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Commercial catch sampling for species proportion, sex, length, and age of jack mackerels in JMA 7 in the 2020–21 fishing year, with a summary of all available data sets

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TABLE OF CONTENTS

EXECUTIVE SUMMARY **1**

1. INTRODUCTION **2**

2. METHODS **3**

3. RESULTS **5**

3.1 Catch sampling 5

3.2 Species proportions 6

3.3 Sex ratios 7

3.4 Catch-at-length 8

3.5 Catch-at-age 9

3.6 Data summaries 14

4. DISCUSSION **20**

5. ACKNOWLEDGEMENTS **21**

6. REFERENCES **21**

APPENDIX A NUMBER OF JACK MACKEREL RECORDS FROM JMA 7 WITH AND WITHOUT SEX INFORMATION, 2010–11 TO 2020–21 **23**

APPENDIX B PROPORTIONS-AT-AGE BY SPECIES AND FISHING YEAR **24**

APPENDIX C JMA 7 SAMPLING PROTOCOL FOR OBSERVERS FROM 2020 **31**

APPENDIX D LENGTHS OF JACK MACKEREL SPECIES REPORTED FROM RESEARCH TRAWL SURVEYS **32**

EXECUTIVE SUMMARY

Moore, B.R[1]; Ó Maolagáin, C.; Spong, K.; Saunders, R.J. (2023). Commercial catch sampling for species proportion, sex, length, and age of jack mackerels in JMA 7 in the 2020–21 fishing year, with a summary of all available data sets.

***New Zealand Fisheries Assessment Report 2023/31.* 32 p.**

This report describes the data collected by the observer sampling programme from trawl landings of jack mackerels (*Trachurus declivis*, *T. murphyi*, and *T. novaezelandiae*) in JMA 7 (central west coast) during the 2020–21 fishing year, including 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 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 60% of the 2020–21 landed catch was sampled, and sampling was considered to be representative of the landings both temporally and spatially. However, a large number of measured individuals of all species did not have associated sex information. For *T. murphyi*, only 1896 length measurements were recorded in 2020–21 (1353 of which had associated sex information), and only 149 otoliths were collected. Data from a single trip, which collected a large proportion of the total number of *T. murphyi* otoliths (n = 106), were removed from the analyses on the recommendation of the Deepwater Working Group due to suspected species identification issues. Once this trip was removed, only 498 length measurements (85 which contained associated sex information) and 43 age estimates were considered appropriate for use in the analyses for this species.

Estimated species proportions based on observer data showed a dominance of *T. declivis* at 61–73% (73% in 2020–21) in the JMA 7 catch and effort data for all statistical areas and the 15 years of sampling, while *T. novaezelandiae* was 21–33% (26% in 2020–21), and *T. murphyi* was 2–8% (2% in 2020–21).

Sex ratios of *T. declivis* and *T. novaezelandiae* have generally been biased slightly toward females than males; however, both were strongly biased toward females (> 56% females) in the 2020–21 fishing year. Sex ratios for *T. murphyi* indicate a population strongly biased towards males in all sampling years.

The scaled length frequency distributions for both *T. declivis* and *T. novaezelandiae* from 2020–21 were similar to those from previous years although there were fewer large (> 40 cm) *T. declivis* in 2020–21 compared with previous years. The scaled age frequency distributions for these two species in 2020–21 had mean weighted CVs below the Fisheries New Zealand target of 30%.

The scaled length frequency distribution for *T. murphyi*, based on all measured individuals, were notably different to those from previous years. In particular, there was a large proportion of small fish (i.e., smaller than 40 cm), which may have resulted from incorrect species identifications. No otoliths were collected from these small individuals, which prevented an examination of otolith shape or length-at-age to assess the accuracy of the identifications. The scaled age frequency distribution for *T. murphyi* was similarly limited by data availability and quality but revealed a sampled population in which most individuals were between 20 and 25 years of age. For *T. murphyi*, both the scaled length and age frequency distributions are thus subject to issues concerning data availability and quality and should be interpreted with caution. Improved communication of, and adherence to, sampling requirements is necessary to improve the data inputs for the analyses presented here.

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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 are necessary to derive catch histories for each species from aggregated catch data at least back to when observer sampling began and these can be used to scale age samples from the various fisheries. Since the mid-2000s the JMA 7 fishery has been primarily a trawl fishery with a small proportion of catches made using purse seine or set net. Before then, larger proportions of the catch came from purse seine fishing (Taylor & Julian 2008).

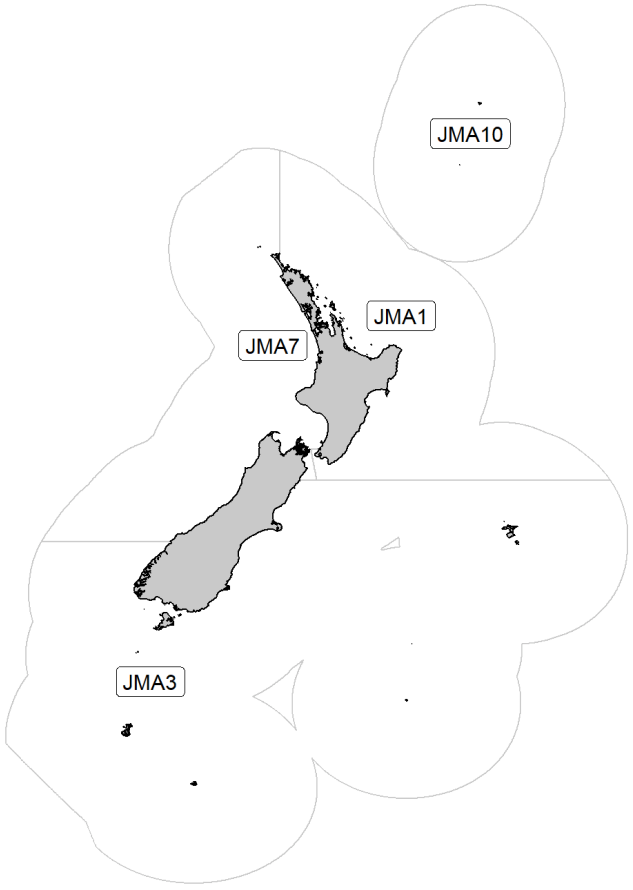

Figure 1: Jack mackerel Quota Management Areas (QMAs).

This report provides estimates of relative species proportions, sex ratios, catch-at-length, and catch-at-age for the three *Trachurus* species in the commercial JMA 7 catch for 2020–21 fishing year (defined as 1 October 2020 to 30 September 2021) using data collection on-board vessels by observers. 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, Saunders et al. (2021) for 2018–19, and Saunders et al. (2022) for 2019–20. 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 MID2021-01 "Routine age determination of deepwater 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 deepwater fishstocks".

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 sample weights by species. All observer data on jack mackerels sampled from JMA 7 in the 2020–21 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 in 2020–21.

Stratification of the data was required because: 1) the observer coverage varied with both month and statistical area; 2) the fishery was not consistent throughout the year; and 3) 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. 2012b). 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 2020–21 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 2020–21 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, where available.

Sets of five otoliths were embedded in blocks of clear epoxy resin and cured at 50 °C. Once hardened, an approximately 380 μm 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. Prior to reading, otolith readers re-trained on otoliths preparations from previous years. Otoliths of *T. declivis* and *T. novaezelandiae* from 2020–21 were then 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).

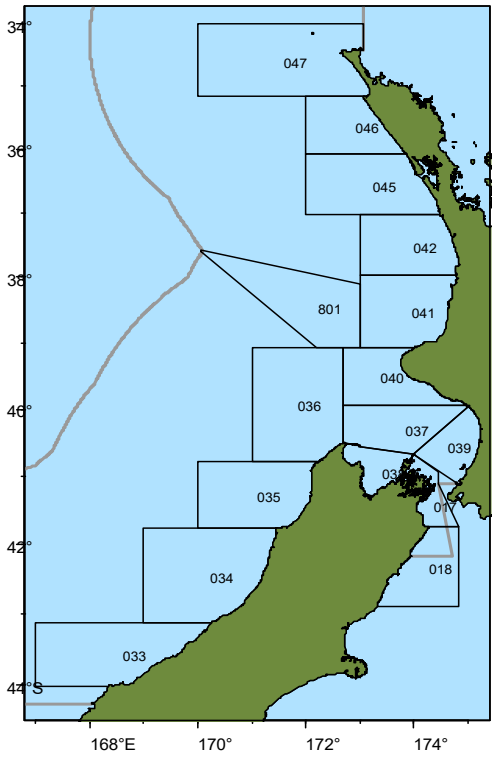

Figure 2: Statistical Areas referred to in the text.

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 derived from the CAA outputs. 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 aged fish were close to the asymptotic length of their growth curve.

A preliminary analysis of all data sets revealed significant discrepancies in the catch-at-length and catch-at-age data for *T. murphyi* compared with previous years, in part due to erroneous species identification of many *T. murphyi* from a single trip (trip 6269) as evidenced by otolith shape. On the

recommendation from the Fisheries New Zealand Deepwater Working Group, all observer data from this trip were excluded from the species proportions, sex ratios, catch-at-length, and catch-at-age analyses (thus this trip was considered not to be observed). In addition to removing data for this trip, a small number of records were removed for the catch-at-age analyses as they were assumed to represent mis-identifications based on an examination of length-at-age data.

3. RESULTS

3.1 Catch sampling

The catch distribution in 2020–21 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 (Statistical Areas 034–036) in May–August. Additionally, significant catch was taken in the South Taranaki Bight Statistical Area 037 in May–June and North Taranaki Bight Statistical Area 041 in May–July (Figure 3, Table 1). The presence of two quite widely separated fishery peaks is consistent with that observed for previous years, albeit not as strong as has been observed in some years (e.g., 2019–20, Saunders et al. 2022).

