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Catch-at-age for barracouta (*Thrysites atun*) in BAR 4 and BAR 5 and gemfish (*Rexea solandri*) in SKI 3 and SKI 7 for the 2019–20 and 2020–21 fishing years

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EXECUTIVE SUMMARY

Devine, J.A.[1]; Sutton, C.; Hart, A.; Saunders, R.J. (2023). Catch-at-age for barracouta (*Thrysites atun*) in BAR 4 and BAR 5 and gemfish (*Rexea solandri*) in SKI 3 and SKI 7 for the 2019–20 and 2020–21 fishing years.

***New Zealand Fisheries Assessment Report 2023/22.* 12 p.**

Catch-at-age distributions were estimated using data and otoliths collected at sea by observers for barracouta (*Thrysites atun*, BAR) in BAR 4 and BAR 5 for the 2019–20 and 2020–21 fishing years and for gemfish (*Rexea solandri*, SKI) in SKI 3 and SKI 7 for the 2020–21 fishing year. Length frequency data and otolith samples were collected from the commercial bottom trawl fisheries by Scientific Observers: 450 otoliths were proposed to be aged for barracouta in each of BAR 4 and BAR 5; and 300 per fishstock were proposed for SKI 3 and SKI 7.

An error was made in the selection of otoliths for barracouta, but it was agreed that too few data were collected from BAR 4 to generate an age-length key (ALK). The trawl fishery in BAR 5 was well covered by the observers and despite the error in otolith selection, enough otoliths were selected from this fishery to generate an ALK. The length frequencies for barracouta in BAR 5 were bimodal, included few fish under 50 cm, and were slightly different between years; the largest mode in 2020–21 was in 60–70 cm fish compared with 70–90 cm fish in 2019–20. Most of the barracouta were ages 2–5 and the CVs for those ages were under 25%, but it was agreed with the Deepwater Working Group that more large fish from BAR 5 would be aged from 2019–20 and 2020–21 and presented with the results of the 2021–22 fishing year.

The length frequencies used to generate the ALK for gemfish in SKI 3 were from the peak in the trawl fishery (1 February–30 April), had multiple modes, including a strong mode under 35 cm. Most of the gemfish in SKI 3 were age 1 with a second mode at ages 4–7; the CVs for those ages were very low. The length and age data for SKI 7 were from the peak in the trawl fishery between 1 June and 30 September. The length frequencies had several modes and included many fish under 40 cm. Most of the gemfish in SKI 7 were ages 5–9, but a moderate number of ages 0–2 were also present; the CVs for were very low. Gemfish of age 3 were largely missing from the commercial trawl fishery. Otoliths are available from the west coast South Island trawl survey (306 in 2016, 481 in 2018, and 545 in 2021) and these could be used to augment the data collected by the observers.

A subset of 30 otoliths of each species was also thin-sectioned and aged to compare with counts from whole otoliths. Both species were aged older with whole otoliths, when compared with thin sections, for younger ages and aged younger for older ages. Zonation patterns were less clear when using thin sections. The Deepwater Working Group agreed that, given this discrepancy, that ageing with whole otoliths was still preferred.

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

1. INTRODUCTION

Catch-at-age data are important for the stock assessment process as they provide information on the year-class strength of recruited cohorts and enable calculation of selectivity ogives for the trawl surveys and commercial fisheries. This report provides analyses of catch-at-age from the bottom trawl fisheries for barracouta (*Thrysites atun*, BAR) in BAR 4 and BAR 5 (Chatham Rise and Southland) from the 2019–20 and 2020–21 fishing years and for gemfish (*Rexea solandri*, SKI) in SKI 3 and SKI 7 (Southeast coast and Challenger) in the 2020–21 fishing year. These results are the first of a three-year catch-at-age series for these two species.

This report fulfils the reporting requirements for barracouta and gemfish in Objective 1 of research project MID2021-01 “Routine age determination of middle depth and deepwater species from commercial fisheries and resource surveys”, funded by Fisheries New Zealand. The overall objective was:

1. To determine the catch-at-age for commercial catch and resource surveys of specified middle depth and deepwater fishstocks.

