in all subsequent years. The 1+ year class in 2008–09 may also be relatively strong. Year classes 4, 5, and 6 in 2006–07 also appear to be relatively strong throughout the series, although there are some inconsistencies (e.g., year classes 7 in 2009–10 and 10 in 2011–12 are weak).

Trachurus declivis

Scaled length-frequencies for *T. declivis*, by fishing year, are often multi-modal (Figure 7). They generally cover similar ranges from about 16 cm to about 50 cm, with a consistent strong mode at 42–44 cm. Most variation in abundance occurs with the fish shorter than 37 cm, presumably relating to the relative strengths of juvenile year classes. Scaled age-frequencies for *T. declivis*, by fishing year, are shown in Figure 7. There is a wide range of ages in the catches, and the distributions are quite variable between years. There is evidence of two relatively strong year classes aged 1 and 2 in 2007–08 that maintain a relatively high abundance in all subsequent years.

Trachurus murphyi

Scaled length-frequencies for *T. murphyi*, by fishing year, are shown in Figure 8. All the distributions are unimodal, peaking at 49–51 cm, and are generally similar with few fish smaller than 45 cm. Scaled age-frequencies for *T. murphyi* by fishing year (Figure 8) exhibit a wide range of ages although few fish younger than 10 years are recorded in any year. There is evidence of relatively strong year classes at ages 11 and 12 in 2006–07 that progress to ages 16 and 17 in 2011–12.