In 2020–21, just under 60% of the catch was sampled by observers (Table 1). Most of the catch was derived from eight Statistical Areas (034–037, 039–042, and 801), and these were all well sampled (Table 1 and Figure 3). The percentages of the catch sampled in the eight most productive months was less consistent than in previous years ranging from 39% to 79% (Table 1).

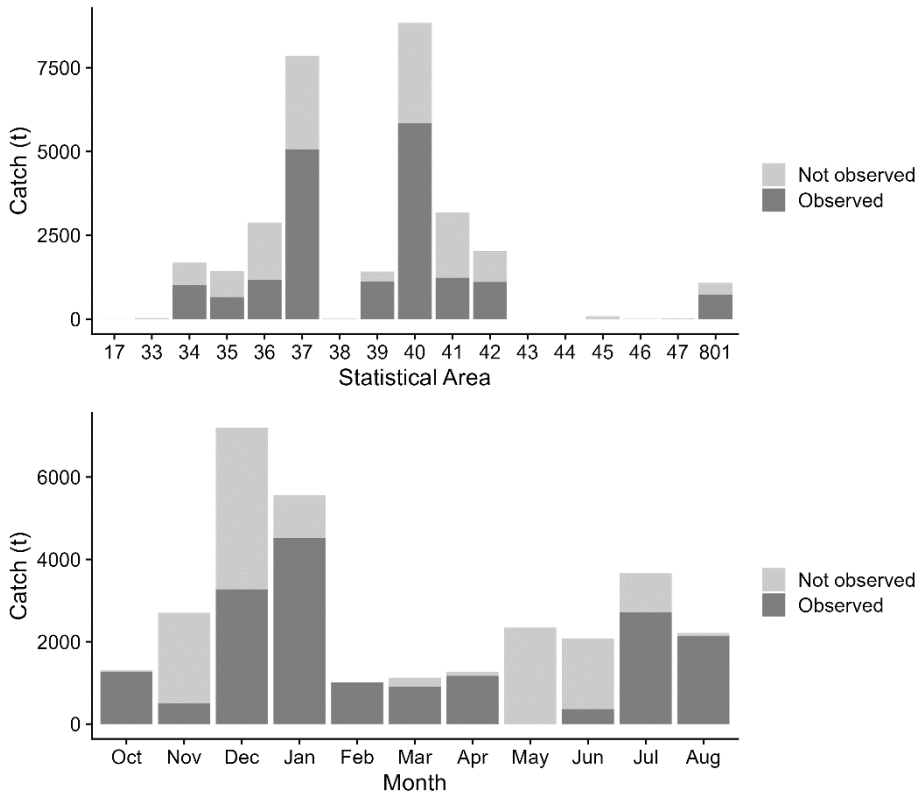

Figure 3: Jack mackerel observed landings and landings that were not observed, by Statistical Area and month, in 2020–21 for the JMA 7 trawl fishery. The observed data excludes a single trip with substantial species identification issues. '17' = Statistical Area 017, '33' = Statistical Area 033, etc.

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 2020–21 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), 2020–21

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	1	0	0	2
033	5	4	4	2	3	1	0	1	2	3	1	5	31
034	3	2	0	0	0	0	2	2	361	738	569	8	1 685
035	0	1	0	0	0	0	0	116	419	593	298	2	1 430
036	1	0	0	0	0	0	179	718	1 079	811	93	0	2 880
037	2	89	1 999	2 159	600	550	602	898	175	171	525	78	7 847
038	3	1	1	0	0	0	0	0	2	1	1	2	12
039	0	1	0	0	0	95	458	252	0	323	288	0	1 417
040	0	208	3 939	3 381	391	479	14	297	12	118	0		8 839
041	335	1 291	1 197	12	0	0	0	7	0	286	55	0	3 184
042	927	1 044	54	0	0	0		0	0	0	0	0	2 026
043	0		0	0	0	0	0	0	0	0	0	0	0
044	0	0	0	0	0	0	0	0		0	0	0	0
045	23	60	0	0	1	0	0	0	0	0			85
046	3	0	0	1	0	0	1	1	0	0	0	1	8
047	2	1	1	0	0	0	4	2	1	0	1	1	12
801				0	0			50	29	618	382		1 079
All	1 304	2 703	7 197	5 556	996	1 127	1 260	2 343	2 079	3 664	2 213	96	30 537

Sampled landings (t) 2020–21*

Stat Area	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	All	%
017									0				0	0
033													0	0
034								0	42	428	542	0	1 012	60
035						0			82	257	320		659	46
036						0	111		239	689	81		1 121	39
037			1 061	1 568	631	487	367			114	548	74	4 849	62
038													0	0
039						34	136			345	330		844	60
040		193	1 809	2 941	381	388	11			118	0		5 840	66
041	330	191	352	14						293	53		1 232	39
042	938	118	51										1 107	55
043													0	0
044														
045	0												0	0
046	0						0						1	11
047							4						4	35
801										471	259		730	68
All	1 268	502	3 273	4 523	1 012	909	629	0	363	2 714	2 133	74	17 399	57
%	97	19	46	81	102	81	50	0	18	74	96	77	57	

* Excludes a single trip with substantial species identification issues.

3.2 Species proportions

Species proportions by fishing year for JMA 7 are presented in Table 2. *Trachurus declivis* (JMD) is the dominant species, representing 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%, although represented just 1% of the catch in 2020–21 once the trip with substantial species identification issues had been removed (Table 2).

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. JMD = *Trachurus declivis*, JMM = *Trachurus murphyi*, JMN = *Trachurus novaezelandiae*.

	Species proportions (%)			Estimated catch (t)			Landed catch (t)		
Fishing year	JMD	JMM	JMN	JMD	JMM	JMN	JMD	JMM	JMN
2006–07	69.5	3.7	26.8	21 248	1 128	8 188	22 273	1 183	8 583
2007–08	64.8	8.2	27.0	21 033	2 671	8 763	22 064	2 802	9 193
2008–09	66.4	8.3	25.3	17 943	2 236	6 826	19 154	2 387	7 287
2009–10	65.9	6.5	27.6	19 487	1 933	8 155	20 526	2 036	8 590
2010–11	70.6	2.5	26.9	18 679	650	7 123	19 897	692	7 587
2011–12	68.6	3.3	28.1	18 184	880	7 456	19 381	938	7 497
2012–13	67.3	3.3	29.7	19 525	950	8 638	21 311	1 037	9 428
2013–14	70.7	5.0	24.3	23 144	1 626	7 961	24 872	1 748	8 555
2014–15	60.7	6.3	33.0	19 231	1 999	10 447	20 623	2 144	11 204
2015–16	65.0	6.6	28.4	18 312	1 845	7 999	20 080	2 024	8 771
2016–17	69.0	4.7	26.3	21 106	1 440	8 051	22 671	1 547	8 649
2017–18	64.0	6.2	29.8	20 464	1 963	9 528	21 896	2 100	10 194
2018–19	72.5	6.5	20.9	21 774	1 961	6 284	23 031	2 075	6 647
2019–20	71.6	6.7	21.7	21 109	1 988	6 401	22 030	2 074	6 681
2020–21	72.8	1.6	25.6	14 442	324	5 075	22 228	499	7 811

3.3 Sex ratios

Sex ratios by fishing year since 2006–07 are shown in Table 3. Sex ratios have been around 50% for *T. declivis* in most years, although were strongly biased towards females in 2020–21. Sex ratios for *T. murphyi* indicate a sampled population quite strongly biased towards males (i.e., 54–62%), including in 2020–21. *Trachurus novaezelandiae* consistently had slightly more females than males in most years and showed a strong bias towards females in 2020–21 (Table 3).

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

	JMD		JMM		JMN	
Fishing year	Males	Females	Males	Females	Males	Females
2006–07	56.8	43.2	54.8	45.2	49.9	50.1
2007–08	51.7	48.3	60.7	39.3	43.4	56.6
2008–09	52.5	47.5	56.9	43.1	45.7	54.3
2009–10	51.5	48.5	54.3	45.7	49.1	50.9
2010–11	46.8	53.2	56.9	43.1	43.4	56.6
2011–12	47.7	52.3	61.6	38.4	48.0	52.0
2012–13	50.8	49.2	55.3	44.7	50.0	50.0
2013–14	51.2	48.8	57.6	42.4	45.4	54.6
2014–15	46.2	53.8	50.2	49.8	44.4	55.6
2015–16	50.7	49.3	48.3	51.7	46.2	53.8
2016–17	51.3	48.7	50.4	49.6	51.8	48.2
2017–18	52.8	47.2	56.2	43.8	54.8	45.2
2018–19	48.4	51.6	51.9	48.1	46.9	53.1
2019–20	49.6	50.4	56.0	44.0	51.3	48.7
2020–21	43.8	56.2	59.6	40.4	43.3	56.7

3.4 Catch-at-length

Unscaled length frequency distributions of jack mackerel species sampled by observers following the removal of the single trip with substantial species identification issues are provided in Figure 4. There were a large number of length records without associated sex information collected across all observed lengths for all three species, but particularly for *T. murphyi* less than 48 cm in length. The large number of unsexed samples contrasts with previous years, when only a small amount of measured fish did not have associated sex information (Appendix A). Unsexed *T. murphyi* had a modal length of 28–32 cm, which overlapped the model length observed for *T. novaezelandiae* and was strikingly different to that observed for *T. murphyi* in previous years, raising concerns over the species identification of these individuals. A similar mode was evident for *T. declivis*. A total of 16 983, 85, and 11 941 individual length measurements with sex information were available for the sex-specific catch-at-length analyses for *T. declivis*, *T. murphyi*, and *T. novaezelandiae*, respectively (Figure 4 and Tables 4–6).

