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Commercial catch sampling for species proportion, sex, length, and age of jack mackerels in JMA 7 in the 2019–20 fishing year, with a summary of all available data sets

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EXECUTIVE SUMMARY

Saunders, R.J.[1]; Ó Maolagáin, C.; Hulston, D.; Spong, K. (2022). Commercial catch sampling for species proportion, sex, length, and age of jack mackerels in JMA 7 in the 2019–20 fishing year, with a summary of all available data sets.

***New Zealand Fisheries Assessment Report 2022/52*. 26 p.**

This report describes the scientific observer sampling programme carried out on trawl landings of jack mackerels (*Trachurus novaezelandiae*, *T. declivis*, and *T. murphyi*) in JMA 7 (central west coast) during the 2019–20 fishing year and provides 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 set included estimated total jack mackerel catch and catch 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 varied with both month and statistical area. About 70% of the 2019–20 landed catch was sampled, and sampling was considered to be representative of the landings both temporally and spatially. However, the rate of misidentifications by observers was at least 8% for *T. novaezelandiae* and at least 3% for *T. declivis*. Thus, catch-at-age for JMA species should be interpreted cautiously.

The scaled length distributions from 2019–20 were similar to those from the 11 previous years although there is a gradual decline in the abundance of large (> 50 cm) *T. declivis*. The scaled age frequency distributions for all species in 2019–20 had mean weighted CVs of 25% or less, which met the Fisheries New Zealand specified target of 30%. The length frequency distributions are also subject to issues concerning species identification and should be interpreted cautiously.

Estimated species proportions based on observer data showed a dominance of *T. declivis* at 61–73% (72% in 2019–20) in the JMA 7 catch and effort data for all statistical areas and the 13 years of sampling, while *T. novaezelandiae* was 21–33% (22% in 2019–20) and *T. murphyi* was 3–8% (6% in 2019–20).

Sex ratios of *T. novaezelandiae* usually have been biased slightly toward females than males but were slightly biased towards males in 2019–20 fishing year. Sex ratios for *T. declivis* have been approximately 50% including the most recent fishing year. The sex ratios for *T. murphyi* indicate a sampled population strongly biased towards males.

[1] All authors: National Institute of Water and Atmospheric Research (NIWA), New Zealand.

1. INTRODUCTION

Commercial catches of jack mackerels are recorded as an aggregate of the three species (*Trachurus declivis*, *T. murphyi*, and *T. novaezelandiae*) under the general code JMA, so separate species catch information is not available from Fisheries New Zealand databases for the jack mackerel fishstock areas (Figure 1). Estimates of proportions of the three *Trachurus* species in the catch are essential for assessment of the individual stocks. Species proportion estimates from scientific observer sampling are necessary to derive catch histories for each species from aggregated catch data, and these can be used to scale age samples from the various fisheries. Since the mid-2000s the JMA 7 fishery was primarily a trawl fishery with a small proportion of catches made using purse seine or set net. Before then, larger proportions of the JMA 7 catch came from purse seine fishing (Taylor & Julian 2008).

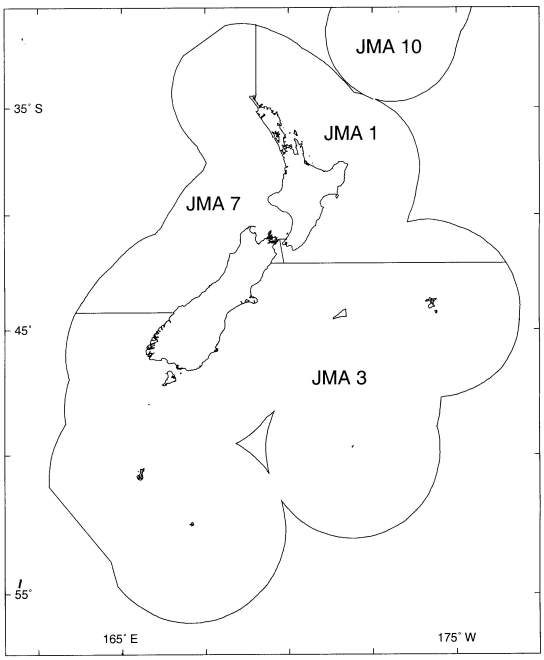

Figure 1: Jack mackerel administrative fishstock areas.

This report provides estimates of relative proportions and catch-at-age for the three *Trachurus* species in the commercial JMA 7 catch for 2019–20 fishing year (1 Oct – 30 Sept) 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, Horn et al. (2012b) for 2010–11, Horn et al. (2013) for 2011–12, Horn et al. (2014) for 2012–13, Horn et al. (2015) for 2013–14, Horn et al. (2017) for 2014–15, Horn et al. (2018) for 2015–16, Horn & Ó Maolagáin (2018) for 2016–17, Horn et al. (2019) for 2017–18, and Saunders et al. (2021) for 2018–19. 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 jack mackerels in objective 1 of Project MID202001 "Routine age determination of deep-water and middle-depth species from commercial fisheries and trawl surveys", funded by Fisheries New Zealand. That objective is "To determine catch-at-age for commercial catches and resource surveys of specified middle-depth and deep-water fishstocks."

The JMA 7 age and size structure of the commercial catch has been determined annually since 2006–07 and this report adds the latest fishing year (2019–20) to that series. In addition, the catch-at-age analyses for the 2015–16 and 2018–19 fishing years have been updated to correct an otolith interpretation problem identified during analysis for those years and to correct the scaling due to inaccurate catch and effort statistics used in the 2015–16 and 2018–19 fishing years.

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 generally carried out according to instructions developed at NIWA and included in the Scientific Observers Manual. Most tows in the observer data set included estimated total jack mackerel catch and weights by species. All observer data on jack mackerels sampled from JMA 7 in the 2019–20 fishing year were extracted for the analyses. As in previous analyses, species proportions (by weight) in each sampled tow were assumed to be the same as the proportions in a randomly selected observer 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 Fisheries New Zealand Enterprise Data Warehouse, were used in these analyses. The data comprised estimated catch and associated date, position, depth, and fishing method data from all fishing events that recorded catches of jack mackerel from JMA 7 (i.e., Quota Management Areas 7, 8, and 9) in 2019–20.

Stratification of the data was required because the observer coverage varied with both month and statistical area, the fishery was not consistent throughout the year, and the species composition varied across area and depth (Taylor et al. 2011). The stratification used for years 2006–07 to 2013–14 was derived by Taylor et al. (2011) based on data from the first three years of that series (shown in appendix A of Horn et al. 2012). The stratification was re-evaluated in 2016 by Horn et al. (2017) and found to be little different to that developed by Taylor et al. (2011). The 2016 stratification (shown in appendix A of Horn et al. 2017) was also used in the analysis of the 2019–20 data presented here. In line with the Horn et al. (2017) stratification, each fishing event from the catch and effort data set and the observer data set was allocated to one of the five strata, i.e.,

1. west of longitude 173.15° E (west coast South Island and deeper west coast North Island waters),
2. Statistical Area 041 (north Taranaki Bight) shallower than 120.25 m,
3. Statistical Area 041 (north Taranaki Bight) deeper than 120.25 m,
4. all remaining areas in March and April,
5. all remaining areas in October–February and May–September.

Species proportions in the catch 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. The percentage catch by species was then calculated for each stratum. The total jack mackerel catch in each stratum was obtained by summing the reported estimated catch weights of all tows (from the catch and effort data set) 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 caught by trawl in Statistical Areas 033–047 and 801 of JMA 7 (Figure 2) in the 2019–20 fishing year, using data and otoliths collected by observers. For each 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 because of low numbers of available otoliths and a higher potential number of age classes per length class. Target sample sizes were about 600 per species.

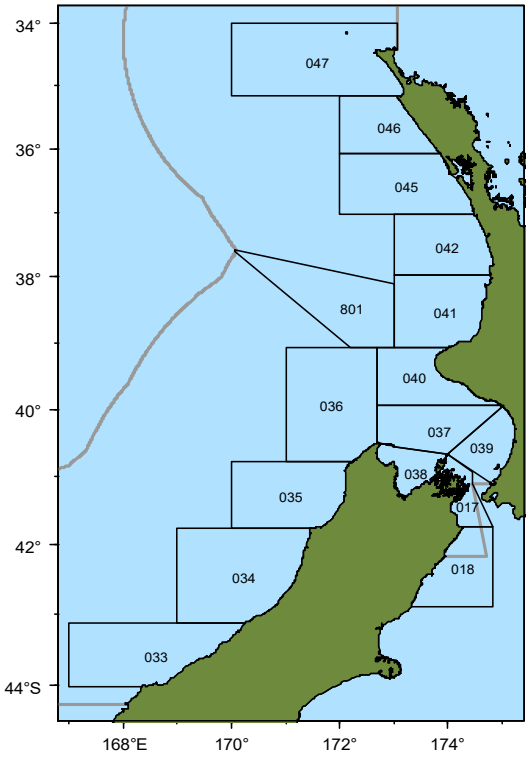

Figure 2: Statistical Areas referred to in the text.

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 (CAA) software (Bull & Dunn 2002). This software also provided estimates of CVs-at-age using a bootstrap procedure. Sex ratios by species were also derived at this stage. The fishery has consistently had two distinct intra-annual peaks (see Results), so the fishing year was split into two equal temporal periods (i.e., October–March and April–September). To account for the growth of fish, particularly of the younger age classes, separate age-length keys were used for each period. For *T. novaezelandiae*, all age data from fish 28 cm or longer were used in both the October–March and April–September age-length keys, because the annual growth increment is slight or negligible for these larger fish. Age data from *T. novaezelandiae* shorter than 28 cm were applied only in the age-length key applicable to their sampling date. For *T. declivis*, a similar procedure was used, but with the length cut-off at 38 cm or greater. For *T. murphyi*, a single age-length key was used for the entire year as virtually all sampled fish were close to the asymptotic length of their growth curve.