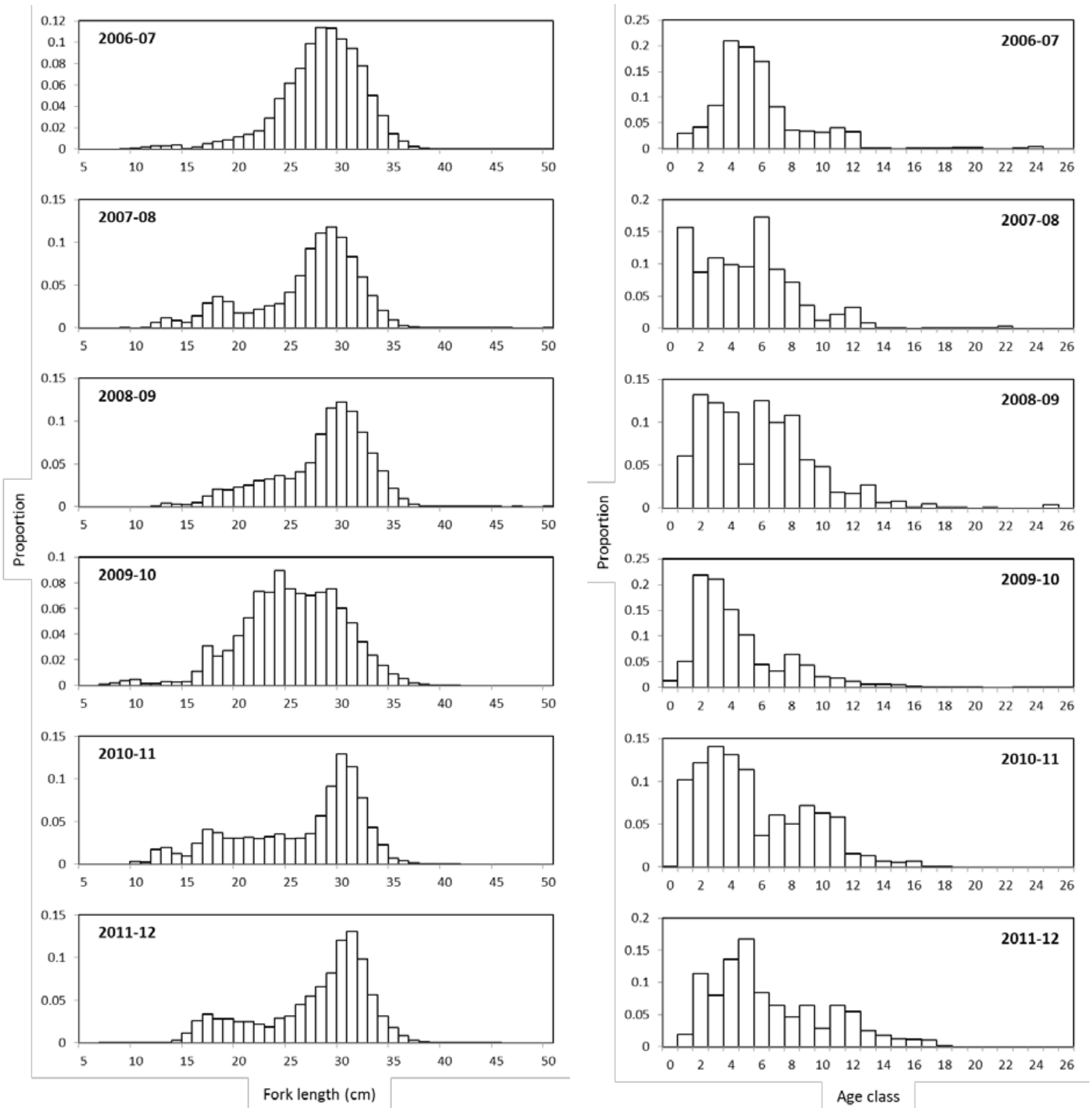

Figure 6: Scaled catch-at-length (left panel) and catch-at-age (right panel) proportions for the catch of *Trachurus novaezelandiae* in all fishing years since 2006–07.