This project was only concerned with availability of length frequency data and otolith samples from commercial fisheries. Where sufficient samples were available, they were aged and age distributions were constructed. There was no formal evaluation of representativeness of observer sampling, nor of the appropriateness of using the resulting age distributions for stock assessment. We expect this evaluation to be carried out as part of subsequent characterisation or assessment projects.

Under-ageing is a common problem in age determination using whole otoliths (Winkler et al. 2019). Thin-section readings were compared with whole otoliths by Horn (2002) to determine whether the use of whole otoliths resulted in under-ageing of larger fish; zonation patterns on thin sections were less clear than whole otoliths, but readings with were only +1 counts from whole otoliths. The comparison of counts from thin section versus whole otolith was repeated for barracouta, to determine if other readers had the same result, and conducted for the first time for gemfish.

2. METHODS

Both barracouta and gemfish are managed as five separate fishstocks within the New Zealand Economic Exclusion Zone (EEZ) (Figure 1). Length frequency data and otolith samples were collected from the commercial fisheries by Scientific Observers. Four hundred and fifty otoliths were proposed to be aged for barracouta in each of BAR 4 and BAR 5, from the peak season of the bottom trawl fishery; this was between February and April for both fishstocks. For gemfish, 300 per fishstock were proposed for SKI 3 and SKI 7. Otoliths were taken from the peak season of bottom trawl fisheries, which was between February and April for SKI 3 and between June and September for SKI 7.

The age structure of each of the commercial bottom trawl fisheries was derived by application of sex-specific age-length keys (ALKs). Otoliths were selected for each sex separately from 1-cm length classes approximately proportionally to their occurrence in the scaled length frequency, where at least one otolith was selected per length class, if available. All otoliths from fish in the extreme right-hand tail of the scaled length frequency were fully sampled (constituting about 2% of the length frequency). This provides a sample with a mean weighted CV similar to that from proportional sampling, but typically is better than uniform sampling for the older age classes.

Otoliths were interpreted whole after a brief period of soaking in water, as per Horn & Hurst (1999) and Horn (2002). Otoliths were read and interpreted by a single reader using standardised methodologies of Horn & Hurst (1999) for gemfish and Horn (2002) for barracouta. Prior to reading otoliths, readers sampled 50 (gemfish) or 100 (barracouta) otoliths from the reference sets and their performance relative to the agreed reference ages was determined. The reference set for gemfish comprised otoliths from 2010 (Langley et al. 2012).