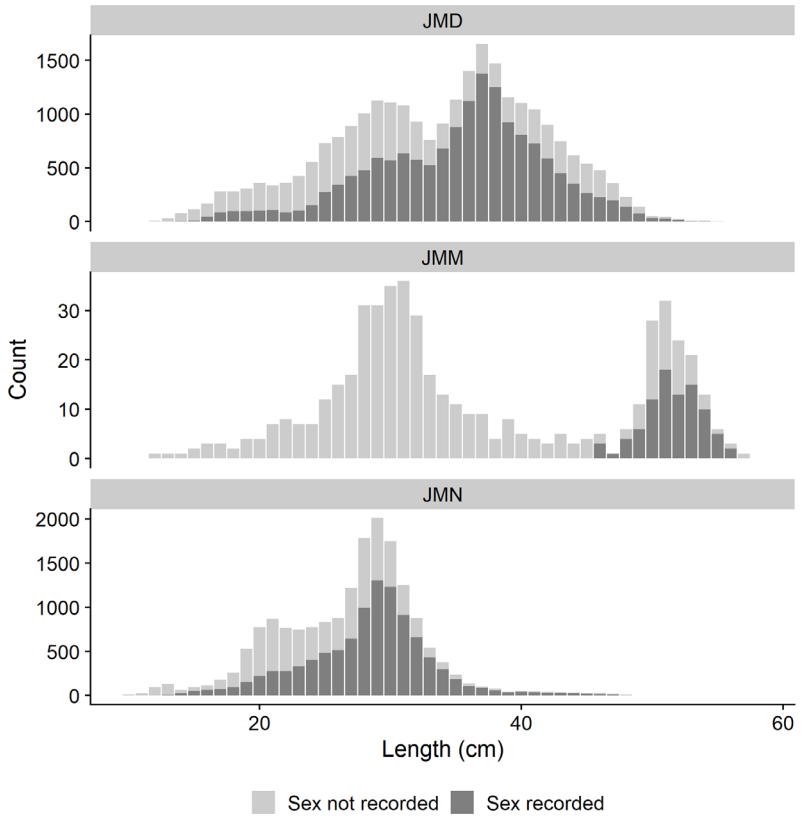

Figure 4: Unscaled counts of jack mackerel individuals with and without sex recorded, by length and species, from observer data in JMA 7 for the 2020–21 fishing year following the removal of a single trip with substantial species identification errors. JMD = *Trachurus declivis*, JMM = *Trachurus murphyi*, JMN = *Trachurus novaezelandiae*.

The estimated catch-at-length distributions by species and sex for trawl-caught jack mackerel from JMA7 in 2020–21 are provided in Figure 5. For *T. declivis* there was a strong bimodality in the length distribution, with a mode at 35–38 cm for both sexes, and a secondary mode at 28 cm, particularly for females. The length range of *T. murphyi* with sex information was narrow, with most males being 49–55 cm, and most females being 48–56 cm. For *T. novaezelandiae* there was a dominant length mode at 27–32 cm for males and 28–31 cm for females (Figure 5).

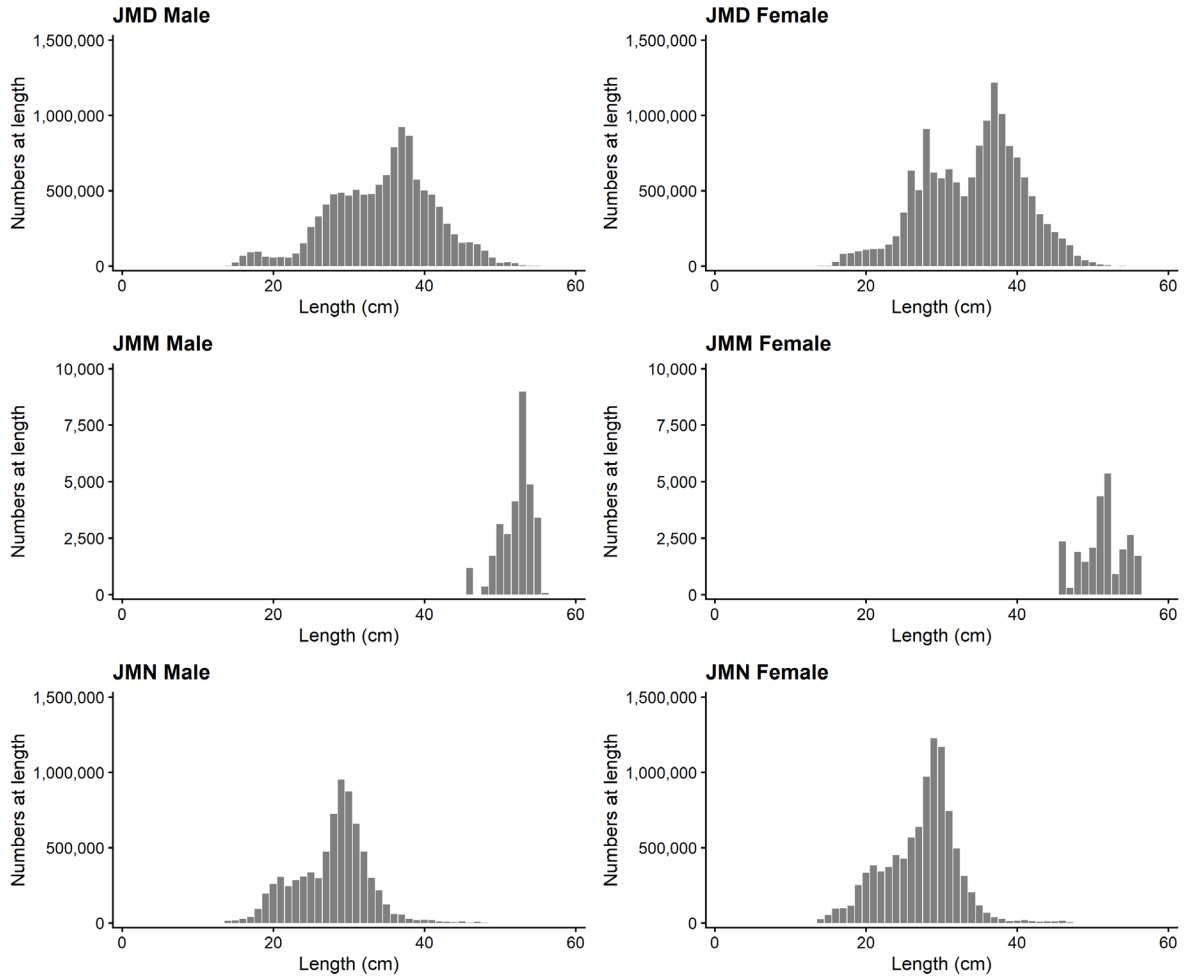

Figure 5: Estimated catch-at-length distributions, by species and sex, for the JMA 7 trawl fishery in 2020–21. JMD = *Trachurus declivis*, JMM = *Trachurus murphyi*, JMN = *Trachurus novaezelandiae*.

3.5 Catch-at-age

The raw distribution of fish sampled for otoliths for each species, excluding the single trip with substantial species identification issues, is provided in Figure 6. Otoliths were available for selection from 1191 *T. declivis*, 149 *T. murphyi* (43 once the single trip with substantial species identification issues had been removed), and 634 *T. novaezelandiae*. With the exception of those otoliths collected during the trip that was removed due to species identification issues, no otoliths were collected from *T. murphyi* less than 46 cm in length (Figure 6). Following otolith selection and data grooming, a total of 591, 43, and 561 age estimates were available for the catch-at-age analyses for *T. declivis*, *T. murphyi*, and *T. novaezelandiae*, respectively (Tables 4–6).

The details of the estimated catch-at-age distributions for trawl-caught jack mackerel from JMA 7 in 2020–21 are presented for *T. declivis* in Table 4, *T. murphyi* in Table 5, and *T. novaezelandiae* in Table 6. The mean weighted CVs (mwCV) for *T. declivis* (14%) and *T. novaezelandiae* (16%) were well below the target value of 30%. The mwCV for *T. murphyi* was high due to the small sample sizes included in the analyses as a result of removal of records with species identification issues. The estimated distributions are plotted in Figure 7. In 2020–21, the catch of *T. declivis* had abundant fish aged 2–5 years, but with relatively few fish older than 10 years. The catch of *T. murphyi* was dominated by fish aged 18–25 years, with very few fish younger than 15 or older than 25 years. The catch of *T. novaezelandiae* was dominated by fish aged 2–8 years, with very few fish older than 12 years (Figure 7).