Sets of five otoliths were embedded in blocks of clear epoxy resin and cured at 50 °C. Once hardened, a thin transverse section of approximately 380 µm 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 stereo microscope 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 of Horn (1993) and Lyle et al. (2000), described in detail by Horn & Ó Maolagáin (2020). 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, Horn & Ó Maolagáin 2020).

A reader drift problem was identified that resulted in over-ageing for the 2018–19 fishing year for *T. declivis* and *T. novaezelandiae*. These were re-aged by an experienced reader and catch-at-age recalculated using the same methods as previously. Furthermore, the catch data used to scale the catch-

at-age in both the 2015–16 and the 2018–19 fishing years was incomplete. Updated catch data were provided by Fisheries New Zealand and catch-at-age for all JMA species in the 2015–16 and 2018–19 fishing years was recalculated incorporating the new updated data using the same methods as previous analyses.

3. RESULTS

3.1 Catch sampling

The catch distribution in 2019–20 shows that there was a fishery from October to January concentrated in Statistical Areas 037 and 040–042, followed by a secondary fishery centred around June–July and concentrated off the northwest South Island (Areas 034–036) in May–August. Additionally, significant catch was taken in the South Taranaki Bight Area 037 in May–June and North Taranaki Bight Area 041 in May–July (Figure 3; Table 1). The presence of two quite widely separated fishery peaks is consistent with previous years (Saunders et al. 2021).

In 2019–20, about 70% of the catch was sampled by observers (Table 1). Most of the catch was derived from six Statistical Areas (035–037, 040–042), and these were all well sampled (Figure 3, Table 1). The percentages of the catch sampled in the eight most productive months was less consistent than in previous years and ranged from 26% to 98% (Table 1). The sampling of the fishery was adequate to estimate the overall catch-at-age but about 10% less than that in 2018–19.

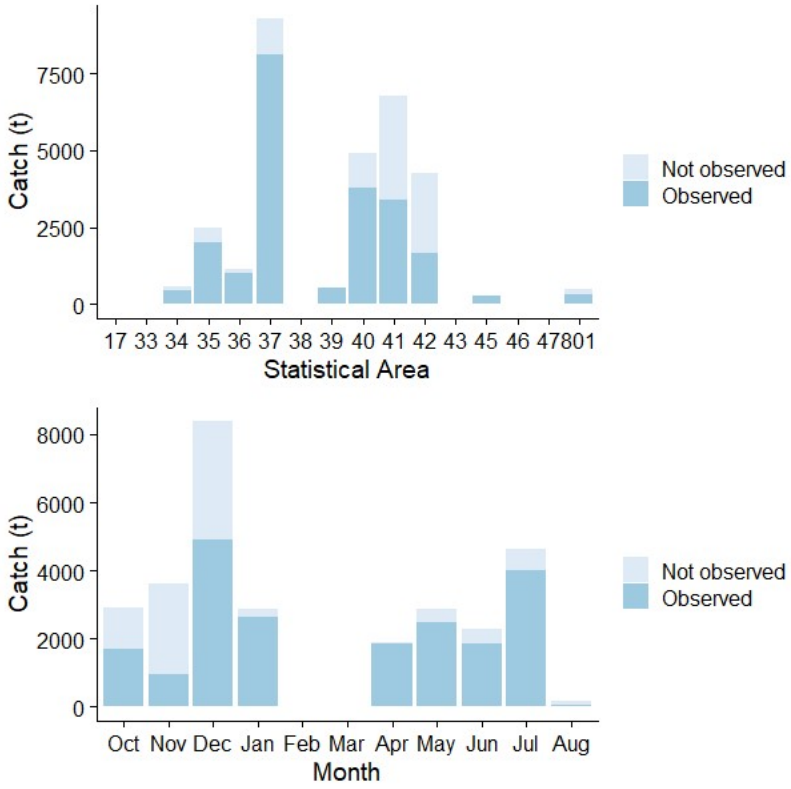

Figure 3: Jack mackerel observed landings and landings that were not observed, by Statistical Area and month, in 2019–20 for the JMA 7 trawl fishery.

Table 1: Distribution of estimated total catch and sampled landings (t, rounded to the nearest tonne) of jack mackerels, by month and Statistical Area (Stat Area), in the 2019–20 fishing year for the JMA 7 trawl fishery. 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), 2019–20

Stat Area	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	All
017	0	0	0	0	0	0	0	0	0	0	0	0	2
033	4	7	1	4	1	1	1	0	0	0	1	5	26
034	2	2	1	0	4	3	1	0	1	461	93	0	568
035	156	1	0	0	0	1	0	0	853	1 440	19	0	2 470
036	107	0	6	7	0		0	291	573	174		0	1 158
037	397	95	1 783	1 567	0		1 487	1 936	849	1 156	0	1	9 271
038	1	0	0	0	0	0	0	0	1	1	1	1	5
039	1	1	0	0	0	0	179	362	0	2	0	1	546
040	336	170	2 473	1 038		0	204	253		410	25		4 908
041	577	1 205	3 660	113	0	0	0	8	0	951	27	256	6 796
042	950	2 041	442	142	0	0	0	0	0	0	0	681	4 256
043	0	0	0	0	0	0	0	0	0	0	0	0	0
045	87	0	1	1	1	3		0	1	0	0	175	269
046	1	0	1	2	1	1	0	0	12	0	0	1	20
047	2	0	0	0	1	1	0	1	1	1	0	13	20
801	302	86	6				17	18		41			470
All	2 922	3 608	8 372	2 874	8	11	1 889	2 870	2 291	4 638	169	1 133	30 785

Sampled landings (t)

Stat Area	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	All	%
017											0		0	0
033														0
034									1	382	55		438	77
035	155								579	1 266	12	0	2 012	81
036	97		6	8				151	575	188			1 024	88
037	257	93	1 410	1 513			1 468	1 721	690	959			8 112	87
038														0
039	1						180	354					535	98
040	28	77	1 857	1 009			190	239		362			3 762	77
041	439	418	1 411	100			0	8		862		164	3 402	50
042	460	283	218	2								690	1 653	39
043														0
045	82	0	0	0	1							173	256	95
046	0	0	1	1									2	10
047	1	0	0	0				0				0	1	5
801	190	82	6				16	18					312	66
All	1 708	954	4 908	2 633	1		1 854	2 493	1 845	4 019	67	1 027	21 509	70
%	58	26	59	92	13	0	98	87	81	87	40	91	70	

3.2 Species proportions

An examination of estimated species proportions by fishing year for all of JMA 7 (Table 2) shows that *T. declivis* (JMD) was the dominant species caught from 2006–07 to 2019–20, with 61–73% of landed weight in all years. *Trachurus novaezelandiae* (JMN) was the second most frequently caught species at 21–33%. *Trachurus murphyi* (JMM) was detected at a much lower and quite variable rate of 3–8%.

Table 2: Estimated species proportions (by weight) and catch weights by species in the JMA 7 trawl fishery since 2006–07. 'Estimated catch' is the sum of all the tow-by-tow estimates of jack mackerel catch. 'Landed catch' results from applying the species proportions to the total reported landings. JMM = *Trachurus murphyi*, JMN = *Trachurus novaezelandiae*, and JMD = *Trachurus declivis*.

	Species proportions (%)			Estimated catch (t)			Landed catch (t)		
Fishing year	JMN	JMD	JMM	JMN	JMD	JMM	JMN	JMD	JMM
2006–07	26.8	69.5	3.7	8 188	21 248	1 128	8 583	22 273	1 183
2007–08	27.0	64.8	8.2	8 763	21 033	2 671	9 193	22 064	2 802
2008–09	25.3	66.4	8.3	6 826	17 943	2 236	7 287	19 154	2 387
2009–10	27.6	65.9	6.5	8 155	19 487	1 933	8 590	20 526	2 036
2010–11	26.9	70.6	2.5	7 123	18 679	650	7 587	19 897	692
2011–12	28.1	68.6	3.3	7 456	18 184	880	7 497	19 381	938
2012–13	29.7	67.3	3.3	8 638	19 525	950	9 428	21 311	1 037
2013–14	24.3	70.7	5.0	7 961	23 144	1 626	8 555	24 872	1 748
2014–15	33.0	60.7	6.3	10 447	19 231	1 999	11 204	20 623	2 144
2015–16	28.4	65.0	6.6	7 999	18 312	1 845	8 771	20 080	2 024
2016–17	26.3	69.0	4.7	8 051	21 106	1 440	8 649	22 671	1 547
2017–18	29.8	64.0	6.2	9 528	20 464	1 963	10 194	21 896	2 100
2018–19	20.9	72.5	6.5	6 284	21 774	1 961	6 647	23 031	2 075
2019–20	21.7	71.6	6.7	6 401	21 109	1 988	6 681	22 030	2 074

3.3 Sex ratios

Sex ratios by fishing year since 2006–07 are shown in Table 3. *Trachurus novaezelandiae* consistently had slightly more females than males in all but four years (average 47.6% males across all years), although three of the last four years were slightly biased towards males including the most recent year. Ratios were around 50% for *T. declivis* (average 50.6% males across all years). The sex ratios for *T. murphyi* indicate a sampled population quite strongly biased towards males (i.e., 54–62% from 2006–07 to 2013–14 and in 2017–18 and 2019–20), although in the three years from 2014–15 to 2016–17 and 2018–19 the samples had almost equal proportions.

Table 3: Estimated sex ratios (%) in the JMA 7 trawl fishery catch by species and fishing year. JMN is *Trachurus novaezelandiae*, JMD is *T. declivis*, and JMM is *T. murphyi*.