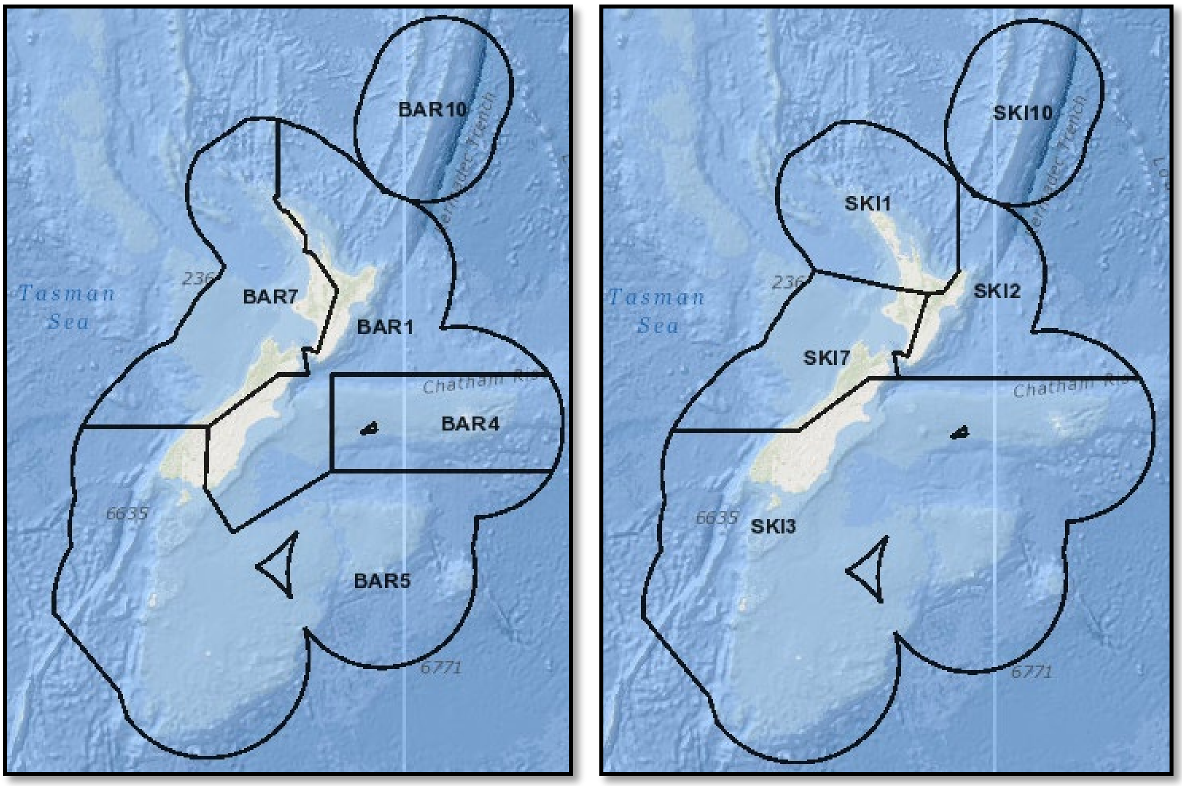

Figure 1: Barracouta (left) and gemfish (right) quota management areas (QMAs).

A subset of 30 otoliths per species was also thin-sectioned and aged to compare with counts from whole otoliths. Sets of five otoliths were embedded in blocks of clear epoxy resin and cured at 50 °C. Once hardened, a ~0.4-mm 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 microscope slide. Otoliths were read with a bright field stereomicroscope at up to 25–100× magnification.

Otolith reading precision was quantified by carrying out within- and between-reader comparison tests following Campana et al. (1995) for both the reference set and thin section vs. whole otolith ageing, including the index of average percentage error (IAPE, Beamish & McFarlane (1983)) and mean coefficient of variation (CV, Chang (1982)), where a CV of 5% serves as a reference point for many fishes of moderate longevity and reading complexity (Campana 2001). Thin sections were read twice. The first reading was done without knowledge of the fish length, the whole otolith age, or (where it existed) information about reading thin sections for that species; the second reading was informed and only those results are presented here.

Commercial fishery catch-at-age distributions were derived by scaling the sample age-frequency estimates to the total estimated catch from each fishery in the time period sampled. The age data were used to construct age-length keys by sex which in turn were used to convert the weighted length composition of the catch to catch-at-age by sex (Bull & Dunn 2002). The length-weight relationships for barracouta were from Hurst & Bagley (1992) and for gemfish, from Hurst & Bagley (1998).

3. RESULTS

3.1 Barracouta

An error was made when selecting the otoliths for ageing; the otoliths were selected from 4 fishstocks (Table 1). Too few otoliths were selected from BAR 4 to continue with the analysis; however, the fishery on the Chatham Rise is not large and mainly from the area surrounding the Chatham Islands (Table 2; Devine et al. 2022). Enough otoliths were collected from BAR 5 to continue the analysis (Table 1).

Table 1: Number of otoliths selected and read for barracouta by fishstock and sex for 2019–20 and 2020–21.

2019–20	Males	Females	Unsexed	2020–21	Males	Females	Unsexed
BAR 7	21	23	0	BAR 7	13	19	0
BAR 1 (ECSI)	69	58	0	BAR 1 (ECSI)	86	98	5
BAR 4	1	0	0	BAR 4	2	3	0
BAR 5	108	154	61	BAR 5	122	133	15
Total	199	235	61	Total	222	253	20

Table 2: Number of observed tows by month and number of measured barracouta by sex contributing to samples of proportion-at-age from the peak in the bottom trawl fishery (February–April) in BAR 5 in 2019–20 (2020) and 2020–21 (2021). Greyed regions are the months that were selected for creating the ALK.