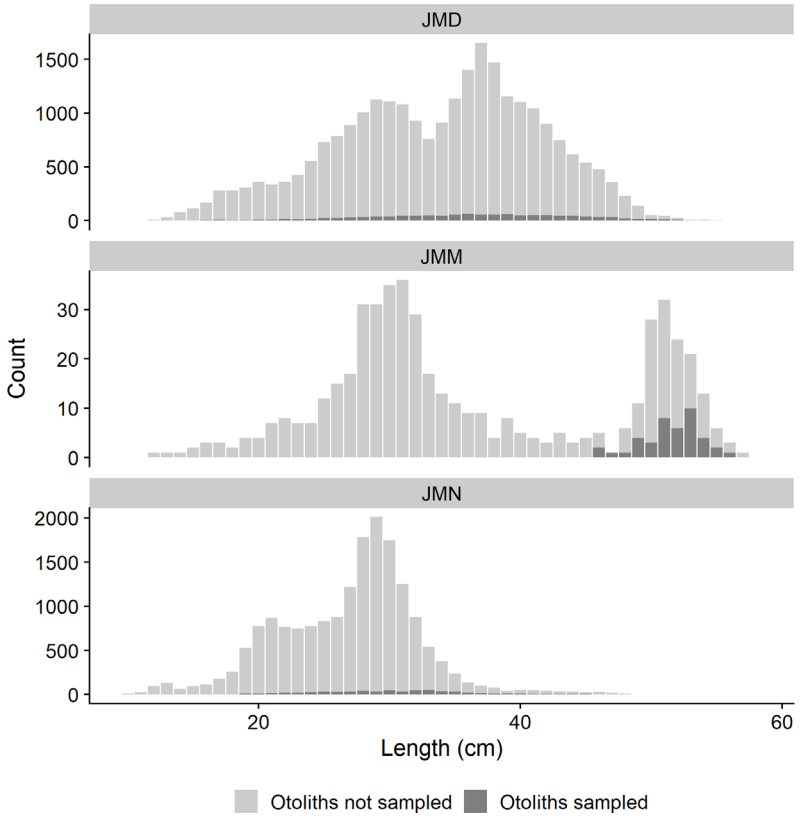

Figure 6: **Unscaled counts of jack mackerel individuals with and without otoliths collected, by length and species, from observer sampling in JMA 7 for the 2020–21 fishing year following the removal of a single trip with substantial species identification errors. JMD = *Trachurus declivis*, JMM = *Trachurus murphyi*, JMN = *Trachurus novaezelandiae*.**

Table 4: Estimated numbers-at-age, separately by sex and both sexes combined, with CVs, for *Trachurus declivis* caught during commercial trawl operations in JMA 7 during the 2020–21 fishing year. Summary statistics for the sample are also presented.

Age (years)	Male	CV	Female	CV	Total	CV
1	457 418	0.30	544 177	0.29	1 001 595	0.23
2	813 807	0.25	1 357 008	0.26	2 170 814	0.19
3	2 622 591	0.14	4 027 637	0.14	6 650 228	0.11
4	3 271 943	0.11	3 204 885	0.11	6 476 829	0.08
5	1 658 796	0.16	1 801 012	0.15	3 459 809	0.11
6	498 601	0.24	1 234 933	0.15	1 733 535	0.13
7	711 738	0.22	847 097	0.19	1 558 835	0.14
8	399 392	0.28	367 706	0.28	767 099	0.20
9	286 386	0.32	301 631	0.29	588 018	0.22
10	178 954	0.36	383 506	0.26	562 459	0.22
11	25 798	0.93	72 842	0.52	98 640	0.47
12	108 781	0.53	186 142	0.36	294 922	0.29
13	86 810	0.54	37 491	0.71	124 301	0.44
14	134 853	0.40	0	0.00	134 853	0.40
15	49 860	0.64	76 984	0.53	126 843	0.41
16	27 767	0.79	73 698	0.55	101 466	0.45
17	60 245	0.60	34 395	0.84	94 640	0.50
18	53 565	0.61	34 395	0.86	87 961	0.51
19	0	0.00	74 555	0.50	74 555	0.50
20	0	0.00	0	0.00	0	0.00
21	4 231	1.19	0	0.00	4 231	1.19
22	0	0.00	1 818	2.04	1 818	2.04
23	0	0.00	0	0.00	0	0.00
24	0	0.00	0	0.00	0	0.00
25	0	0.00	8 671	1.00	8 671	1.00
26	0	0	0	0	0	0
No. measured*	7 049		8 409		15 458† (25 756‡)	
No. aged*	269		322		591	
No. of tows sampled*						254
Mean weighted CV (%)		19.0		18.2		13.8

* Excludes a single trip with substantial species identification issues.
† Includes individuals measured and sexed.
‡ Includes all individuals measured, including those without sex information.

Table 5: Estimated numbers-at-age, separately by sex and both sexes combined, with CVs, for *Trachurus murphyi* caught during commercial trawl operations in JMA 7 during the 2020–21 fishing year. Summary statistics for the sample are also presented.

Age (years)	Male	CV	Female	CV	Total	CV
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
7	0	0	0	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	0	0	0	0	0	0
11	0	0	1 879	1.29	1 879	1.29
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	0	0	2 350	1.63	2 350	1.63
15	0	0	0	0	0	0
16	2 436	1.36	0	0	2 436	1.36
17	0	0	0	0	0	0
18	1 284	1.21	0	0	1 284	1.21
19	0	0	767	1.30	767	1.30
20	3 138	0.80	480	1.44	3 618	0.75
21	4 601	0.87	871	1.27	5 473	0.76
22	4 124	0.77	3 037	0.77	7 161	0.55
23	5 004	0.75	3 372	0.74	8 376	0.56
24	5 873	0.61	7 862	0.49	13 735	0.40
25	2 981	1.07	0	0	2 981	1.07
26	1 033	1.37	0	0	1 033	1.37
No. measured*	44		45		89† (502‡)	
No. aged*	23		20		43	
No. of tows sampled*						43
Mean weighted CV (%)		87.1		85.9		73.8

* Excludes a single trip with substantial species identification issues.
† Includes individuals measured and sexed.
‡ Includes all individuals measured, including those without sex information.

Table 6: Estimated numbers-at-age, separately by sex and both sexes combined, with CVs, for *Trachurus novaezelandiae* caught during commercial trawl operations in JMA 7 during the 2020–21 fishing year. Summary statistics for the sample are also presented.

Age (years)	Male	CV	Female	CV	Total	CV
1	0	0	0	0	0	0
2	399 923	0.34	677 828	0.41	1 077 752	0.28
3	1 830 114	0.17	2 485 462	0.18	4 315 577	0.14
4	789 333	0.22	1 190 767	0.19	1 980 100	0.14
5	1 252 939	0.16	1 302 389	0.14	2 555 328	0.12
6	254 390	0.38	798 712	0.20	1 053 102	0.18
7	1 214 615	0.15	1 083 495	0.16	2 298 110	0.12
8	325 238	0.26	708 070	0.19	1 033 308	0.16
9	386 612	0.21	175 712	0.27	562 324	0.17
10	227 874	0.26	399 612	0.20	627 486	0.16
11	170 011	0.30	285 080	0.30	455 091	0.21
12	215 166	0.24	74 190	0.34	289 354	0.20
13	69 364	0.33	101 619	0.30	170 984	0.23
14	71 423	0.32	59 090	0.38	130 512	0.26
15	10 291	0.77	14 930	0.70	25 221	0.54
16	39 722	0.52	22 779	0.59	62 501	0.40
17	0	0	15 544	0.72	15 544	0.72
18	11 517	0.75	0	0.00	11 517	0.75
19	9 557	0.85	5 033	1.11	14 591	0.69
20	0	0	0	0.00	0	0
21	37 206	0.43	0	0.00	37 206	0.43
22	0	0	0	0.00	0	0
23	9 557	0.86	0	0.00	9 557	0.86
24	2 535	1.59	0	0.00	2 535	1.59
25	0	0	4 074	1.19	4 074	1.19
26	0	0	5 603	1.03	5 603	1.03
No. measured*	4 510		5 637		10 147† (17 852‡)	
No. aged*	253		308		561	
No. of tows sampled*						198
Mean weighted CV (%)		21.0		20.4		15.9

* Excludes a single trip with substantial species identification issues.
† Includes individuals measured and sexed.
‡ Includes all individuals measured, including those without sex information.