	JMN		JMD		JMM	
Fishing year	Males	Females	Males	Females	Males	Females
2006–07	49.9	50.1	56.8	43.2	54.8	45.2
2007–08	43.4	56.6	51.7	48.3	60.7	39.3
2008–09	45.7	54.3	52.5	47.5	56.9	43.1
2009–10	49.1	50.9	51.5	48.5	54.3	45.7
2010–11	43.4	56.6	46.8	53.2	56.9	43.1
2011–12	48.0	52.0	47.7	52.3	61.6	38.4
2012–13	50.0	50.0	50.8	49.2	55.3	44.7
2013–14	45.4	54.6	51.2	48.8	57.6	42.4
2014–15	44.4	55.6	46.2	53.8	50.2	49.8
2015–16	46.2	53.8	50.7	49.3	48.3	51.7
2016–17	51.8	48.2	51.3	48.7	50.4	49.6
2017–18	54.8	45.2	52.8	47.2	56.2	43.8
2018–19	46.9	53.1	48.4	51.6	51.9	48.1
2019–20	51.3	48.7	49.6	50.4	56.0	44.0

3.4 Catch-at-length

The estimated catch-at-length distributions, by species for trawl-caught jack mackerel from JMA 7 in 2019–20, are plotted in Figure 4. For *T. novaezelandiae* there was a dominant length mode at 27–30 cm. For *T. declivis* there was a strong length mode at 35–37 cm, a secondary mode at 27–29 cm. The length range of *T. murphyi* was narrow, with most males being 49–56 cm, and most females being 48–55 cm.

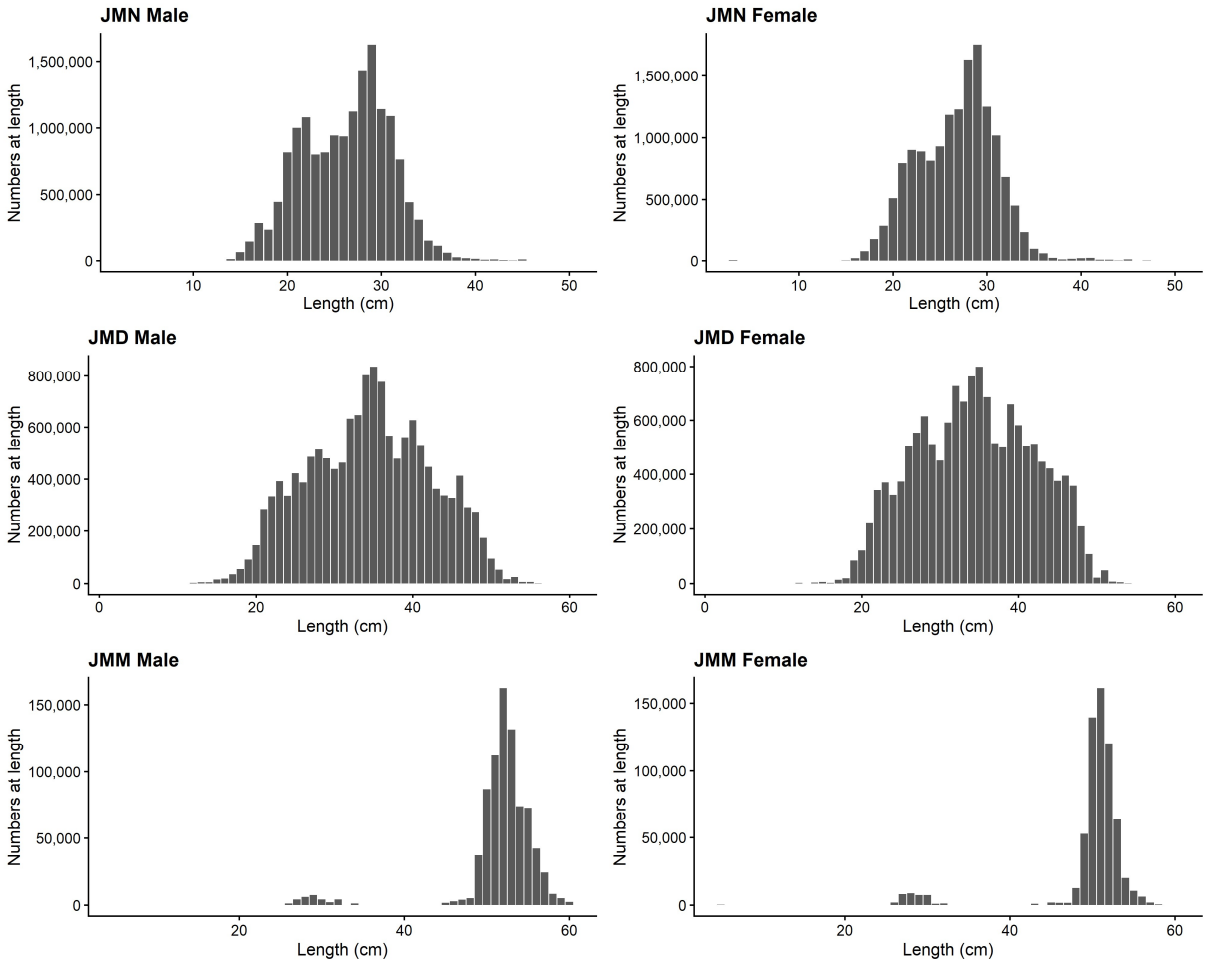

Figure 4: Estimated catch-at-length distributions, by species and sex, for the JMA 7 trawl fishery in 2019-20. JMN is *Trachurus novaezelandiae*, JMD is *T. declivis*, and JMM is *T. murphyi*. Length is caudal fork length.

3.5 Catch-at-age

The details of the estimated catch-at-age distributions for trawl-caught jack mackerel from JMA 7 in 2019–20 are presented for *T. novaezelandiae* in Table 4, *T. declivis* in Table 5, and *T. murphyi* in Table 6. The mean weighted CVs for *T. novaezelandiae* (12.5%), *T. declivis* (16.3%), and *T. murphyi* (24.1%) were all well below the target value of 30%. The estimated distributions are plotted in Figure 5. The catch of *T. novaezelandiae* was dominated by fish aged 2–9 years, with very few fish older than 17 years. The catch of *T. declivis* had abundant fish aged 2–6 years, but with a relatively strong drop-off in fish older than 16 years, and no fish aged under 2 years. The catch of *T. murphyi* was dominated by fish aged 18–26 years, with very few fish younger than 15 or older than 26 years.

Table 4: Estimated numbers-at-age, separately by sex, with CVs, for *Trachurus novaezelandiae* caught during commercial trawl operations in JMA 7 during the 2019–20 fishing year. Summary statistics for the sample are also presented.

Age (years)	Male	CV	Female	CV	Total	CV
1	0	0.00	0	0.00	0	0.00
2	1 449 695	0.27	1 371 093	0.22	2 820 788	0.23
3	1 675 824	0.18	1 591 533	0.16	3 26 7356	0.13
4	1 353 640	0.17	1 483 368	0.16	2 837 008	0.11
5	1 447 287	0.15	1 758 713	0.15	3 206 000	0.10
6	1 628 620	0.13	1 459 242	0.17	3 087 862	0.11
7	874 523	0.18	916 758	0.17	1 791 281	0.13
8	754 723	0.18	677 428	0.21	1 432 150	0.13
9	296 812	0.27	609 520	0.21	906 332	0.17
10	206 057	0.33	197 909	0.33	403 966	0.24
11	123 007	0.39	7 6365	0.49	199 373	0.30
12	215 715	0.38	127 496	0.36	343 211	0.28
13	174 161	0.34	199 609	0.36	373 770	0.26
14	31 439	0.80	53 691	0.58	85 131	0.45
15	63 744	0.59	28 852	0.77	92 595	0.48
16	111 462	0.38	456	2.17	111 917	0.37
17	40 879	0.63	0	0.00	40 879	0.63
18	13 237	0.95	0	0.00	13 237	0.95
19	0	0.00	0	0.00	0	0.00
20	0	0.00	0	0.00	0	0.00
21	31 439	0.75	0	0.00	31 439	0.75
No. measured		6 819		6 536		13 641
No. aged		299		303		602
No. of tows sampled						172
Mean weighted CV (%)		16.9		15.4		12.5

Table 5: Estimated numbers-at-age, separately by sex, with CVs, for *Trachurus declivis* caught during commercial trawl operations in JMA 7 during the 2019–20 fishing year. Summary statistics for the sample are also presented.

Age (years)	Male	CV	Female	CV	Total	CV
1	0	0.00	0	0.00	0	0.00
2	1 465 717	0.23	1 299 778	0.23	2 765 495	0.19
3	1 847 769	0.14	1 989 235	0.16	3 837 004	0.11
4	1 127 671	0.15	1 783 048	0.37	2 910 720	0.23
5	712 662	0.16	753 417	0.18	1 466 079	0.12
6	954 735	0.14	1 376 716	0.14	2 331 451	0.11
7	334 155	0.22	375 025	0.22	709 181	0.16
8	590 467	0.19	651 692	0.18	1 242 159	0.13
9	326 591	0.29	251 989	0.33	578 579	0.22
10	147 341	0.36	402 663	0.23	550 005	0.20
11	247 119	0.33	125 817	0.44	372 935	0.27
12	239 864	0.33	42 700	0.70	282 565	0.29
13	268 214	0.32	346 215	0.30	614 429	0.21
14	243 753	0.35	82 358	0.59	326 110	0.29
15	131 164	0.48	251 084	0.35	382 248	0.28
16	124 207	0.47	140 092	0.52	264 298	0.37
17	73 041	0.63	0	0.00	73 041	0.63
18	0	0.00	269 709	0.36	269 709	0.36
19	129 029	0.50	66 381	0.64	195 410	0.40
20	0	0.00	43 861	0.83	43 861	0.83
21	0	0.00	89 397	0.63	89 397	0.63
22	93 433	0.64	48 750	0.73	142 184	0.51
23	0	0.00	0	0.00	0	0.00
24	49 493	0.84	0	0.00	49 493	0.84
25	41 615	0.81	89 092	0.72	130 707	0.55
26	0	0.00	41 686	0.84	41 686	0.84
27	6 156	1.03	0	0.00	6 156	1.03
28	0	0.00	7 062	1.17	7 062	1.17
No. measured		15 163		15 644		30 807
No. aged		307		297		604
No. of tows sampled						372
Mean weighted CV (%)		17.2		23.6		16.3

Table 6: Estimated numbers-at-age, separately by sex, with CVs, for *Trachurus murphyi* caught during commercial trawl operations in JMA 7 during the 2019–20 fishing year. Summary statistics for the sample are also presented.