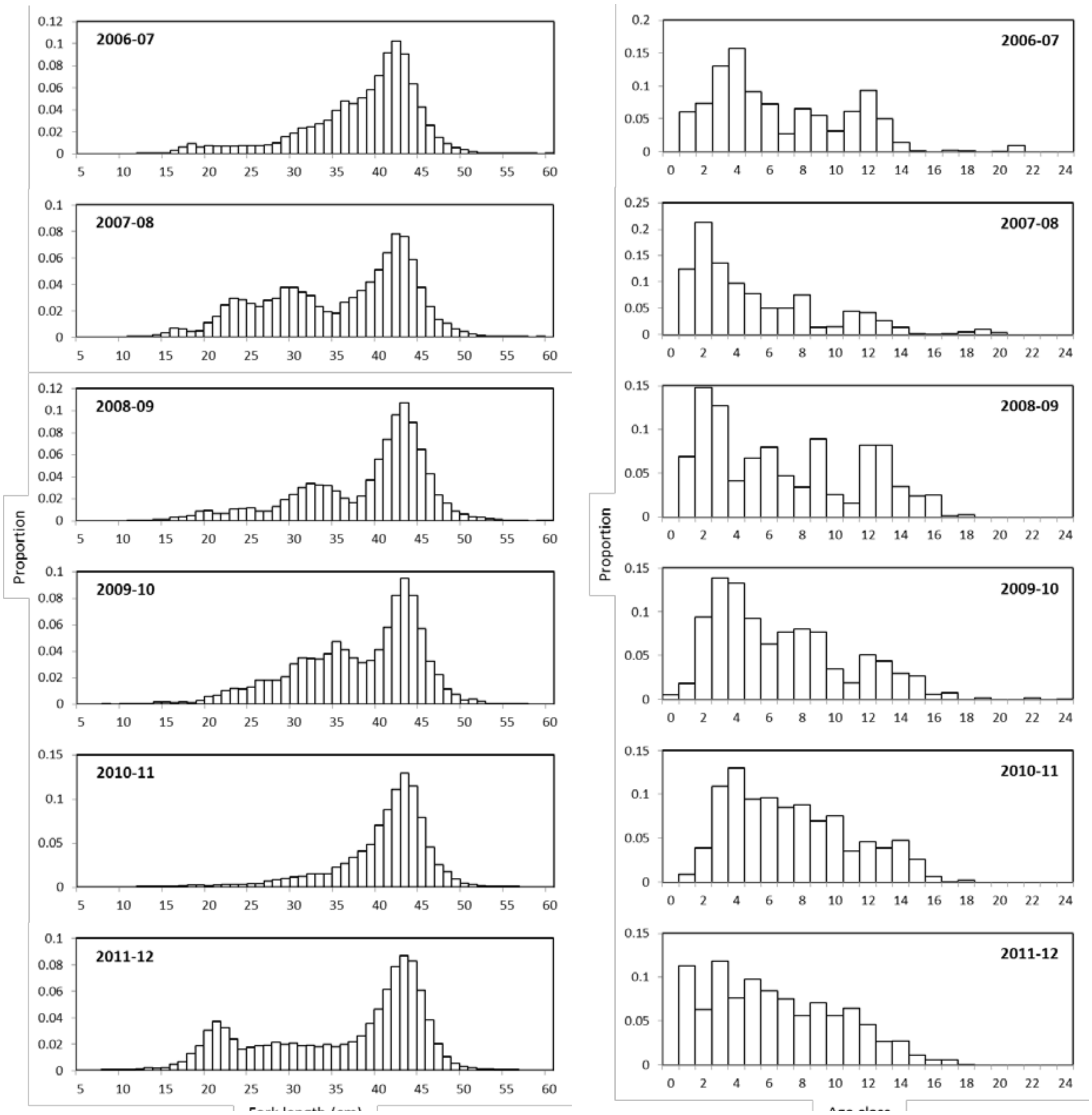

Figure 7: Scaled catch-at-length (left panel) and catch-at-age (right panel) proportions for the catch of *Trachurus declivis* in all fishing years since 2006–07.