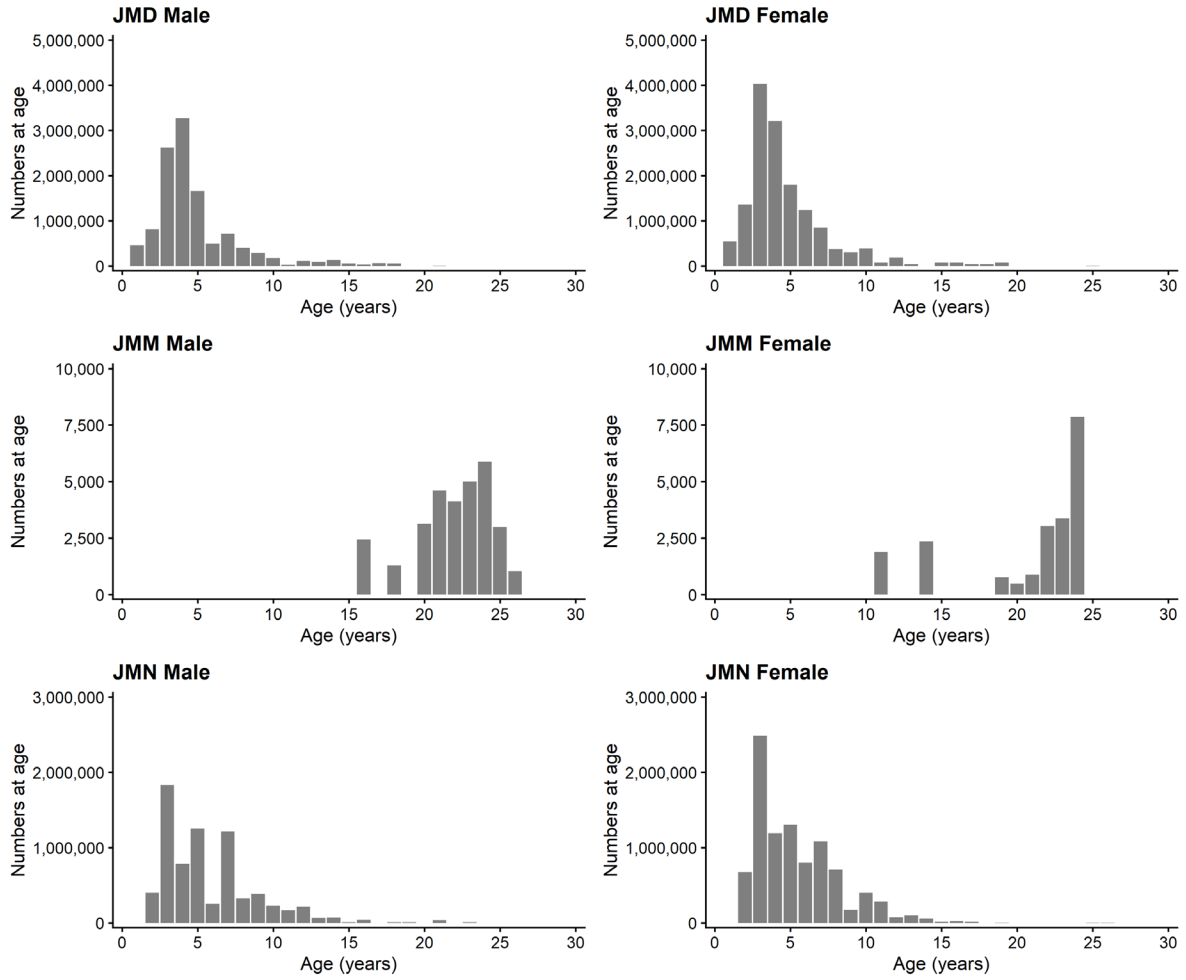

Figure 7: Estimated commercial catch-at-age distributions, by species and sex, for the JMA 7 trawl fishery in 2020–21. JMD = *Trachurus declivis*, JMM = *Trachurus murphyi*, JMN = *Trachurus novaezelandiae*.

3.6 Data summaries

Catch-at-length and catch-at-age data from the JMA 7 fishery are available for 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, 2007–08 (age only), and in the current year (2020–21) likely resulting from small sample sizes of both measured and aged individuals.

Total (i.e., sexes combined) scaled length and age distributions, by species and fishing year since 2006–07 are shown in Figures 8–10. The data used to produce these catch-at-age distributions are listed in Appendix B.

Trachurus declivis

Scaled catch-at-length and catch-at-age frequencies for *T. declivis* by fishing year since 2006–07 are shown in Figure 8. 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. 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 to 2017–18 where they were age 7 and age 4, respectively. Since 2014–15, the length mode

previously clearly obvious at 50–54 cm has declined significantly, 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. In 2020–21, fish aged 3–4 years dominated in approximately equal proportions (Figure 8).

Trachurus murphyi

Scaled catch-at-length and catch-at-age frequency distributions for *T. murphyi* by fishing year since 2006–07 are shown in Figure 9. With the exception of 2020–21, scaled annual length 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 in 2020–21 were, however, strikingly different to those from previous years. There was a large proportion of small fish (i.e., smaller than 40 cm). None of these individuals had accompanying sex information, and no otoliths were collected for age estimation, resulting in a disconnect between the catch-at-length and catch-at-age analyses for this year.

Trachurus novaezelandiae

Scaled catch-at-length and catch-at-age frequency distributions for *T. novaezelandiae* by fishing year are shown in Figure 10. 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. The large peak in 5-year-olds in 2018–19 was evident as 7-year-olds in 2020–21 (Figure 10).

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, 2006–07 to 2020–21. 'Total' in this table refers to males and females combined, and excludes unsexed individuals.

		Catch-at-age mwCV (%)			Catch-at-length mwCV (%)		
Species	Fishing year	Males	Females	Total	Males	Females	Total
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
	2020–21	19	18	14	16	17	12
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
	2020–21	87	86	74	75	83	57
T. 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
	2020–21	21	20	16	18	19	20

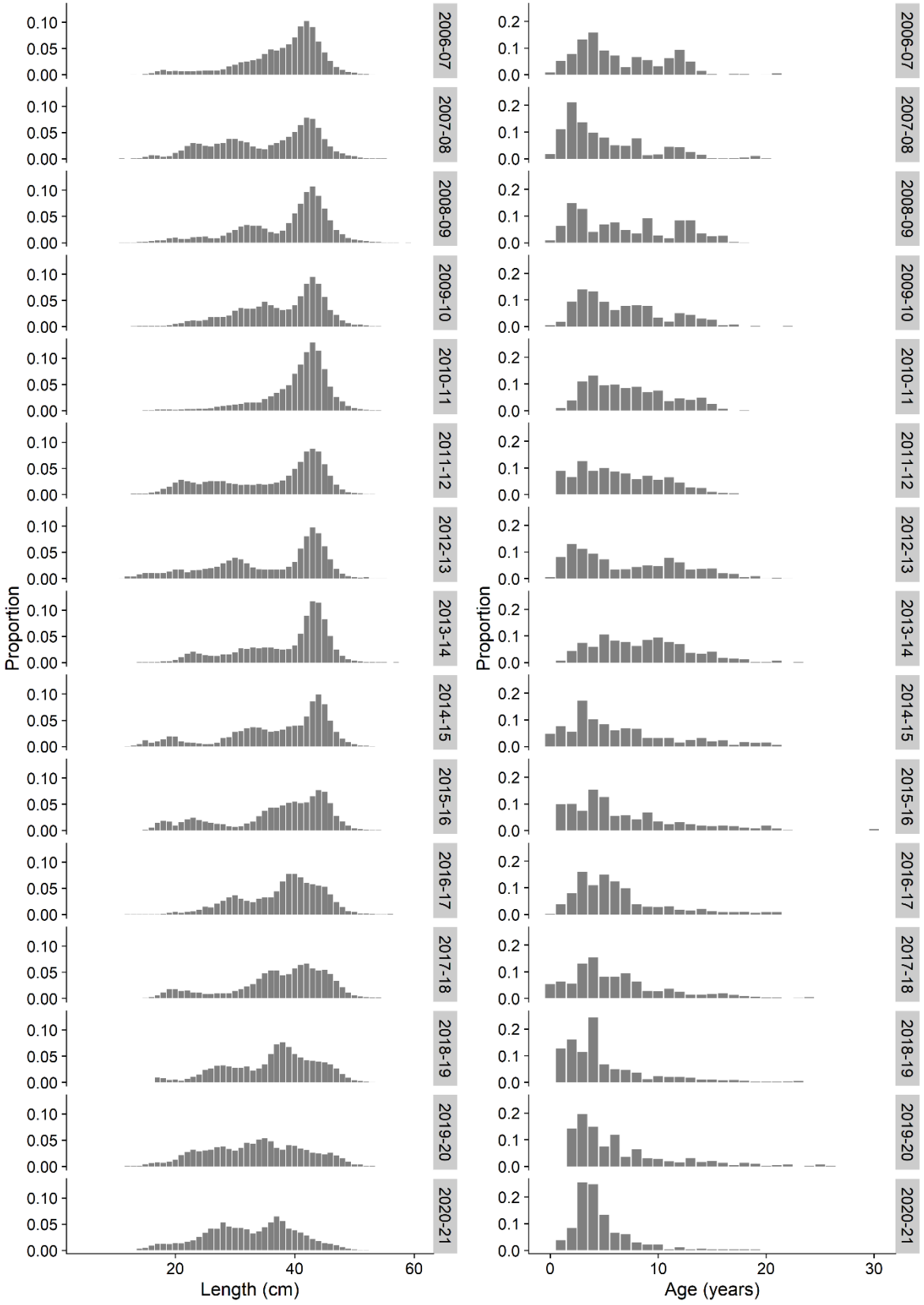

Figure 8: **Scaled catch-at-length (left panel) and catch-at-age (right panel) proportions for the catch of *Trachurus declivis* sampled from the 2006–07 to 2020–21 fishing years for the JMA 7 trawl fishery. Note the catch-at-age plots here are based on estimated numbers of males and females combined in observed age classes only.**