Age (years)	Male	CV	Female	CV	Total	CV
4	0	0.00	8 536	1.28	8 536	1.28
5	0	0.00	20 542	1.30	20 542	1.30
6	7 682	1.42	0	0.00	7 682	1.42
7	0	0.00	0	0.00	0	0.00
8	0	0.00	0	0.00	0	0.00
9	0	0.00	5 376	1.57	5 376	1.57
10	0	0.00	4 199	0.84	4 199	0.84
11	9 866	0.92	3 762	1.12	13 629	0.73
12	5 780	1.07	0	0.00	5 780	1.07
13	0	0.00	0	0.00	0	0.00
14	0	0.00	3 762	1.02	3 762	1.02
15	2 876	1.06	8 716	0.77	11 592	0.64
16	23 067	0.47	4 123	1.28	27 190	0.46
17	6 745	0.75	9 622	0.60	16 367	0.46
18	26 960	0.42	31 395	0.37	58 355	0.28
19	42 182	0.32	13 085	0.52	55 268	0.28
20	96 161	0.21	50 318	0.27	146 479	0.16
21	85 956	0.21	78 212	0.22	164 168	0.15
22	111 323	0.19	94 659	0.20	205 982	0.13
23	103 750	0.18	86 675	0.21	190 425	0.13
24	135 235	0.16	106 229	0.19	241 464	0.10
25	60 726	0.26	38 380	0.31	99 106	0.19
26	28 250	0.34	10 144	0.56	38 394	0.28
27	9 509	0.56	22 992	0.36	32 501	0.29
28	12 292	0.47	4 199	0.78	16 491	0.39
29	9 314	0.61	17 615	0.47	26 929	0.36
30	0	0.00	0	0.00	0	0.00
31	5 562	0.75	5 453	0.80	11 015	0.54

No. measured	806	664	2 031
No. aged	258	200	458
No. of tows sampled			92
Mean weighted CV (%)	29.4	36.0	24.1

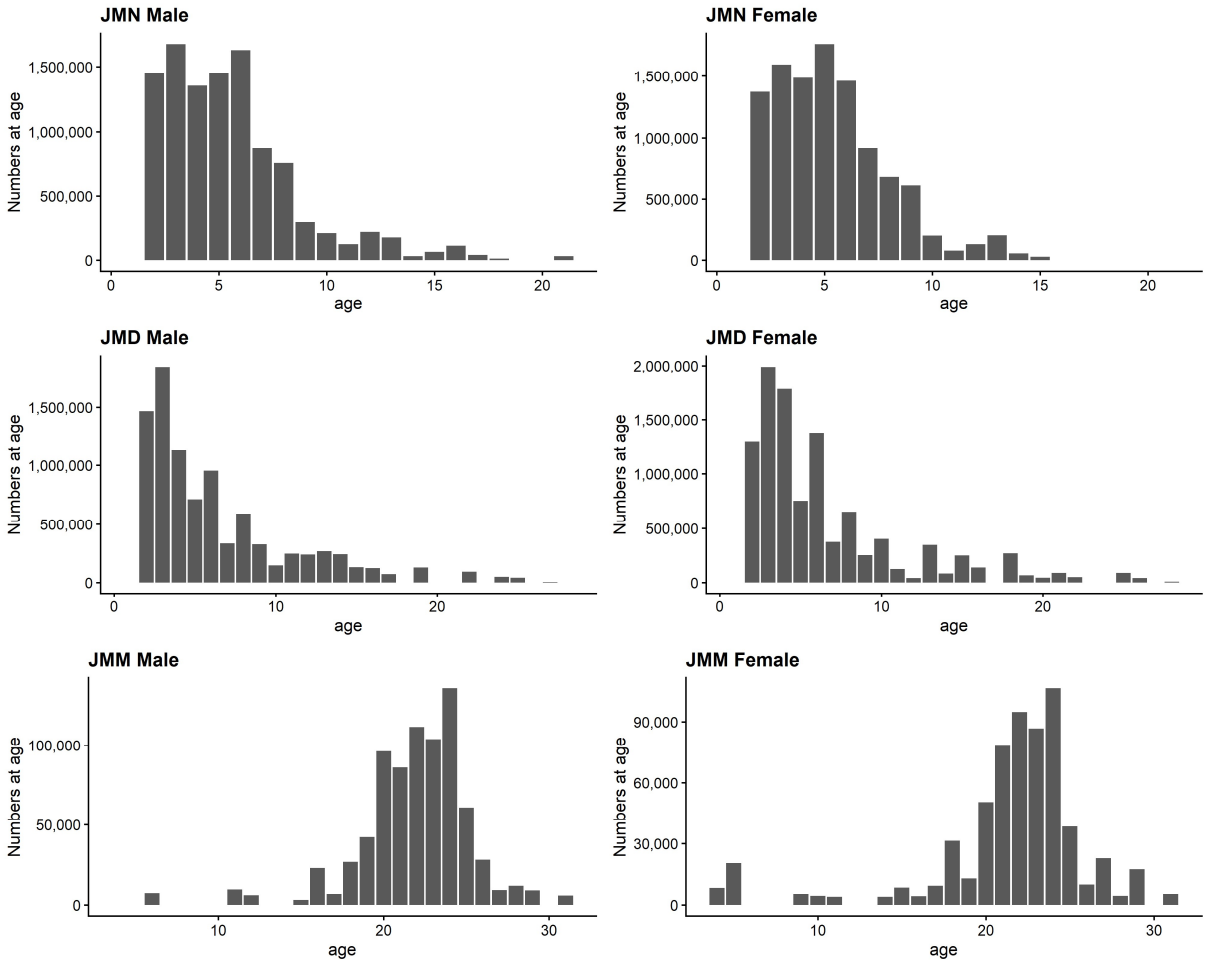

Figure 5: Estimated commercial catch-at-age distributions, by species and sex, for the JMA 7 trawl fishery in 2019–20. JMN is *Trachurus novaezelandiae*, JMD is *T. declivis*, and JMM is *T. murphyi*. Length is caudal fork length.

3.6 Data summaries

Catch-at-length and catch-at-age data from the JMA 7 fishery are available from fourteen consecutive years since 2006–07. Mean weighted CVs for the length and age distributions, by sex and year, are listed for each species in Table 7. The target CV of 30% was achieved for all species in all years, except for *T. murphyi* in 2006–07 and 2007–08.

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 CVs (mwCV) for catch-at-age and catch-at-length distributions, by species, sex, and fishing year for the JMA 7 trawl fishery.

		Catch-at-age mwCV (%)			Catch-at-length mwCV (%)		
Species	Fishing year	Males	Females	Total	Males	Females	Total
Trachurus novaezelandiae	2006–07	26	25	20	17	16	14
	2007–08	28	27	22	17	12	13
	2008–09	39	40	30	14	11	11
	2009–10	32	27	23	16	15	12
	2010–11	28	24	20	20	16	15
	2011–12	23	21	16	17	16	14
	2012–13	24	25	19	19	17	16
	2013–14	19	19	14	15	13	12
	2014–15	21	19	15	14	11	10
	2015–16	26	25	19	12	11	10
	2016–17	20	21	15	16	14	13
	2017–18	19	20	14	15	14	11
	2018–19	26	27	19	12	11	9
	2019–20	17	15	13	16	14	13
T. declivis	2006–07	31	38	26	12	12	9
	2007–08	26	34	23	13	13	12
	2008–09	35	40	28	11	10	9
	2009–10	25	28	20	13	12	10
	2010–11	25	23	18	12	11	9
	2011–12	21	20	16	15	15	13
	2012–13	22	22	17	17	16	14
	2013–14	20	21	15	16	14	13
	2014–15	21	20	16	17	15	14
	2015–16	27	24	20	19	15	15
	2016–17	19	19	14	15	14	12
	2017–18	20	21	16	15	15	13
	2018–19	22	24	17	13	14	11
	2019–20	17	24	16	14	15	13
T. murphyi	2006–07	39	55	35	37	37	31
	2007–08	34	50	31	17	21	14
	2008–09	36	49	30	20	21	15
	2009–10	35	47	30	27	28	23
	2010–11	31	36	23	28	28	21
	2011–12	26	30	20	20	22	16
	2012–13	26	35	21	30	33	24
	2013–14	27	33	21	26	26	18
	2014–15	24	28	19	19	19	14
	2015–16	25	27	19	22	18	15
	2016–17	28	30	20	33	29	23
	2017–18	30	39	25	28	29	23
	2018–19	28	25	20	23	17	16
	2019–20	29	36	24	31	30	24

Trachurus novaezelandiae

Scaled catch-at-length and catch-at-age frequency distributions for *T. novaezelandiae* by fishing year are shown in Figure 6. Most variation in abundance occurred for fish shorter than 25 cm, presumably related to the relative strengths of juvenile year classes. Scaled catch-at-age frequencies by fishing year varied between years. The 1+ year class was strong in 2007–08 and maintained a relatively high abundance in all subsequent years. Year classes 4, 5, and 6 in 2006–07 also appeared to be relatively strong throughout the series, although there were some inconsistencies e.g., year classes 7 in 2009–10

and 10 in 2011–12 were weak. The 2+ year class in 2011–12 was also relatively strong, and it progressed as a dominant year class in subsequent years but was not particularly strong in 2017–18. The two subsequent year classes (age classes 3+ and 4+ in 2014–15) also appeared to be relatively strong in the subsequent four years of sampling but were not evident in 2019–20. A large peak in 5 year olds in 2018–19 was not evident in earlier or subsequent years. In 2019–20 the 2–6 age classes dominated in approximately equal proportions.