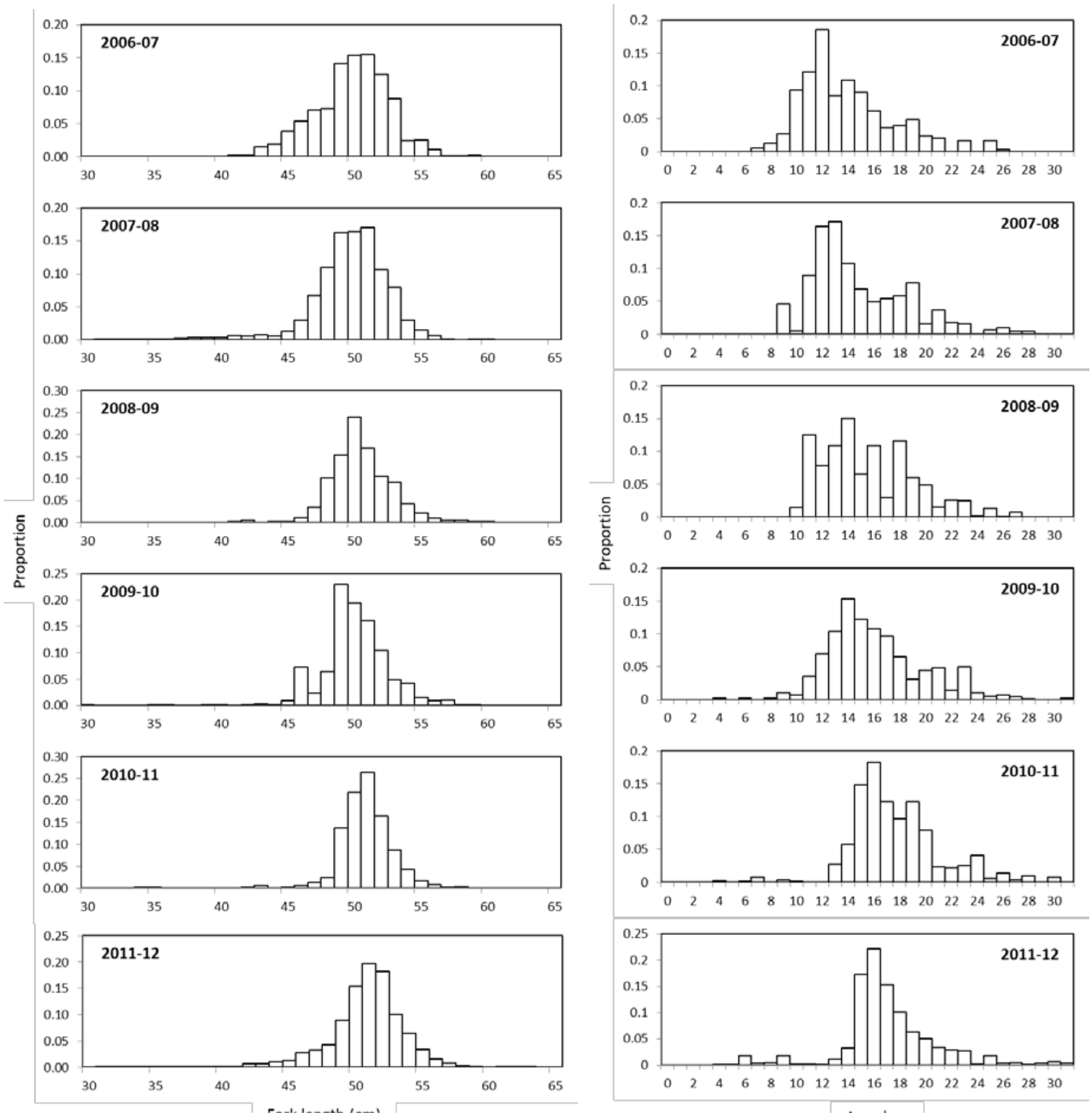

Figure 8: Scaled catch-at-length (left panel) and catch-at-age (right panel) proportions for the catch of *Trachurus murphyi* in all fishing years since 2006–07.

4. DISCUSSION

The jack mackerel trawl fishery in 2011–12 was comprehensively sampled. Sampling intensity was high in all months except February when landings were moderate but no sampling occurred. Spatially, there was very good coverage of catch in the heavily fished Statistical Areas (037, 040–042). Estimates of the 2011–12 catch-at-age for all three jack mackerel species had mean weighted c.v.s over all age classes of 21% or less, well below the target of 30%.

Estimates of species proportions indicate a consistent predominance of *T. declivis* at around 65–71% of total catch weight in the six fishing years from which data are available. The percentage of *T. novaezelandiae* is also consistent temporally at 25–28%. The predominance of *T. declivis* overall is expected given that this species generally occurs deeper and further offshore than *T. novaezelandiae* and that most of the vessels targeting jack mackerels are restricted to fishing at least 12 n.miles, and often 25 n.miles off the coast.

Most of the *T. declivis* catch in all years comprises adult fish at least 37 cm long. Differences between years in the length distributions occur primarily in the abundance of fish shorter than 37 cm, and this is a consequence of variation in year class strengths.

The mean age of *T. murphyi* in the catch has generally increased over the six sampled years. In 2006–07, most fish were 10–15 years old, compared with 15–20 years old in 2010–11 and 2011–12. This is indicative of a strong recruitment pulse, comprising several year classes, possibly as a result of immigration from international waters. These year classes are now growing through, with no evidence of any significant new immigration or recruitment through spawning success. The collected data on sex of *T. murphyi* indicate a population consistently biased towards males (i.e., 54–62% of sampled fish). It is known (author's unpublished data) that *T. murphyi* can, at times, be quite difficult to sex, with deposits of fat in the body cavity often appearing like male gonads when the gonads are in a regressed state. However, it is interesting to note that in four research surveys conducted on the Stewart-Snares shelf in February each year from 1993 to 1996 males were also dominant, ranging from 62 to 71% of the sexed mackerels (Hurst & Bagley 1997).

The *T. novaezelandiae* catch also has a consistent strong adult length mode (at about 28–31 cm) in all sampled years, although in 2009–10 the relative abundance of 2–4 year old fish (i.e., lengths about 20–27 cm) outweighs the adult mode. The progression of some relatively strong year classes through the time series is apparent. Taylor (2008) noted that there was a preference in the JMA 7 trawl fishery for larger jack mackerel (i.e., *T. declivis*). Vessels attempting to maximise their catch of *T. declivis* may consequently not comprehensively sample the *T. novaezelandiae* population in the area, resulting in a greater degree of between-year variation in the *T. novaezelandiae* length and age distributions, so it is pleasing that year class progressions are still apparent under this sampling regime.

The 2011–12 commercial fishery length and age distributions for *T. novaezelandiae* and *T. declivis* can be compared with the distributions estimated from a pilot research survey conducted primarily in the south Taranaki Bight in February 2012 (Appendix B). Differences between the survey and the fishery distributions would be expected because of temporal (i.e., the whole year compared with 10 days in February) and areal (i.e., all of area JMA 7 more than 12 n.miles offshore compared with south Taranaki Bight as shallow as 25 m) differences between the two data sources. For *T. declivis*, the survey catch is dominated by small, young fish which the fishery tries to avoid and which often occur within 12 n.miles of the coast. Consequently, the survey and fishery age distributions differ markedly. In contrast, the survey and fishery length distributions for *T. novaezelandiae* are similar, but with the modal adult length in the survey (32 cm) being slightly higher than the fishery modal length (31 cm). Consequently, there is a greater proportion of fish older than about 7 years in the survey than in the fishery. Clearly, the fishery and survey selectivity ogives would differ markedly.