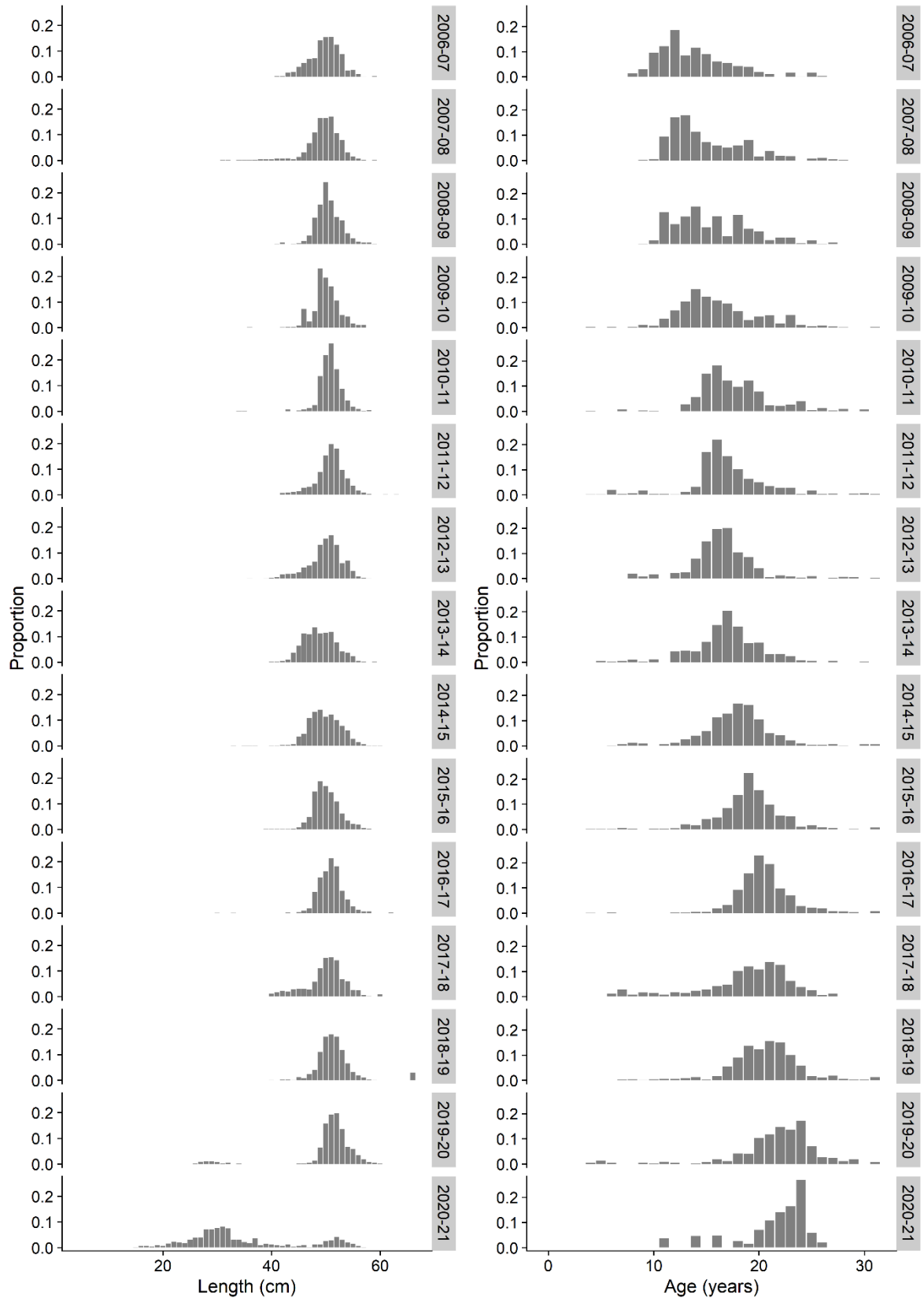

Figure 9: **Scaled catch-at-length (left panel) and catch-at-age (right panel) proportions for the catch of *Trachurus murphyi* sampled from the 2006–07 to 2020–21 fishing years for the JMA 7 trawl fishery. Note the catch-at-age plots here are based on estimated numbers of males and females combined in observed age classes only.**

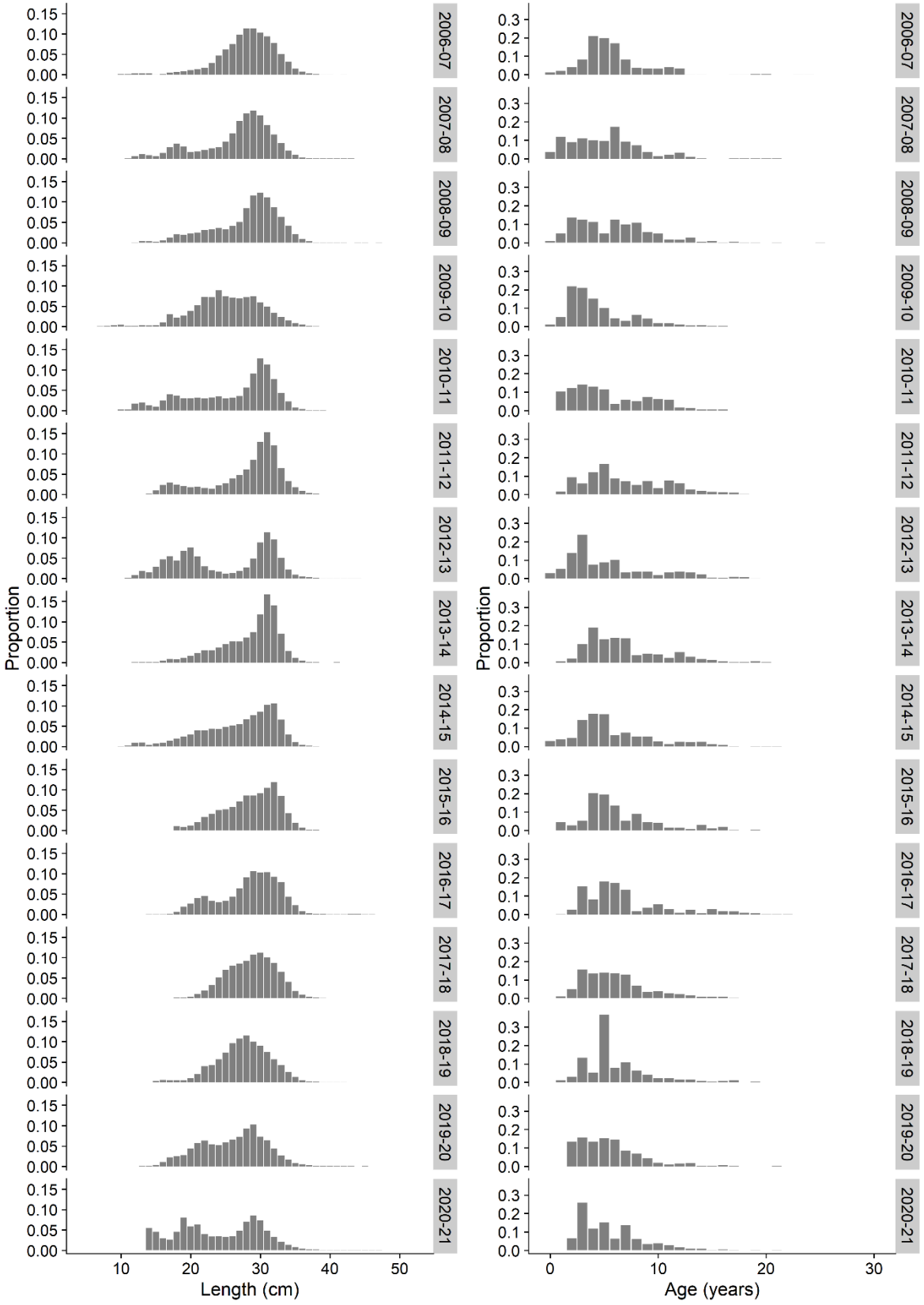

Figure 10: Scaled catch-at-length (left panel) and catch-at-age (right panel) proportions for the catch of *Trachurus novaezelandiae* sampled from the 2006–07 to 2020–21 fishing years for the JMA 7 trawl fishery. Note the catch-at-age plots here are based on estimated numbers of males and females combined in observed age classes only.

4. DISCUSSION

The 2020–21 jack mackerel trawl fishery in JMA 7 was well sampled with respect to the spatial and temporal distribution of the fishery (as it was in all years since at least 2006–07) with good coverage of catch in the most fished Statistical Areas (034–037, 039–042, and 801). *Trachurus declivis* and *T. novaezelandiae* comprised an estimated 99% of the catch in 2020–21. Estimates of the 2020–21 catch-at-age for the two main species (*T. declivis* and *T. novaezelandiae*) 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 15 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. However, given the bimodality often observed in length frequency data for *T. declivis*, and for *T. murphyi* in 2020–21, it may be that proportions of *T. novaezelandiae* in the catch are underestimated.

Data availability was a significant issue in the current study, particularly for *T. murphyi*. Only 1896 length measurements were recorded for this species in 2020–21 (1353 of which had associated sex information), and only 149 otoliths were collected. Once data grooming was performed, only 498 length measurements were available for the catch-at-length analyses, 85 of which had associated sex information, and only 43 individuals were deemed appropriate for use in the catch-at-age analyses once the single trip with species identification issues was removed.

The large number of measured individuals that lacked sex information and were not sampled for otoliths in 2020–21 was unexpected, as observer sampling protocols for 2020 indicate that sex should be determined for all measured fish (Appendix C). Similarly, otoliths should have been collected from the smallest individuals of JMD and JMN, in accordance with sampling protocols, which states "If there are any fish outside this range [27 cm to 65 cm], their otoliths should also be collected and noted on the otolith collection tally sheet" (Appendix C). While having a small number of fish without sex information is expected (e.g., due to being unable to determine sex in small, immature individuals), in 2020–21 fish without sex information occurred across all observed length ranges for species, including the largest individuals, while for *T. murphyi*, otoliths were lacking from small individuals. This resulted in inconsistencies between sex-specific and overall catch-at-length distributions, and between catch-at-length and catch-age-age distributions, as only observed age classes are included in the age-length key used to generate scaled catches-at-age. Improved communication of, and adherence to, sampling requirements is required to improve the data inputs for the analyses presented here.

Species identification has been an ongoing problem in the JMA fishery (Horn et al. 2019, Saunders et al. 2021) and may have strongly influenced the results of the current study. In the current analysis, a single trip was excluded on the recommendation of the Deepwater Working Group due to suspected species identification issues. Removing this trip reduced the overall sampled catch and restricted sample sizes for the catch-at-length and catch-at-age analyses for *T. murphyi*. Other than removing data for this trip, data grooming for outliers followed established practices used for previous JMA 7 catch-at-length and catch-at-age analyses. However, many small (i.e., < 38 cm) unsexed *T. murphyi* were reported on several other trips and by different observers in 2020–21. As these fish have generally been retained in previous analyses (e.g., Saunders et al. 2022), they were retained here. No otoliths were collected from these small individuals, precluding an examination of otolith shape (see below) or examination of length-at-age to assess whether they were correctly identified. Accordingly, it is unclear whether the small *T. murphyi* retained in the current study are the result of species identification errors or result from an episodic and previously undocumented recruitment of small *T. murphyi*. However, fish of these

lengths have previously only comprised a small number of sampled individuals in previous years, while an examination of length data for *T. murphyi* caught during research trawl surveys suggests *T. murphyi* less than 40 cm fork length are extremely rare in New Zealand waters (Appendix D). As such, it is likely that these individuals may have been *T. declivis* or *T. novaezelandiae* that were incorrectly identified as *T. murphyi*. Thus, and in conjunction with the small sample sizes described above, the catch-at-length results for *T. murphyi* in 2020-21 should be interpreted with caution. Further investigation is required into the validity of the small *T. murphyi* retained in the analyses for 2020–21. This could be achieved, for example, by applying the otolith shape approach of Moore et al. (in review) to otoliths collected by the relevant observers in previous years to gauge their species identification accuracy. In future years, any small *T. murphyi* (i.e., < 40 cm fork length) observed on-board should be processed as per observer sampling protocols (i.e., measured fish should be sexed and otoliths should be retained for ageing), and a subset of fish should be retained whole to validate on-board identifications.