Trachurus declivis

Scaled catch-at-length and catch-at-age frequency distributions for *T. declivis* by fishing year are shown in Figure 7. Most variation in abundance has occurred for the fish shorter than 37 cm, presumably related to the relative strengths of juvenile year classes. There was a wide range of scaled catch-at-age, and the distributions varied between years. No 0+ or 1+fish were observed in 2019–20. There was evidence of two relatively strong year classes aged 1+ and 2+ years in 2007–08 that maintained a relatively high abundance up to 2011–12 but were relatively weak from 2012–13. The 2011–12 and 2014–15 1+ year classes maintained relatively strong presences through to 2017–18 where they were aged 7 and age 4, respectively. Since 2014–15, the length mode previously clearly obvious at ~50 cm has markedly declined and the length frequency is now much flatter. This is also evident in the age frequencies with far fewer fish over 10 years old present in the distribution.

Trachurus murphyi

Scaled catch-at-length and catch-at-age frequency distributions for *T. murphyi* by fishing year are shown in Figure 8. All the distributions were unimodal at 49–51 cm (except for the 2013–14 distribution which had a broad mode at 46–51 cm) and were generally similar with few fish smaller than 45 cm. Scaled catch-at-age frequencies by fishing year exhibited a wide range of ages although few fish younger than 10 years were recorded in any year. There was evidence of relatively strong year classes at ages 11 and 12 years in 2006–07 that progressed to ages 16 and 17 in 2011–12. Since about 2012–13, the older of these two year classes had lost much of its dominance. Fish aged 18 years dominated the 2014–15 distribution, and this cohort was still dominant at age 21 in 2017–18. This year class has been relatively strong since 2011–12 (when it was age 15) and also contributed substantially to the catch throughout the time series (since 2006–07 when it was age 10). The length and age distributions from 2017–18 were, however, notably different to those from all previous years. There was a distinct left-hand tail of relatively small fish (i.e., smaller than 45 cm), which manifests as ages 5 to about 13 years in the age distribution. Fish in that age range have occurred rarely in age distributions since 2010–11. In the most recent age frequency distribution this left-hand tail remains evident. It is unclear whether these individuals are correctly identified as *T. murphyi* or mis-identified *T. declivis* or *T. novaezelandiae*.

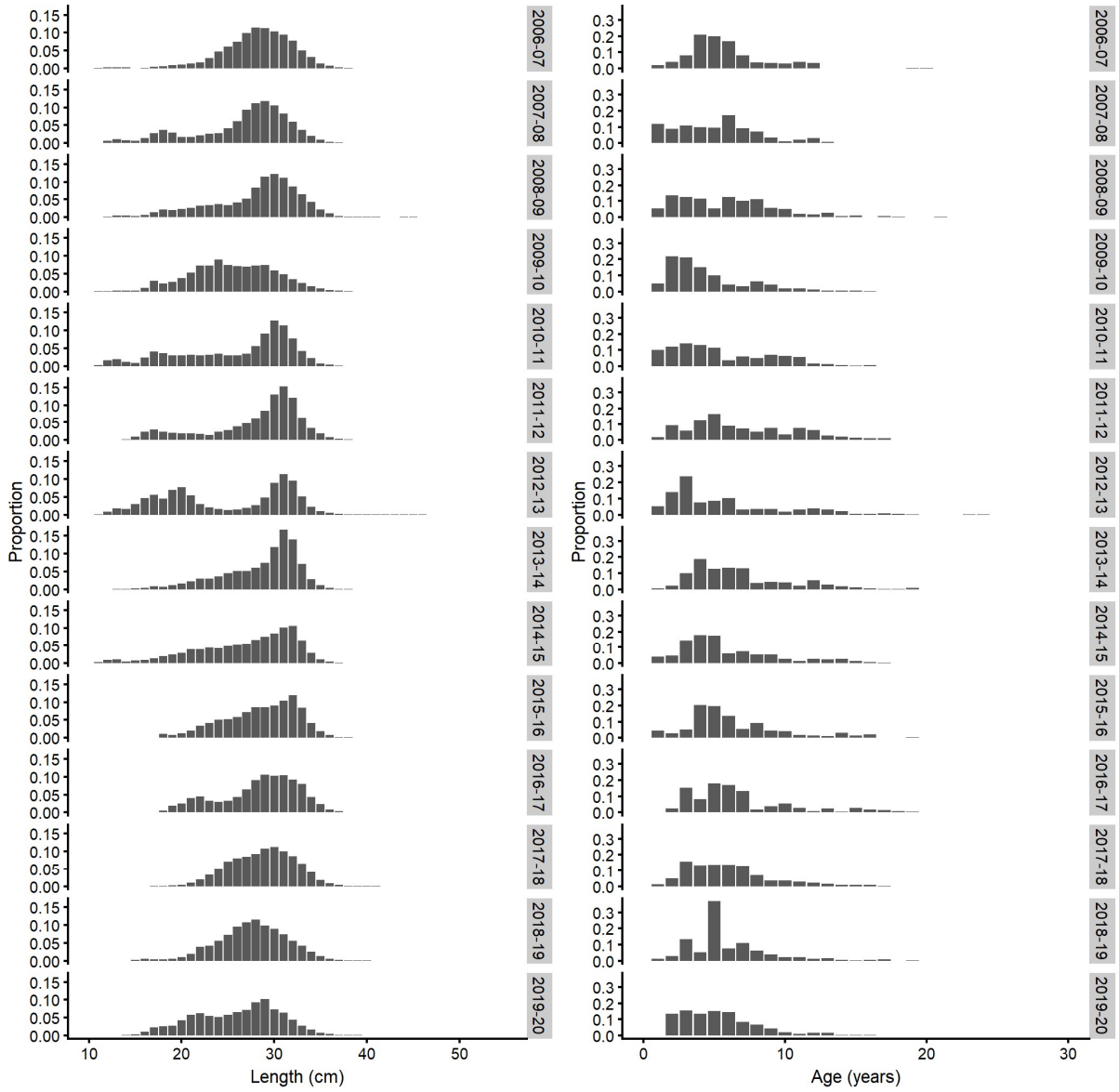

Figure 6: Scaled catch-at-length (left panel) and catch-at-age (right panel) proportions for the catch of *Trachurus novaezelandiae* sampled from the 2006–07 to 2019–20 fishing years for the JMA 7 trawl fishery. Note these include updated catch-at-age information for 2015–16 and 2018–19 fishing years.

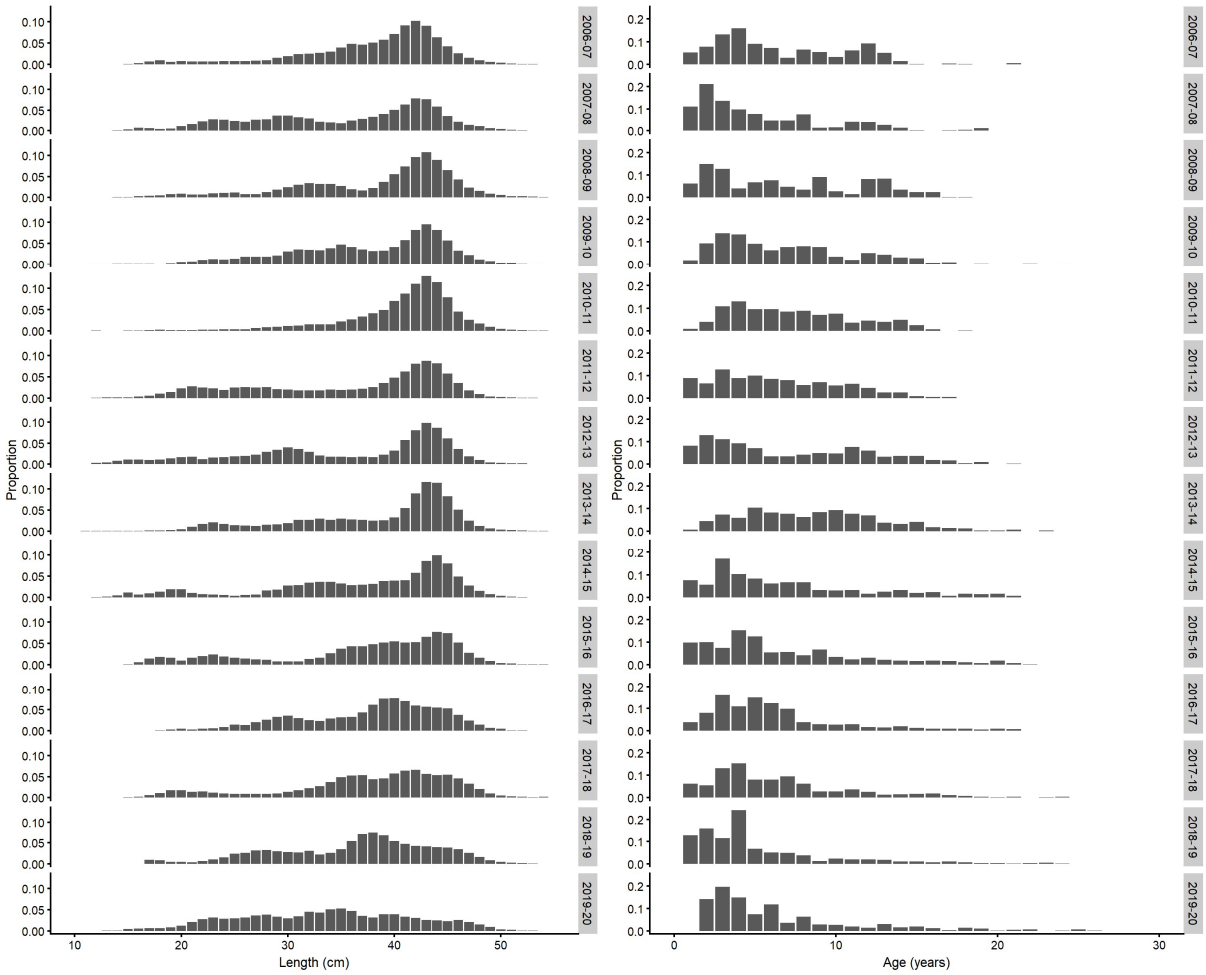

Figure 7: Scaled catch-at-length (left panel) and catch-at-age (right panel) proportions for the catch of *Trachurus declivis* sampled from the 2006–07 to 2019–20 fishing years for the JMA 7 trawl fishery. Note these include updated catch-at-age information for 2015–16 and 2018–19 fishing years.