5. ACKNOWLEDGMENTS

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Appendix A: Proportions-at-age by species and fishing year

This appendix lists the estimated proportions-at-age in the JMA 7 trawl fishery, by species and fishing year. The columns in each table are headed so that, for example, the year 2007 refers to the 2006–07 fishing year. Data are presented with sexes combined, in a format that can easily be converted to a CASAL input file in a single-sex model.

Table A1: Proportions-at-age (male, female, and unsexed combined), with c.v.s, for *T. novaezelandiae*, by fishing year.

	Proportion						c.v.					
Age	2007	2008	2009	2010	2011	2012	2007	2008	2009	2010	2011	2012
0	0	0	0	0.0127	0.0007	0				0.913	2.006	
1	0.0294	0.1574	0.0605	0.0510	0.1021	0.0187	0.419	0.416	0.327	0.389	0.378	0.487
2	0.0422	0.0871	0.1319	0.2183	0.1216	0.1136	0.349	0.138	0.162	0.213	0.249	0.209
3	0.0846	0.1091	0.1225	0.2108	0.1408	0.0795	0.224	0.144	0.188	0.186	0.185	0.219
4	0.2088	0.0985	0.1116	0.1517	0.1312	0.1359	0.124	0.171	0.309	0.172	0.114	0.109
5	0.1970	0.0959	0.0509	0.1020	0.1137	0.1670	0.106	0.176	0.399	0.209	0.124	0.097
6	0.1693	0.1727	0.1244	0.0443	0.0367	0.0845	0.126	0.131	0.277	0.281	0.228	0.133
7	0.0819	0.0911	0.0992	0.0319	0.0604	0.0642	0.193	0.203	0.330	0.227	0.193	0.176
8	0.0358	0.0712	0.1079	0.0639	0.0503	0.0461	0.276	0.216	0.293	0.211	0.189	0.187
9	0.0334	0.0357	0.0557	0.0426	0.0722	0.0642	0.301	0.243	0.314	0.204	0.141	0.157
10	0.0316	0.0121	0.0485	0.0206	0.0631	0.0279	0.319	0.463	0.356	0.230	0.160	0.252
11	0.0404	0.0220	0.0180	0.0181	0.0586	0.0639	0.281	0.328	0.459	0.274	0.170	0.145
12	0.0324	0.0321	0.0167	0.0115	0.0160	0.0551	0.311	0.302	0.518	0.252	0.328	0.166
13	0.0010	0.0080	0.0270	0.0058	0.0131	0.0254	1.040	0.341	0.313	0.327	0.316	0.222
14	0.0012	0.0006	0.0062	0.0066	0.0071	0.0181	0.944	1.193	0.454	0.367	0.429	0.272
15	0	0.0002	0.0081	0.0046	0.0051	0.0121		1.358	0.655	0.336	0.392	0.305
16	0.0004	0	0.0003	0.0027	0.0067	0.0112	1.203		1.060	0.494	0.451	0.311
17	0.0008	0.0012	0.0048	0.0005	0.0006	0.0101	0.643	1.028	1.002	0.594	1.160	0.374
18	0.0006	0.0004	0.0004	0.0001	0.0001	0.0024	0.864	1.021	1.251	2.105	1.712	0.565
19	0.0026	0.0011	0.0003	0.0001	0	0	0.671	0.949	0.884	1.916		
20	0.0025	0.0003	0	0.0000	0	0	0.898	0.895		1.253		
21	0	0.0003	0.0009	0	0	0		0.835	0.769			
22	0	0.0029	0	0	0	0		0.572				
23	0.0010	0	0	0.0000	0	0	1.022			1.134		
24	0.0034	0	0	0.0001	0	0	0.544			0.887		
25	0	0	0.0042	0.0000	0	0			0.518	2.166		
26	0	0	0	0.0002	0	0				1.049		

Table A2: Proportions-at-age (male, female, and unsexed combined), with c.v.s, for *T. declivis*, by fishing year.