BAR 4	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	No. males	No. females	No. total
2020	22	14	29	5	0	0	1	3	0	0	0	0	56	23	79
2021	2	0	0	9	0	6	0	0	2	0	0	0	270	161	431
Total	24	14	29	14	0	6	1	3	2	0	0	0			
BAR 5															
2020	18	2	22	96	129	131	19	3	10	0	0	25	4 587	5 678	11 321
2021	20	15	17	11	103	125	16	1	1	0	0	11	4 042	4 698	8 750
Total	38	17	39	107	232	256	35	4	11	0	0	36			

3.1.1 Reference set check

The CV and IAPE calculated for the between readers comparison were 3.8% and 2.7%, respectively. No large systematic differences in interpretation of barracouta otoliths existed between reader 1 and the reference set (Figure 2).

3.1.2 Thin section vs. whole otolith ageing

The second reading of the thin sections was compared to whole otolith ages of the same fish (Figure 2). Fish were generally aged older using whole otoliths than thin sections until about age 8, after which, fish were aged younger; the difference in ages could be as much as 5 years. This lack of precision was apparent in the high CV (13%) and IAPE (9%). The Deepwater Working Group requested examples of this discrepancy be included in the report (Figure 3).

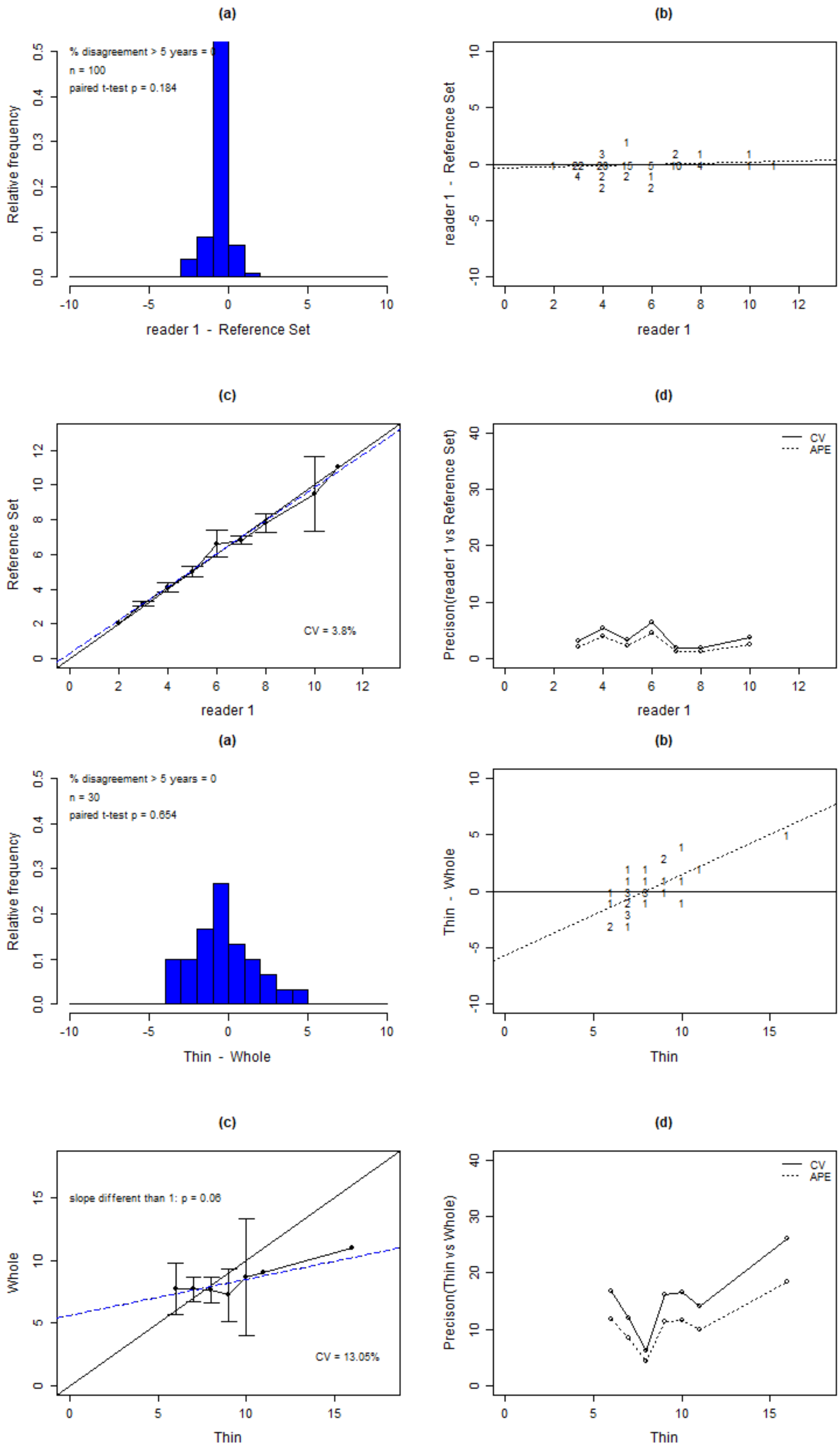

Figure 2: Results of the between-reader comparison test: (top) reader 1 and the reference set and (bottom) of the thin section vs. whole otolith for barracouta. (a) Histograms of differences between readings for the same otolith; (b) differences between the first and second reading for a given age assigned during the first reading; (c) bias plots; and (d) CV and APE profiles relative to the ages assigned during the first set of readings. The expected one-to-one (solid line) and actual relationship (dashed line) between the first and second ages are overlaid on (b) and (c).

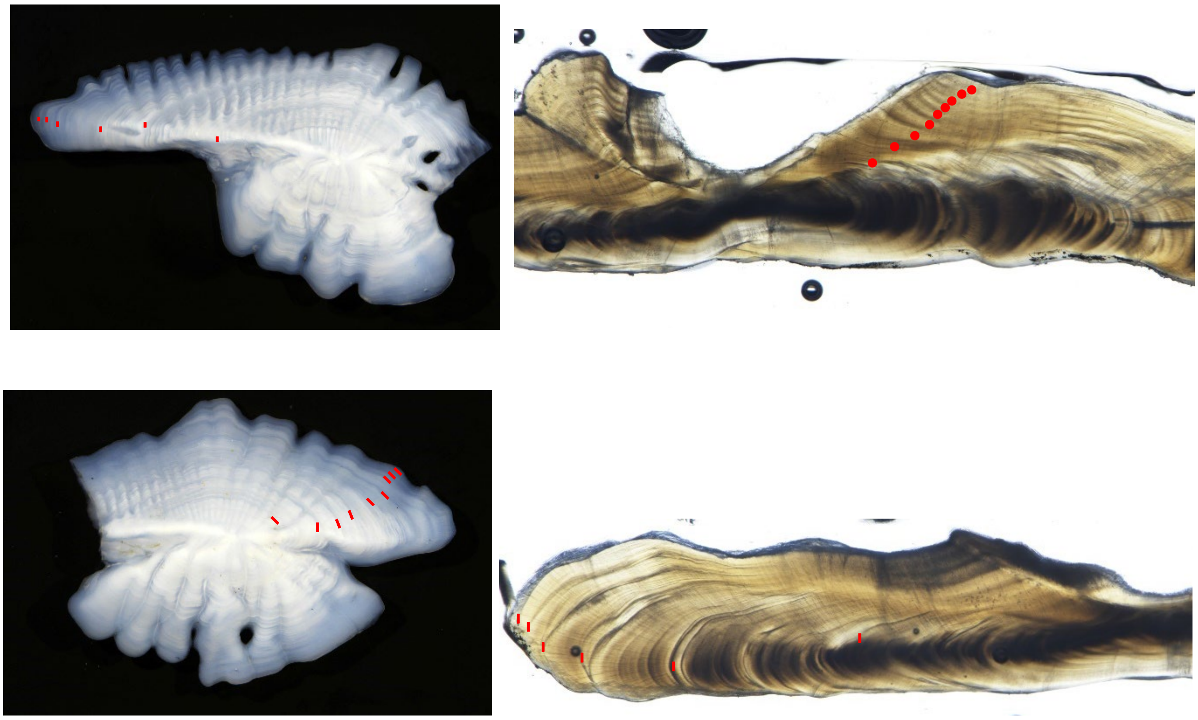

Figure 3: Examples of discrepancy between ages based on whole otoliths and thin sections. Upper two panels: (left) whole otolith, aged 6 years, and (right) thin section, aged 9 years, from a barracouta of 84 cm length. Lower two panels: (left) whole otolith, aged 9 years, and (right) thin section, aged 6 years, from a barracouta of 91 cm length. Red marks indicate approximate location of annuli that were counted.