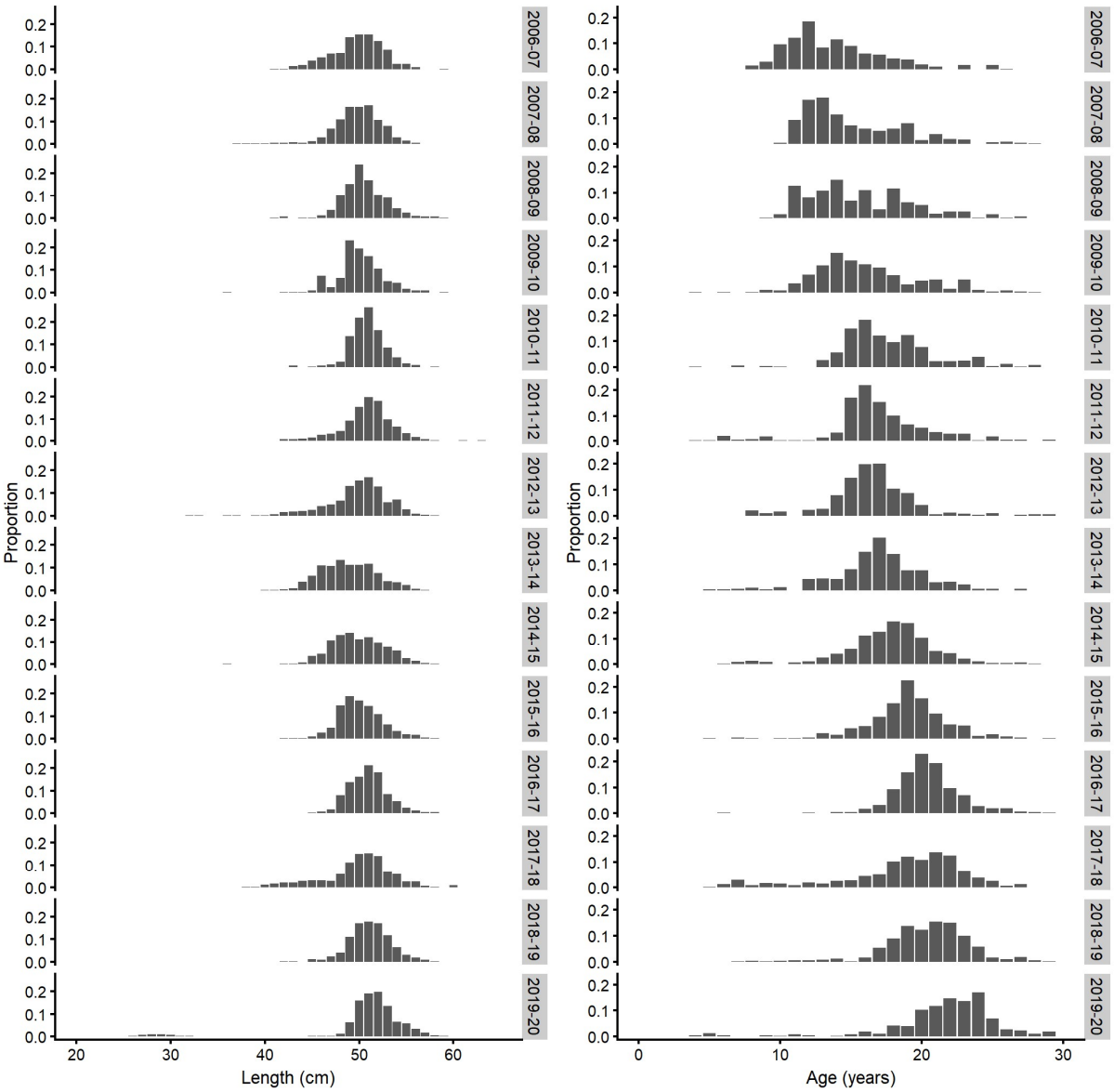

Figure 8: Scaled catch-at-length (left panel) and catch-at-age (right panel, age in years) proportions for the catch of *Trachurus murphyi* sampled from the 2006–07 to 2019–20 fishing year for the JMA 7 trawl fishery. Note these include updated catch-at-age information for 2015–16 and 2018–19 fishing years.

4. DISCUSSION

The 2019–20 jack mackerel trawl fishery was well sampled (as it was in all years since at least 2006–07). Spatially, there was very good coverage of catch in the most fished Statistical Areas (034–037, 040–042). Estimates of the 2019–20 catch-at-age for all three jack mackerel species had mean weighted CVs over all age classes of 25% or less, well below the target of 30%.

Estimates of species proportions, based on observer identifications, indicated a consistent predominance of *T. declivis* at 61–73% of total catch weight in the 13 fishing years from which data were available. The percentage of *T. novaezelandiae* was also consistent temporally at 21–33%. The predominance of *T. declivis* overall is expected given that this species generally occurs deeper and further offshore than *T. novaezelandiae* and because most of the vessels targeting jack mackerels were restricted to fishing at least 12 n. miles, and often 25 n. miles, off the coast. The lowest proportion of *T. declivis* and highest proportion of *T. novaezelandiae* in the time series were reported in 2014–15. This probably relates to relatively low catches in the autumn–winter fishery, which was usually strongly dominated by landings of *T. declivis* off the west coast of South Island.

Species identification has been an ongoing problem in the JMA fishery (Horn et al. 2019, Saunders et al. 2021). By utilising growth curves, the errors in identification of larger fish are readily groomed out of the age-length key for *T. novaezelandiae* and for *T. declivis* with error rates of 3% and 8%, respectively. However, these errors cannot be groomed for *T. murphyi* as the growth curve overlaps with *T. declivis.* Thus, the error rates will be higher for both *T. declivis* and *T. murphyi.* In addition, the errors for smaller and mid-sized fish are not readily identifiable and none of these errors can be groomed out of the length frequency information. The identification problems suggest that the catch-at-age results should be interpreted with caution.

Ongoing training in species identification should be provided to observers to ensure best-quality data are collected. Approaches to retrospectively identify and resolve misidentifications in historical data through an examination of the shape of otoliths themselves is currently being explored under project SEA202012.

5. ACKNOWLEDGEMENTS

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

This appendix lists the estimated proportions-at-age and CVs in the JMA 7 trawl fishery, by species and fishing year. The columns in each table are headed so that, for example, the year 2016 refers to the 2015–16 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. In the proportions-at-age tables, "0" indicates that there were no fish of that age, "0.00000" indicates that there were fish of that age but that they accounted for less than $5e^{-4}$ % of the sample. Note these have been updated to reflect re-calculation of catch-at-age for the 2015–16 and 2018–19 fishing years.

Table A1a: Estimated proportions-at-age (male, female, and unsexed combined) for *Trachurus novaezelandiae*, by fishing year in the JMA 7 trawl fishery.

Proportion

Age (Yr)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	0.01321	0.03725	0.00935	0.01267	0.00073	0	0.02842	0.00003	0.02970	0	0	0.00071	0	0
1	0.02091	0.11805	0.05117	0.05100	0.10213	0.01682	0.05307	0.00564	0.03966	0.04420	0.00081	0.01141	0.01198	0
2	0.03921	0.08945	0.13462	0.21826	0.12161	0.09338	0.13993	0.02163	0.04576	0.02846	0.02648	0.05034	0.02985	0.13404
3	0.08228	0.10983	0.12296	0.21079	0.14075	0.05978	0.23802	0.10037	0.14410	0.05284	0.15238	0.15743	0.13346	0.15526
4	0.20901	0.09878	0.11173	0.15171	0.13125	0.12095	0.07646	0.18902	0.17775	0.20242	0.08092	0.13437	0.05309	0.13481
5	0.19822	0.09602	0.05099	0.10195	0.11373	0.16678	0.08754	0.12679	0.17515	0.19436	0.17871	0.13836	0.36878	0.15235
6	0.16968	0.17309	0.12458	0.04429	0.03665	0.08684	0.10115	0.13419	0.06151	0.13499	0.17019	0.13802	0.07810	0.14673
7	0.08227	0.09136	0.09923	0.03191	0.06038	0.07120	0.03203	0.13137	0.07492	0.05314	0.13429	0.12974	0.10925	0.08512
8	0.03604	0.07130	0.10806	0.06385	0.05033	0.05233	0.03601	0.03885	0.05358	0.09168	0.01838	0.06803	0.06437	0.06805
9	0.03356	0.03584	0.05580	0.04261	0.07219	0.07388	0.03698	0.04782	0.05391	0.04544	0.03727	0.03470	0.04124	0.04307
10	0.03189	0.01209	0.04857	0.02056	0.06306	0.03340	0.01990	0.04237	0.02826	0.04206	0.05466	0.03748	0.02380	0.01920
11	0.04065	0.02205	0.01810	0.01806	0.05858	0.07569	0.03210	0.02426	0.01392	0.01703	0.02936	0.02946	0.02197	0.00947
12	0.03277	0.03203	0.01677	0.01151	0.01598	0.06087	0.03787	0.05635	0.02566	0.01351	0.00830	0.02250	0.01449	0.01631
13	0.00097	0.00819	0.02686	0.00583	0.01313	0.02769	0.03231	0.03028	0.02395	0.00925	0.02367	0.01548	0.01611	0.01776
14	0.00116	0.00058	0.00629	0.00662	0.00707	0.02005	0.02240	0.01895	0.02531	0.03079	0.00545	0.00924	0.00646	0.00405
15	0	0.00019	0.00808	0.00463	0.00511	0.01431	0.00531	0.01227	0.01266	0.01293	0.02835	0.00934	0.00389	0.00440
16	0.00037	0	0.00026	0.00266	0.00665	0.01266	0.00375	0.00597	0.00809	0.01974	0.01822	0.00936	0.00787	0.00532
17	0.00075	0.00120	0.00487	0.00052	0.00058	0.01101	0.00865	0.00145	0.00289	0.00186	0.01623	0.00324	0.01053	0.00194
18	0.00058	0.00045	0.00040	0.00005	0.00008	0.00236	0.00622	0.00382	0	0	0.00876	0.00023	0.00026	0.00063
19	0.00260	0.00114	0.00024	0.00006	0	0	0.00114	0.00775	0.00088	0.00405	0.00554	0	0.00449	0
20	0.00235	0.00063	0	0.00000	0	0	0	0.00083	0.00092	0.00124	0.00077	0.00016	0	0
21	0	0.00029	0.00082	0	0	0	0	0	0.00143	0	0.00013	0	0	0.00149
22	0	0.00016	0	0	0	0	0	0	0	0	0.00113	0	0	0
23	0.00097	0	0	0.00000	0	0	0.00051	0	0	0	0	0.00016	0	0
24	0.00056	0	0	0.00012	0	0	0.00022	0	0	0	0	0	0	0
25	0	0	0.00026	0.00000	0	0	0	0	0	0	0	0.00026	0	0
26	0	0	0	0.00024	0	0	0	0	0	0	0	0	0	0

Table A1b: CVs for estimated proportions-at-age (male, female, and unsexed combined) for *Trachurus novaezelandiae*, by fishing year in the JMA 7 trawl fishery.