To resolve the issues concerning species mis-identification and a lack of sex information, ongoing training in both species identification and sex determination should be provided to observers to ensure best-quality data are collected. In addition, adherence to current observer data collection protocols, including the collection of sex information from measured individuals, should be stressed. Approaches to identify species through an examination of the shape of otoliths themselves is currently being explored under project SEA202012 (Moore et al. in review). Outputs from this work could be retrospectively applied to previously collected otoliths to accurately identify and resolve mis-identifications in historical data. Application of otolith shape would also facilitate the development of data grooming rules are less reliant on length-at-age based approaches, that necessitate the generation of age data in the first instance.

5. ACKNOWLEDGEMENTS

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APPENDIX A NUMBER OF JACK MACKEREL RECORDS FROM JMA 7 WITH AND WITHOUT SEX INFORMATION, 2010–11 TO 2020–21

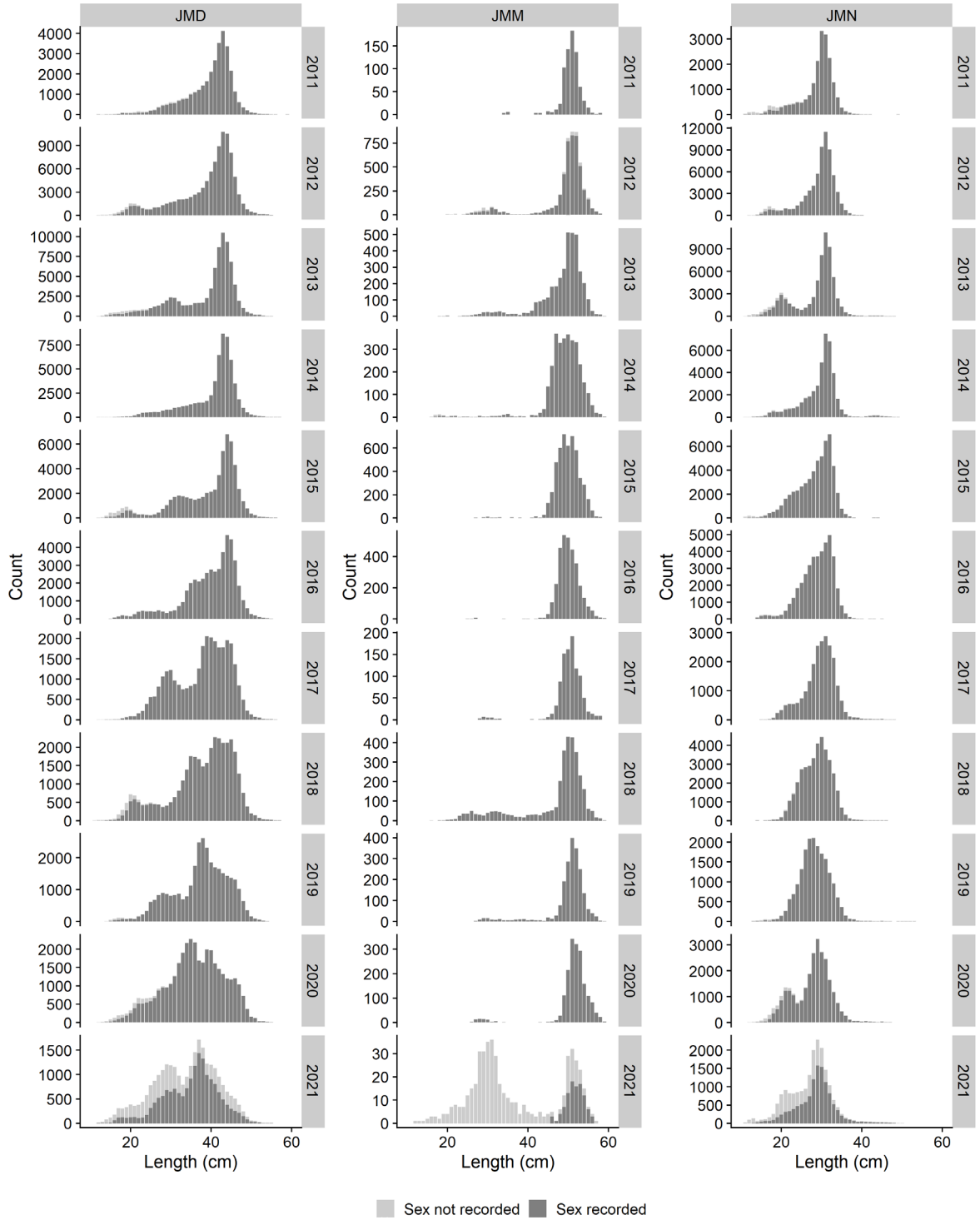

Figure A1: Counts of JMA records from observers in JMA 7 with and without sex information by length and species prior to data grooming, 2010–11 to 2020–21. JMD = *Trachurus declivis*, JMM = *Trachurus murphyi*, JMN = *Trachurus novaezelandiae*.

APPENDIX B 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 between 2006–07 and 2020–21. The columns in each table are named 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.

Table B1: Estimated proportions-at-age (males and females 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	2021
0	0.00893	0.01782	0.00806	0.00539	0	0	0.00410	0.00023	0.04777	0	0.00119	0.05380	0	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	0.03834
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	0.08310
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	0.25458
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	0.24794
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	0.13245
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	0.06636
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	0.05967
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	0.02937
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	0.02251
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	0.02153
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	0.00378
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	0.01129
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	0.00476
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	0.00516
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	0.00486
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	0.00388
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	0.00362
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	0.00337
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	0.00285
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	0
21	0.00459	0	0	0	0	0	0.00208	0.00722	0.00693	0.00727	0.00820	0.00417	0.00116	0.00455	0.00016
22	0	0	0	0.00234	0	0	0.00131	0	0	0.00175	0	0.00072	0.00217	0.00723	0.00007
23	0	0	0	0	0	0	0	0.00201	0	0.00039	0	0.00255	0.00285	0.00000	0
24	0	0	0	0.00028	0	0	0	0	0	0	0	0.00463	0.00026	0.00252	0
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00665	0.00033
26	0		0	0	0	0	0	0	0	0	0	0	0	0.00212	0

Table B2: CVs for estimated proportions-at-age (males and females combined) for *Trachurus declivis* 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	2021
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	0.233
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	0.192
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	0.111
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	0.079
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	0.109
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	0.133
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	0.143
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	0.200
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	0.219
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	0.218
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	0.468
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	0.287
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	0.441
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	0.405
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	0.408
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	0.449
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	0.502
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	0.511
19		0.784		1.020			0.292	0.456	0.254	0.383	0.373	0.388	0.327	0.829	0.502
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	1.186
22				0.963			0.801			0.537		0.769	0.436		2.042
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	0.997
26															

Table B3: Estimated proportions-at-age (males and females 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	2021
4	0	0	0	0.00205	0.00259	0.00176	0	0	0	0.00136	0.00029	0	0	0.00525	0
5	0	0	0	0	0	0.00211	0	0.00393	0	0.00169	0	0.00101	0	0.01273	0
6	0	0	0	0.00209	0.00049	0.01934	0	0.00283	0.00118	0.00143	0.00271	0.01186	0	0.00472	0
7	0.00018	0	0	0	0.00726	0.00436	0	0.00485	0.00759	0.00509	0	0.02866	0.00183	0.00000	0
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	0
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	0
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	0
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	0.03678
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	0
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	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	0.04599
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	0
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	0.04768
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	0
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	0.02513
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	0.01501
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	0.07081
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	0.10712
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	0.14016
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	0.16394
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	0.26882
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	0.05834
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	0.02022
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	0
28	0	0.00218	0	0.00113	0.00921	0.00066	0.00628	0	0.00196	0	0.00589	0	0.00514	0.01172	0
29	0	0	0	0	0	0.00457	0.00488	0	0	0.00180	0.00312	0	0.00174	0.01928	0
30	0	0	0	0	0.00729	0.00655	0	0.00231	0.00588	0	0	0	0.00228	0	0
31	0	0	0	0.00268	0	0.00394	0.00226	0	0.00569	0.00699	0.00727	0	0.01215	0.00785	0