3.1.3 BAR 5

Population proportion-at-age was generated from observer data for the bottom trawl fishery, where data were included if a tow occurred between 1 February and 30 April and if at least five barracouta were measured to ensure that tows had representative length data (see Table 2). The length frequencies used to generate the ALK were bimodal, included few fish under 50 cm, and were slightly different between years, where the largest mode in 2020–21 was in 60–70 cm fish compared with 70–90 cm fish in 2019–20 (Figure 4). Details of the estimated catch-at-age distribution for trawl-caught barracouta in the 2019–20 and 2020–21 fishing years are given in Table 3. Most of the barracouta were ages 2–5 and the CVs for those ages were under 25% (Table 3, Figure 4).

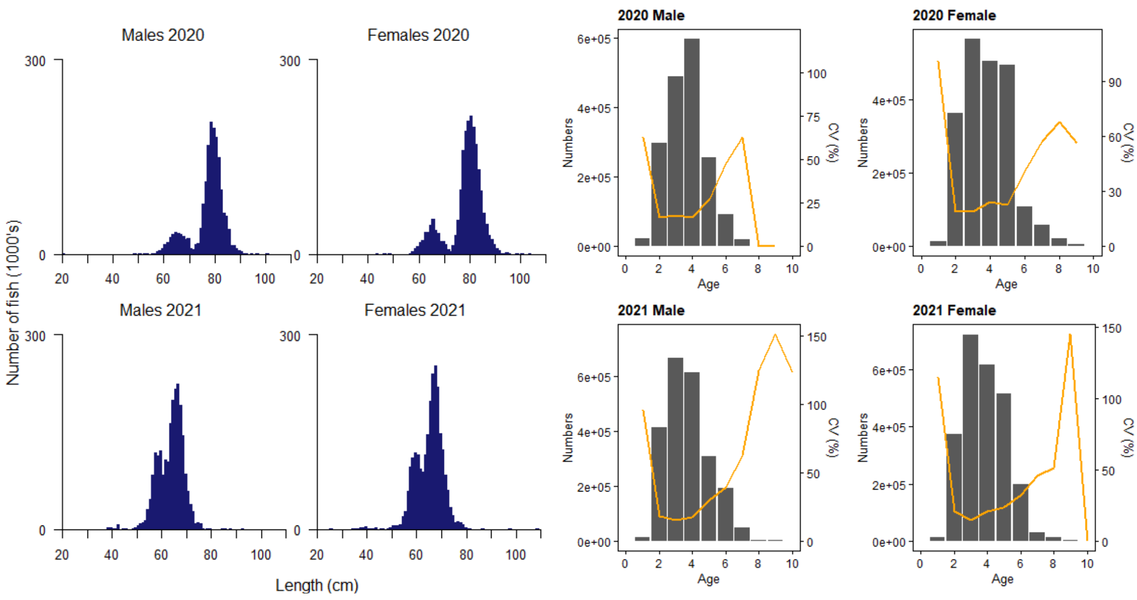

Figure 4: (left) Length frequency distribution (by sex) developed from the peak of the trawl fishery (Feb–Apr) and (right) proportions-at-age by sex for BAR 5 in the 2019–20 and 2020–21 fishing years.

Table 3: Calculated numbers-at-age, separately by sex, with CVs, for barracouta (BAR 5) sampled by observers during commercial trawl operations for the 2019–20 and 2020–21 fishing years. Age is in years.