	CV													
Age (yr)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	0.488	0.460	0.759	0.913	2.006		0.524	1.709				0.712		
1	0.515	0.305	0.297	0.389	0.378	0.487	0.463	0.516	0.481	0.525	1.064	0.273	0.448	0
2	0.347	0.134	0.184	0.213	0.249	0.209	0.244	0.349	0.355	0.435	0.415	0.247	0.365	0.225
3	0.218	0.147	0.175	0.186	0.185	0.219	0.151	0.201	0.274	0.296	0.190	0.122	0.160	0.125
4	0.134	0.182	0.316	0.172	0.114	0.109	0.179	0.117	0.133	0.121	0.170	0.137	0.245	0.115
5	0.118	0.198	0.397	0.209	0.124	0.097	0.101	0.108	0.084	0.085	0.092	0.114	0.063	0.103
6	0.130	0.135	0.278	0.281	0.228	0.133	0.089	0.083	0.070	0.099	0.093	0.104	0.151	0.108
7	0.195	0.210	0.314	0.227	0.193	0.176	0.183	0.093	0.138	0.169	0.092	0.098	0.125	0.126
8	0.281	0.216	0.272	0.211	0.189	0.187	0.172	0.167	0.123	0.123	0.268	0.154	0.158	0.134
9	0.335	0.253	0.336	0.204	0.141	0.157	0.159	0.163	0.135	0.177	0.157	0.186	0.204	0.170
10	0.304	0.451	0.398	0.230	0.160	0.252	0.226	0.174	0.144	0.172	0.153	0.146	0.255	0.236
11	0.265	0.331	0.432	0.274	0.170	0.145	0.163	0.247	0.208	0.265	0.191	0.179	0.254	0.302
12	0.288	0.313	0.527	0.252	0.328	0.166	0.144	0.147	0.289	0.324	0.374	0.185	0.283	0.277
13	1.023	0.320	0.321	0.327	0.316	0.222	0.165	0.163	0.225	0.374	0.206	0.213	0.342	0.257
14	0.949	1.264	0.480	0.367	0.429	0.272	0.179	0.199	0.187	0.221	0.378	0.268	0.430	0.453
15		1.348	0.625	0.336	0.392	0.305	0.358	0.232	0.180	0.313	0.184	0.288	0.595	0.477
16	1.059		1.035	0.494	0.451	0.311	0.458	0.275	0.296	0.232	0.238	0.261	0.440	0.371
17	0.731	1.006	1.042	0.594	1.160	0.374	0.280	0.512	0.325	0.503	0.244	0.461	0.326	0.626
18	0.818	1.092	1.148	2.105	1.712	0.565	0.317	0.385	0.512	0.000	0.294	0.791	1.088	0.954
19	0.702	1.023	0.972	1.916			0.769	0.287	0.000	0.528	0.349		0.473	0
20	0.896	0.940		1.253				0.673	0.434	0.569	0.581	0.978	0	0
21		0.869	0.832						0.862		1.016			0.751
22		1.138									0.550			
23	1.079			1.134			0.835					0.941		
24	1.065			0.887			0.903							
25			1.037	2.166								1.041		
26				1.049										

Table A2a: Estimated proportions-at-age (male, female, and unsexed combined) for *Trachurus declivis*, by fishing year in the JMA 7 trawl fishery.

													Proportion	
Age (yr)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	0.00893	0.01782	0.00806	0.00539	0	0	0.00410	0.00023	0.04777	0	0.00119	0.05380	0	0
1	0.05147	0.11061	0.06219	0.01797	0.00917	0.08889	0.08129	0.00658	0.07537	0.09888	0.03761	0.06324	0.07697	0
2	0.07715	0.21069	0.14881	0.09418	0.03899	0.06589	0.12900	0.04371	0.05627	0.10020	0.07940	0.05568	0.09760	0.14060
3	0.13149	0.13626	0.12663	0.13873	0.10908	0.12607	0.11182	0.07295	0.17127	0.07434	0.15979	0.13068	0.06859	0.19508
4	0.15853	0.09736	0.04033	0.13272	0.13015	0.08856	0.09327	0.05894	0.10254	0.15311	0.10923	0.15273	0.14722	0.14799
5	0.09108	0.07846	0.06792	0.09225	0.09495	0.10043	0.07181	0.10419	0.08304	0.12599	0.14900	0.08134	0.04072	0.07454
6	0.07142	0.04928	0.07629	0.06288	0.09627	0.08595	0.03411	0.08160	0.06172	0.05459	0.12449	0.08024	0.03016	0.11854
7	0.02851	0.04917	0.04758	0.07667	0.08508	0.07956	0.03508	0.07788	0.06723	0.05726	0.09841	0.09511	0.02893	0.03606
8	0.06552	0.07556	0.03432	0.08013	0.08833	0.05749	0.04294	0.06227	0.06664	0.04115	0.03926	0.06261	0.02246	0.06315
9	0.05500	0.01309	0.09075	0.07678	0.07007	0.06999	0.05031	0.08451	0.03254	0.06690	0.02900	0.02793	0.00730	0.02942
10	0.03159	0.01537	0.02699	0.03447	0.07495	0.05556	0.04689	0.09361	0.03089	0.03376	0.02733	0.02748	0.01390	0.02796
11	0.06188	0.04438	0.01596	0.01922	0.03545	0.06416	0.07710	0.07679	0.03161	0.02375	0.03031	0.03637	0.01207	0.01896
12	0.09305	0.04229	0.08242	0.05073	0.04577	0.04540	0.06055	0.06892	0.01506	0.03167	0.01706	0.02566	0.01193	0.01437
13	0.04966	0.02600	0.08367	0.04349	0.03910	0.02561	0.03305	0.03672	0.02444	0.02276	0.01431	0.01417	0.01064	0.03124
14	0.01375	0.01372	0.03512	0.02986	0.04785	0.02543	0.03635	0.03249	0.03146	0.01741	0.02094	0.01456	0.00663	0.01658
15	0.00149	0.00241	0.02400	0.02638	0.02556	0.00993	0.03722	0.04085	0.01949	0.01709	0.01321	0.01718	0.00652	0.01943
16	0	0.00042	0.02509	0.00566	0.00680	0.00554	0.01925	0.01730	0.02311	0.01844	0.00863	0.01920	0.00437	0.01344
17	0.00313	0.00172	0.00225	0.00753	0.00041	0.00505	0.01721	0.01378	0.00682	0.01670	0.00879	0.01248	0.00577	0.00371
18	0.00127	0.00417	0.00163	0	0.00203	0.00050	0.00477	0.01154	0.01641	0.01057	0.00913	0.00854	0.00416	0.01371
19	0	0.01041	0	0.00234	0	0	0.00942	0.00284	0.01405	0.00738	0.00609	0.00539	0.00173	0.00994
20	0.00048	0.00083	0	0	0	0	0.00107	0.00306	0.01535	0.01866	0.00863	0.00355	0.00146	0.00223
21	0.00459	0	0	0	0	0	0.00208	0.00722	0.00693	0.00727	0.00820	0.00417	0.00116	0.00455
22	0	0	0	0.00234	0	0	0.00131	0	0	0.00175	0	0.00072	0.00217	0.00723
23	0	0	0	0	0	0	0	0.00201	0	0.00039	0	0.00255	0.00285	0.00000
24	0	0	0	0.00028	0	0	0	0	0	0	0	0.00463	0.00026	0.00252
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00665
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00212

Table A2b: CVs for estimated proportions-at-age (male, female, and unsexed combined) for *Trachurus declivis*, by fishing year for the JMA7 trawl fishery.