	Proportion						c.v.					
Age	2007	2008	2009	2010	2011	2012	2007	2008	2009	2010	2011	2012
0	0	0	0	0.0054	0	0				0.428		
1	0.0605	0.1245	0.0693	0.0180	0.0092	0.1132	0.220	0.175	0.170	0.326	0.355	0.267
2	0.0737	0.2125	0.1478	0.0942	0.0390	0.0628	0.172	0.145	0.134	0.207	0.191	0.229
3	0.1307	0.1357	0.1273	0.1387	0.1091	0.1185	0.141	0.119	0.144	0.141	0.134	0.162
4	0.1574	0.0972	0.0416	0.1327	0.1301	0.0760	0.118	0.176	0.311	0.130	0.113	0.182
5	0.0907	0.0784	0.0678	0.0923	0.0949	0.0977	0.244	0.227	0.299	0.160	0.143	0.115
6	0.0728	0.0492	0.0798	0.0629	0.0963	0.0845	0.303	0.325	0.322	0.190	0.153	0.114
7	0.0270	0.0491	0.0475	0.0767	0.0851	0.0753	0.503	0.256	0.385	0.168	0.169	0.117
8	0.0654	0.0755	0.0343	0.0801	0.0883	0.0562	0.310	0.371	0.437	0.186	0.175	0.140
9	0.0549	0.0131	0.0894	0.0768	0.0701	0.0704	0.309	0.503	0.260	0.177	0.176	0.124
10	0.0315	0.0154	0.0257	0.0345	0.0750	0.0563	0.486	0.482	0.463	0.300	0.184	0.137
11	0.0618	0.0443	0.0160	0.0192	0.0354	0.0647	0.272	0.329	0.635	0.367	0.230	0.127
12	0.0934	0.0422	0.0819	0.0507	0.0458	0.0463	0.254	0.301	0.286	0.214	0.216	0.158
13	0.0496	0.0260	0.0823	0.0435	0.0391	0.0270	0.363	0.454	0.281	0.236	0.237	0.208
14	0.0137	0.0138	0.0352	0.0299	0.0478	0.0275	0.537	0.456	0.476	0.268	0.209	0.183
15	0.0015	0.0024	0.0240	0.0264	0.0256	0.0111	0.858	0.912	0.400	0.273	0.295	0.339
16	0	0.0005	0.0251	0.0057	0.0068	0.0061		0.686	0.335	0.469	0.545	0.472
17	0.0031	0.0017	0.0023	0.0075	0.0004	0.0058	0.973	0.966	0.581	0.647	1.049	0.438
18	0.0013	0.0042	0.0028	0	0.0020	0.0006	1.050	0.395	0.633		1.091	0.690
19	0	0.0104	0	0.0023	0	0		0.762		1.020		
20	0.0006	0.0038	0	0	0	0	1.101	0.975				
21	0.0104	0	0	0	0	0	0.430					
22	0	0	0	0.0023	0	0				0.963		
23	0	0	0	0	0	0						
24	0	0	0	0.0003	0	0				1.254		

Table A3: Proportions-at-age (male, female, and unsexed combined), with c.v.s, for *T. murphyi*, by fishing year.