	2019–20			
Age	Male	CV	Female	CV
1	22 626	62.8	12 303	101.0
2	294 938	16.4	362 903	18.6
3	486 815	17.4	564 239	19.0
4	594 765	16.5	504 206	23.9
5	255 282	26.8	494 200	22.2
6	89 576	47.7	108 291	40.8
7	17 574	62.4	57 128	57.0
8	0	0.0	19 258	68.0
9	0	0.0	3 993	56.5
10+	4 899	147.3	948	134.8

	2020–21			
Age	Male	CV	Female	CV
1	11 788	95.9	13 468	115.2
2	414 347	18.1	375 353	21.0
3	667 332	15.4	721 543	15.0
4	614 325	17.3	619 187	20.7
5	308 996	29.9	515 230	23.7
6	191 441	39.4	197 754	32.3
7	47 712	62.3	29 931	45.9
8	791	124.5	11 612	51.5
9	839	150.9	867	145.0
10	1 564	122.9	0	0.0
11+	3 966	117.9	2 683	140.3

3.2 Gemfish

Nearly all the otoliths collected by observers in both SKI 3 and SKI 7 were read (Table 4).

Table 4: Number of gemfish otoliths by sex and fishstock collected by observers and subsequently read in the 2020–21 fishing year.

	Collected by observers		Read	
	Male	Female	Male	Female
SKI 3	170	256	126	210
SKI 7	197	202	170	175

3.2.1 Reference set check

No large systematic differences in interpretation of gemfish otoliths existed between reader 1 and the reference set except maybe a slight discrepancy for the older ages (Figure 5). The CV and IAPE calculated for the between-reader comparison were 5.7 and 4.0%, respectively.