	CV													
Age (yr)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0	0.465	0.320	0.354	0.428			0.793	1.197	0.337		0.756	0.375		
1	0.230	0.193	0.198	0.326	0.355	0.267	0.238	0.441	0.190	0.464	0.341	0.218		0.194
2	0.175	0.138	0.140	0.207	0.191	0.229	0.199	0.409	0.188	0.218	0.157	0.157	0.186	0.115
3	0.145	0.128	0.145	0.141	0.134	0.162	0.161	0.222	0.104	0.147	0.119	0.119	0.143	0.231
4	0.121	0.170	0.293	0.130	0.113	0.182	0.161	0.191	0.098	0.101	0.117	0.104	0.109	0.123
5	0.237	0.195	0.264	0.160	0.143	0.115	0.153	0.129	0.100	0.104	0.083	0.121	0.067	0.106
6	0.328	0.324	0.340	0.190	0.153	0.114	0.170	0.114	0.120	0.122	0.080	0.113	0.106	0.159
7	0.452	0.264	0.424	0.168	0.169	0.117	0.149	0.136	0.114	0.127	0.095	0.087	0.147	0.131
8	0.324	0.344	0.436	0.186	0.175	0.140	0.135	0.123	0.111	0.178	0.161	0.112	0.126	0.218
9	0.310	0.471	0.268	0.177	0.176	0.124	0.125	0.099	0.167	0.118	0.184	0.176	0.153	0.198
10	0.497	0.486	0.488	0.300	0.184	0.137	0.140	0.093	0.184	0.180	0.182	0.177	0.256	0.272
11	0.266	0.286	0.682	0.367	0.230	0.127	0.099	0.108	0.169	0.240	0.173	0.150	0.189	0.292
12	0.241	0.289	0.307	0.214	0.216	0.158	0.113	0.111	0.258	0.191	0.223	0.174	0.201	0.215
13	0.360	0.448	0.293	0.236	0.237	0.208	0.149	0.142	0.201	0.208	0.244	0.242	0.218	0.294
14	0.564	0.466	0.458	0.268	0.209	0.183	0.143	0.146	0.182	0.281	0.200	0.252	0.226	0.279
15	0.921	0.851	0.386	0.273	0.295	0.339	0.149	0.138	0.218	0.249	0.260	0.233	0.269	0.369
16		0.747	0.312	0.469	0.545	0.472	0.211	0.221	0.200	0.242	0.328	0.209	0.283	0.626
17	1.019	1.015	0.636	0.647	1.049	0.438	0.243	0.230	0.358	0.295	0.282	0.263	0.294	0.356
18	1.056	0.376	0.841		1.091	0.690	0.399	0.254	0.251	0.315	0.324	0.335	0.307	0.400
19		0.784		1.020			0.292	0.456	0.254	0.383	0.373	0.388	0.327	0.829
20	1.052	1.018					0.868	0.409	0.277	0.234	0.329	0.406	0.568	0.629
21	1.006						0.701	0.335	0.369	0.334	0.355	0.415	0.561	0.512
22				0.963			0.801			0.537		0.769	0.436	
23								0.624		1.031		0.472	0.467	0.838
24				1.254								0.425	0.419	0.553
25													0.695	0.839
26														

Table A3a: Estimated proportions-at-age (male, female, and unsexed combined) for *Trachurus murphyi*, by fishing year in the JMA 7 trawl fishery.

													Proportion	
Age (yr)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
4	0	0	0	0.00205	0.00259	0.00176	0	0	0	0.00136	0.00029	0	0	0.00525
5	0	0	0	0	0	0.00211	0	0.00393	0	0.00169	0	0.00101	0	0.01273
6	0	0	0	0.00209	0.00049	0.01934	0	0.00283	0.00118	0.00143	0.00271	0.01186	0	0.00472
7	0.00018	0	0	0	0.00726	0.00436	0	0.00485	0.00759	0.00509	0	0.02866	0.00183	0.00000
8	0.01384	0	0	0.00264	0	0.00587	0.02012	0.01073	0.01191	0.00279	0	0.00761	0.00413	0.00000
9	0.02858	0.00161	0.00036	0.01051	0.00357	0.01798	0.00865	0.00280	0.00935	0	0	0.01643	0.00164	0.00400
10	0.09570	0.00555	0.01443	0.00710	0.00123	0.00300	0.01566	0.01110	0	0.00217	0	0.01434	0.00420	0.00300
11	0.12119	0.09376	0.12603	0.03502	0	0.00300	0	0	0.00644	0.00221	0	0.00750	0.00628	0.00884
12	0.18510	0.17118	0.07832	0.06924	0	0.00209	0.02195	0.04305	0.01152	0.00453	0.00264	0.01769	0.00547	0.00461
13	0.08478	0.17870	0.10889	0.10402	0.02734	0.01276	0.02521	0.04480	0.02497	0.02071	0.00107	0.01430	0.00847	0
14	0.11525	0.11388	0.14963	0.15299	0.05670	0.03200	0.07794	0.04321	0.04011	0.01581	0.00500	0.02411	0.01283	0.00258
15	0.08987	0.07196	0.06621	0.12274	0.14876	0.16939	0.14660	0.08019	0.05947	0.04071	0.00439	0.02742	0.00192	0.00791
16	0.06119	0.05845	0.10982	0.10803	0.18226	0.21936	0.19724	0.14793	0.11335	0.04764	0.01739	0.04314	0.01713	0.01864
17	0.05582	0.05184	0.03163	0.09647	0.12240	0.15442	0.20045	0.20283	0.12763	0.08425	0.03250	0.04871	0.05511	0.01145
18	0.04196	0.06025	0.11673	0.06577	0.09623	0.10191	0.10438	0.14046	0.16779	0.13716	0.09311	0.10183	0.08965	0.04134
19	0.03892	0.08091	0.06023	0.03084	0.12267	0.06330	0.08599	0.07661	0.16213	0.22415	0.15721	0.12037	0.13793	0.04029
20	0.01919	0.01560	0.04916	0.04496	0.07841	0.05144	0.04172	0.07686	0.10548	0.15459	0.22960	0.10896	0.12344	0.10373
21	0.01118	0.03763	0.01568	0.04920	0.02333	0.03487	0.00552	0.03144	0.05015	0.09715	0.19400	0.13764	0.15550	0.11800
22	0	0.01883	0.02495	0.01512	0.02230	0.02878	0.01253	0.03243	0.04128	0.05538	0.09776	0.12516	0.14981	0.14728
23	0.01679	0.01674	0.02514	0.05006	0.02552	0.02702	0.00761	0.02328	0.02143	0.05129	0.07021	0.06269	0.09973	0.13569
24	0.00038	0	0.00215	0.01035	0.04088	0.00300	0.00340	0.00681	0.01036	0.01007	0.02829	0.03814	0.05822	0.17013
25	0.01679	0.00654	0.01377	0.00481	0.00511	0.01772	0.00917	0.00555	0.00401	0.01668	0.02016	0.02449	0.01653	0.07022
26	0.00327	0.01014	0.00133	0.00757	0.01335	0.00414	0	0	0.00435	0.00942	0.01927	0.00672	0.01097	0.02734
27	0	0.00425	0.00554	0.00460	0.00309	0.00466	0.00244	0.00599	0.00598	0.00495	0.00812	0.01124	0.01788	0.02340
28	0	0.00218	0	0.00113	0.00921	0.00066	0.00628	0	0.00196	0	0.00589	0	0.00514	0.01172
29	0	0	0	0	0	0.00457	0.00488	0	0	0.00180	0.00312	0	0.00174	0.01928
30	0	0	0	0	0.00729	0.00655	0	0.00231	0.00588	0	0	0	0.00228	0
31	0	0	0	0.00268	0	0.00394	0.00226	0	0.00569	0.00699	0.00727	0	0.01215	0.00785

Table A3b: CVs for the estimated proportions-at-age for *Trachurus murphyi*, by fishing year for the JMA 7 trawl fishery.

													CV
Age (yr)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
4				2.236	1.146	1.047				1.3969	1.866			1.2812
5						0.747		0.766		1.5272		1.649		1.3044
6				1.423	2.163	0.420		1.105	0.848	1.4666	1.096	0.852		1.4214
7	2.343				1.841	1.093		0.741	0.632	0.6456		0.541	0.9977	0
8	0.605			1.481		0.891	0.710	0.519	0.452	0.9645		0.910	1.2671	0
9	0.420	1.054	1.736	0.948	0.873	0.596	0.869	0.972	0.577	0		0.705	0.9638	1.5667
10	0.322	0.581	0.663	0.803	1.888	1.225	0.714	0.531		1.5192		0.589	0.786	0.8442
11	0.301	0.251	0.227	0.383		1.119			0.593	1.1048		0.945	0.6971	0.733
12	0.189	0.178	0.291	0.584		1.043	0.499	0.237	0.445	0.6892	1.057	0.734	0.914	1.0722
13	0.266	0.184	0.255	0.178	0.363	0.511	0.432	0.261	0.338	0.3383	1.259	0.697	0.5034	0
14	0.221	0.225	0.206	0.233	0.235	0.322	0.231	0.252	0.245	0.3711	0.722	0.429	0.5355	1.0159
15	0.332	0.347	0.333	0.271	0.144	0.119	0.142	0.184	0.188	0.2441	0.850	0.520	1.0184	0.6392
16	0.344	0.299	0.242	0.192	0.130	0.102	0.111	0.145	0.133	0.1914	0.495	0.215	0.3216	0.4582
17	0.480	0.337	0.351	0.178	0.174	0.119	0.107	0.113	0.133	0.1685	0.350	0.210	0.2105	0.455
18	0.427	0.339	0.233	0.222	0.183	0.165	0.145	0.142	0.110	0.1247	0.187	0.152	0.1528	0.2752
19	0.665	0.314	0.365	0.304	0.155	0.182	0.164	0.183	0.109	0.0943	0.136	0.150	0.1241	0.2785
20	0.699	0.543	0.345	0.235	0.228	0.198	0.245	0.192	0.128	0.1153	0.098	0.139	0.1224	0.1633
21	0.878	0.461	0.781	0.269	0.374	0.231	0.664	0.313	0.201	0.1445	0.122	0.114	0.1143	0.1482
22		0.767	0.451	0.433	0.392	0.267	0.479	0.312	0.220	0.1787	0.180	0.130	0.1135	0.1279
23	1.041	0.860	0.495	0.273	0.340	0.298	0.487	0.368	0.301	0.1994	0.225	0.202	0.1486	0.1254
24	4.020		0.823	0.576	0.295	0.831	0.894	0.643	0.431	0.4362	0.332	0.305	0.1888	0.1036
25	1.074	1.120	0.898	0.655	0.763	0.336	0.532	0.607	0.720	0.3666	0.434	0.307	0.3058	0.187
26		1.083	0.869	0.564	0.543	0.788			0.679	0.4512	0.502	0.439	0.4109	0.2827
27		1.018	0.654	0.791	1.018	0.673	0.915	0.688	0.644	0.5995	0.528	0.435	0.3554	0.2946
28		1.070		1.060	0.630	1.301	0.816		1.069	0	0.700		0.5873	0.3934
29						0.780	0.785			1.0865	1.109		1.0231	0.3648
30					0.836	0.645		0.997	0.610	0			0.9793	0
31				1.014		0.693	1.045		0.539	0.499	0.604		0.3795	0.5403