Table B4: CVs for estimated proportions-at-age (males and females combined) for *Trachurus murphyi* 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	2021
4				2.236	1.146	1.047				1.397	1.866			1.281	
5						0.747		0.766		1.527		1.649		1.304	
6				1.423	2.163	0.420		1.105	0.848	1.467	1.096	0.852		1.421	
7	2.343				1.841	1.093		0.741	0.632	0.646		0.541	0.998	0.000	
8	0.605			1.481		0.891	0.710	0.519	0.452	0.965		0.910	1.267	0.000	
9	0.420	1.054	1.736	0.948	0.873	0.596	0.869	0.972	0.577	0.000		0.705	0.964	1.567	
10	0.322	0.581	0.663	0.803	1.888	1.225	0.714	0.531		1.519		0.589	0.786	0.844	
11	0.301	0.251	0.227	0.383		1.119			0.593	1.105		0.945	0.697	0.733	1.290
12	0.189	0.178	0.291	0.584		1.043	0.499	0.237	0.445	0.689	1.057	0.734	0.914	1.072	
13	0.266	0.184	0.255	0.178	0.363	0.511	0.432	0.261	0.338	0.338	1.259	0.697	0.503	0.000	
14	0.221	0.225	0.206	0.233	0.235	0.322	0.231	0.252	0.245	0.371	0.722	0.429	0.536	1.016	1.631
15	0.332	0.347	0.333	0.271	0.144	0.119	0.142	0.184	0.188	0.244	0.850	0.520	1.018	0.639	
16	0.344	0.299	0.242	0.192	0.130	0.102	0.111	0.145	0.133	0.191	0.495	0.215	0.322	0.458	1.360
17	0.480	0.337	0.351	0.178	0.174	0.119	0.107	0.113	0.133	0.169	0.350	0.210	0.211	0.455	
18	0.427	0.339	0.233	0.222	0.183	0.165	0.145	0.142	0.110	0.125	0.187	0.152	0.153	0.275	1.213
19	0.665	0.314	0.365	0.304	0.155	0.182	0.164	0.183	0.109	0.094	0.136	0.150	0.124	0.279	1.297
20	0.699	0.543	0.345	0.235	0.228	0.198	0.245	0.192	0.128	0.115	0.098	0.139	0.122	0.163	0.750
21	0.878	0.461	0.781	0.269	0.374	0.231	0.664	0.313	0.201	0.145	0.122	0.114	0.114	0.148	0.762
22		0.767	0.451	0.433	0.392	0.267	0.479	0.312	0.220	0.179	0.180	0.130	0.114	0.128	0.546
23	1.041	0.860	0.495	0.273	0.340	0.298	0.487	0.368	0.301	0.199	0.225	0.202	0.149	0.125	0.556
24	4.020		0.823	0.576	0.295	0.831	0.894	0.643	0.431	0.436	0.332	0.305	0.189	0.104	0.403
25	1.074	1.120	0.898	0.655	0.763	0.336	0.532	0.607	0.720	0.367	0.434	0.307	0.306	0.187	1.071
26		1.083	0.869	0.564	0.543	0.788			0.679	0.451	0.502	0.439	0.411	0.283	1.374
27		1.018	0.654	0.791	1.018	0.673	0.915	0.688	0.644	0.600	0.528	0.435	0.355	0.295	
28		1.070		1.060	0.630	1.301	0.816		1.069	0.000	0.700		0.587	0.393	
29						0.780	0.785			1.087	1.109		1.023	0.365	
30					0.836	0.645		0.997	0.610	0.000			0.979	0.000	
31				1.014		0.693	1.045		0.539	0.499	0.604		0.380	0.540	

Table B5: Estimated proportions-at-age (males and females 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	2021
0	0.01321	0.03725	0.00935	0.01267	0.00073	0	0.02842	0.00003	0.02970	0	0	0.00071	0	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	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	0.06439
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	0.25784
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	0.11830
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	0.15267
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	0.06292
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	0.13730
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	0.06174
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	0.03360
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	0.03749
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	0.02719
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	0.01729
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	0.01022
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	0.00780
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	0.00151
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	0.00373
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	0.00093
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	0.00069
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	0.00087
20	0.00235	0.00063	0	0.00000	0	0	0	0.00083	0.00092	0.00124	0.00077	0.00016	0	0	0
21	0	0.00029	0.00082	0	0	0	0	0	0.00143	0	0.00013	0	0	0.00149	0.00222
22	0	0.00016	0	0	0	0	0	0	0	0	0.00113	0	0	0	0
23	0.00097	0	0	0.00000	0	0	0.00051	0	0	0	0	0.00016	0	0	0.00057
24	0.00056	0	0	0.00012	0	0	0.00022	0	0	0	0	0	0	0	0.00015
25	0	0	0.00026	0.00000	0	0	0	0	0	0	0	0.00026	0	0	0.00024
26	0	0	0	0.00024	0	0	0	0	0	0	0	0	0	0	0.00033

Table B6: CVs for estimated proportions-at-age (males and females 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	2021
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		
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	0.283
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	0.141
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	0.143
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	0.122
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	0.180
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	0.120
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	0.159
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	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	0.160
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	0.215
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	0.196
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	0.227
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	0.262
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	0.537
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	0.400
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	0.724
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	0.746
19	0.702	1.023	0.972	1.916			0.769	0.287	0.000	0.528	0.349		0.473		0.688
20	0.896	0.940		1.253				0.673	0.434	0.569	0.581	0.978			
21		0.869	0.832						0.862		1.016			0.751	0.428
22		1.138									0.550				
23	1.079			1.134			0.835					0.941			0.855
24	1.065			0.887			0.903								1.585
25			1.037	2.166								1.041			1.193
26				1.049											1.032

APPENDIX C JMA 7 SAMPLING PROTOCOL FOR OBSERVERS FROM 2020

Biological Data Collection

- The target species for this trip is expected to be **JMA and BAR**
- If the vessel targets any other species, please confirm the target species with the skipper and notify OSU.

JMA LF

- Please carry out one length frequency test **every day (when targeted).**
- Each sample must consist of 100kg or 150 fish, whichever comes first.
- Catches greater than 1 tonne but less than 10 tonne – collect sample as three random sub samples throughout the catch (i.e 3 tests of 50 fish or 3 tests weighed to 100 kg).
- Catches greater than 10 tonne – take four random sub samples (totalling at least 150 fish) throughout the catch (i.e 4 tests of 37-38 fish or weighed up to 100 kg).

All fish from these samples must first be sorted into the three sub-species (JMM/JMD/JMN). **Do not use JMA code in YUMA, must separate by species and enter as either JMM, JMD, or JMN.**

Each group of sub-species must then be weighed, measured, sexed, and gonads staged (females only).

If you encounter any difficulties with this sampling, please make contact with shore staff as soon as possible. We appreciate that this sampling programme is not necessarily always achievable, so please just do your best.

Ensure that you take regular breaks and exercises when cutting fish.

Please note that JMM sampling is higher priority than EMA

Otolith packets – The sex and stage should be recorded on all otolith packets. **NEVER write 'JMA' on an otolith packet**, ALWAYS write the sub-species otherwise the otoliths are of no use.

In addition, a sub-sample of otoliths must be collected as follows:

- **JMN & JMD:**

Over the trip you should collect at least three otoliths in each 1 cm size class from 27cm to 65cm where possible. If there are any fish outside this range, their otoliths should also be collected and noted on the otolith collection tally sheet.

The tally sheets included with this request are to assist in keeping track of the number of otoliths you have collected as well as providing a clear summary of what has been collected at the end of the trip. It should be amended with any additional

APPENDIX D LENGTHS OF JACK MACKEREL SPECIES REPORTED FROM RESEARCH TRAWL SURVEYS

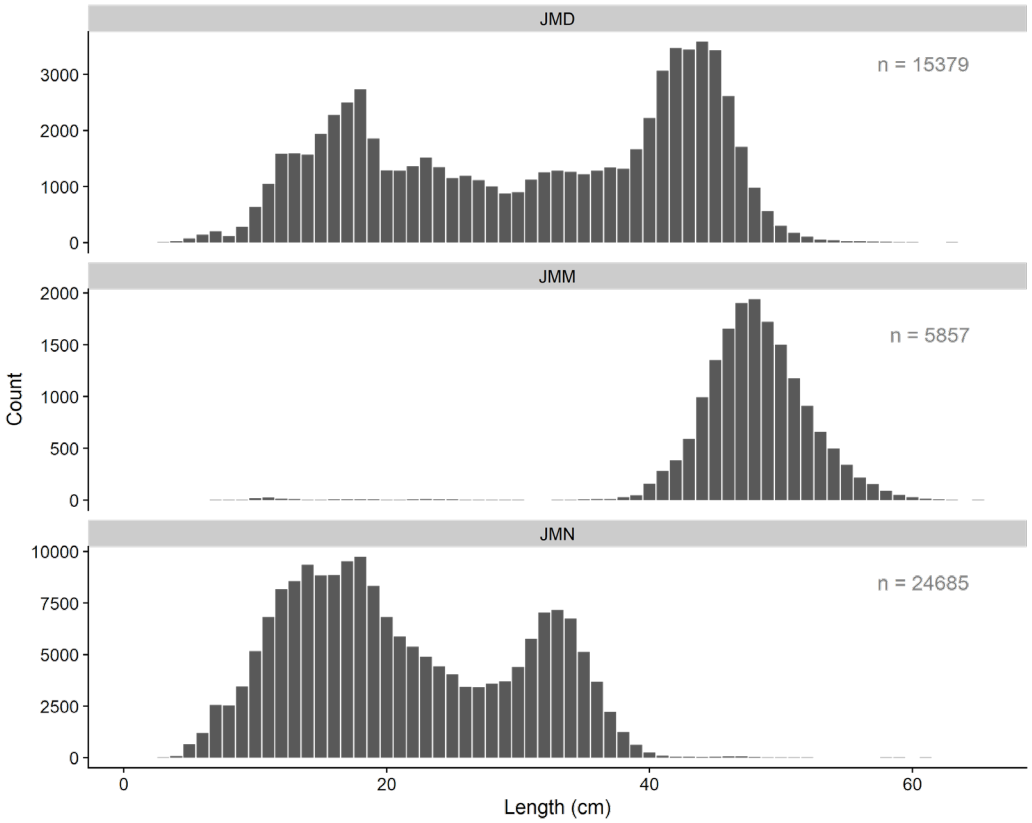

Figure D1: Numbers in 1-cm length bins of *T. declivis* (JMD; top), *T. murphyi* (JMM; middle) and *T. novaezelandiae* (JMN; bottom) from research trawl surveys in New Zealand waters.