	Proportion						c.v.					
Age	2007	2008	2009	2010	2011	2012	2007	2008	2009	2010	2011	2012
4	0	0	0	0.0020	0.0026	0.0016				2.236	1.146	1.047
5	0	0	0	0	0	0.0018						0.747
6	0	0	0	0.0021	0.0005	0.0182				1.423	2.163	0.420
7	0.0055	0	0	0	0.0073	0.0043	1.041				1.841	1.093
8	0.0126	0	0	0.0026	0	0.0047	0.625			1.481		0.891
9	0.0272	0.0458	0	0.0105	0.0036	0.0177	0.413	0.333		0.948	0.873	0.596
10	0.0935	0.0053	0.0144	0.0071	0.0012	0.0032	0.335	0.594	0.615	0.803	1.888	1.225
11	0.1216	0.0895	0.1258	0.0350	0	0.0032	0.301	0.263	0.222	0.383		1.119
12	0.1857	0.1634	0.0784	0.0692	0	0.0021	0.201	0.190	0.304	0.584		1.043
13	0.0847	0.1708	0.1092	0.1040	0.0273	0.0124	0.282	0.172	0.241	0.178	0.363	0.511
14	0.1092	0.1083	0.1499	0.1530	0.0567	0.0323	0.231	0.248	0.208	0.233	0.235	0.322
15	0.0900	0.0687	0.0657	0.1227	0.1488	0.1722	0.300	0.323	0.318	0.271	0.144	0.119
16	0.0628	0.0484	0.1092	0.1080	0.1823	0.2219	0.410	0.309	0.235	0.192	0.130	0.102
17	0.0363	0.0538	0.0305	0.0965	0.1224	0.1537	0.514	0.318	0.299	0.178	0.174	0.119
18	0.0395	0.0580	0.1163	0.0658	0.0962	0.1010	0.476	0.380	0.243	0.222	0.183	0.165
19	0.0489	0.0783	0.0606	0.0308	0.1227	0.0635	0.639	0.306	0.334	0.304	0.155	0.182
20	0.0244	0.0154	0.0486	0.0450	0.0784	0.0508	0.722	0.521	0.371	0.235	0.228	0.198
21	0.0211	0.0364	0.0159	0.0492	0.0233	0.0342	0.647	0.436	0.821	0.269	0.374	0.231
22	0	0.0180	0.0256	0.0151	0.0223	0.0284		0.770	0.406	0.433	0.392	0.267
23	0.0168	0.0160	0.0251	0.0501	0.0255	0.0272	1.119	0.755	0.541	0.273	0.340	0.298
24	0	0	0.0024	0.0103	0.0409	0.0030			0.778	0.576	0.295	0.831
25	0.0168	0.0063	0.0138	0.0048	0.0051	0.0179	1.093	1.019	0.854	0.655	0.763	0.336
26	0.0033	0.0097	0.0009	0.0076	0.0134	0.0041	1.247	1.032	1.217	0.564	0.543	0.788
27	0	0.0041	0.0078	0.0046	0.0031	0.0049		0.980	0.643	0.791	1.018	0.673
28	0	0.0039	0	0.0011	0.0092	0.0006		0.933		1.060	0.630	1.301
29	0	0	0	0	0	0.0046						0.780
30	0	0	0	0	0.0073	0.0065					0.836	0.645
31	0	0	0	0.0027	0	0.0040				1.014		0.693

Appendix B: Catch composition of jack mackerels from survey TAN1202

This appendix presents the estimated catch-at-length and catch-at-age for *Trachurus declivis* and *T. novaezelandiae* caught in bottom trawl stations used to identify acoustic marks during survey TAN1202 conducted in early February 2012 in the south Taranaki Bight and Tasman Bay (O'Driscoll 2012). Catches of *T. murphyi* in the survey were negligible. The aim of this 10-day voyage was to better understand the vertical distribution and schooling behaviour of jack mackerel (and co-occurring species) in areas of high abundance, with the goal of formulating a scientifically robust acoustic survey methodology.

Estimated length- and age-frequency distributions for the population in the survey area, by species with sexes combined, are presented in Figure B1. The estimated catch-at-age data are listed in a format that can easily be converted to a CASAL input file in a single-sex model (Table B1).

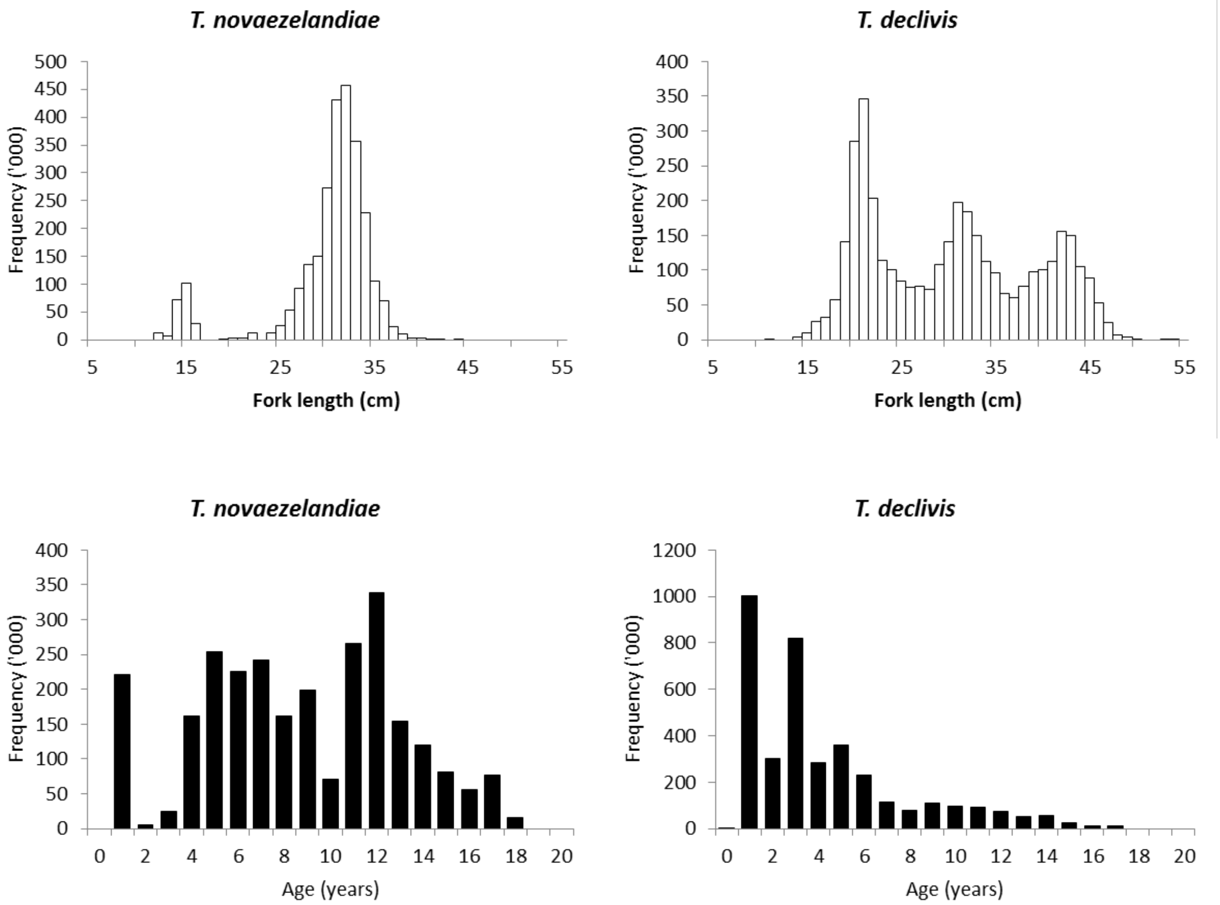

Figure B1: Estimated catch-at-length (top panel) and catch-at-age (bottom panel) distributions, by species, from survey TAN1202 in February 2012.

Table B1: Calculated proportions-at-age for sexes combined, with c.v.s, for *Trachurus novaezelandiae* and *T. declivis* caught during survey TAN1202. Summary statistics for the sample are also presented.

	T. novaezelandiae		*T. declivis*	
Age class (years)	Proportion	c.v.	Proportion	c.v.
0	0	–	0.0002	4.900
1	0.0828	0.958	0.2691	0.309
2	0.0018	1.022	0.0812	0.456
3	0.0093	0.585	0.2198	0.393
4	0.0607	0.432	0.0759	0.447
5	0.0950	0.337	0.0967	0.384
6	0.0845	0.338	0.0623	0.301
7	0.0904	0.342	0.0312	0.315
8	0.0606	0.328	0.0215	0.393
9	0.0741	0.311	0.0294	0.371
10	0.0263	0.460	0.0260	0.388
11	0.0996	0.307	0.0252	0.356
12	0.1265	0.290	0.0194	0.360
13	0.0574	0.359	0.0138	0.425
14	0.0451	0.404	0.0147	0.394
15	0.0302	0.444	0.0066	0.562
16	0.0207	0.483	0.0032	0.758
17	0.0287	0.414	0.0036	0.678
18	0.0062	0.630	0	–
19	0	–	0	–
20	0	–	0	–
No. measured		1345		2281
No. aged		340		371
No. of tows sampled		31		38
Mean weighted c.v.		40.4		37.3