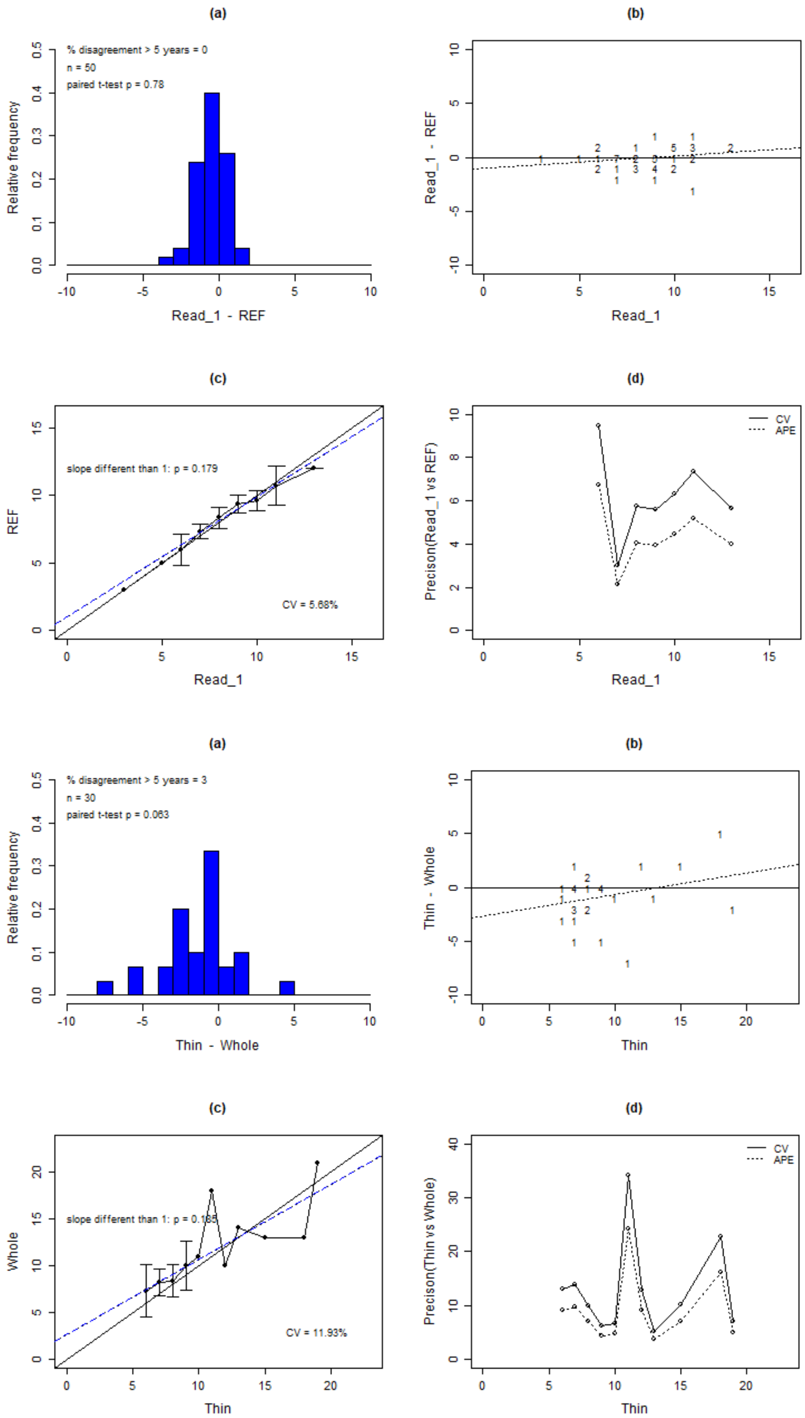

Figure 5: Results of the between-reader comparison test; (left) reader 1 and the reference set and (right) of the thin section vs. whole otolith for gemfish. (a) Histograms of differences between readings for the same otolith; (b) differences between the first and second reading for a given age assigned during the first reading; (c) bias plots; and (d) CV and APE profiles relative to the ages assigned during the first set of readings. The expected one-to-one (solid line) and actual relationship (dashed line) between the first and second ages are overlaid on (b) and (c).

3.2.2 Thin section vs. whole otolith ageing

Ages from the second reading of the thin sections were compared with whole otolith ages of the same fish (Figure 5). Fish were generally aged older using whole otoliths than thin sections until about age 12, after which, fish were aged younger; 3% of the readings had differences in ages that were greater than 5 years. This lack of precision was apparent in the high CV (12%) and IAPE (8%). The Deepwater Working Group requested examples of this discrepancy be included in the report (Figure 6).

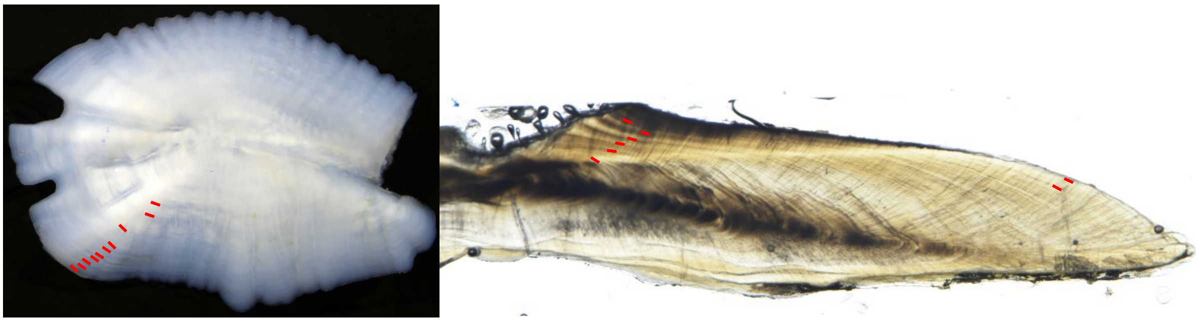

Figure 6: Example of discrepancy between ages based on whole otoliths and thin sections. (left) Whole otolith, aged 10 years, and (right) thin section, aged 8 years, from a gemfish of 99 cm length. Red marks indicate approximate location of annuli that were counted.

3.2.3 SKI 3

Proportion-at-age was generated from observer data for the bottom trawl fishery, where data were included if at least five gemfish were measured to ensure that tows had representative length data and a tow occurred between 1 February and 30 April (Table 5). The length frequencies used to generate the ALK had multiple modes and included a strong mode under 40 cm (Figure 7). Details of the estimated catch-at-age distribution for trawl-caught gemfish in the 2020–21 fishing year are given in Table 6. Most of the gemfish in SKI 3 were age 1 with a second mode at ages 4–7; the CVs for those ages were very low (Table 6, Figure 7).

Table 5: Number of observed tows by month and number of measured gemfish by sex contributing to samples of proportion-at-age from the peak in the bottom trawl fishery in SKI 3 and SKI 7 in 2021. Greyed regions are the months that were selected for creating the ALK.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	No. males	No. females	No. total
SKI 3															
2021	1	2	9	26	37	15	1	2	1	0	2	96	634	901	2 011
SKI 7															
2021	0	0	0	0	0	0	0	3	4	62	12	81	723	803	1 552

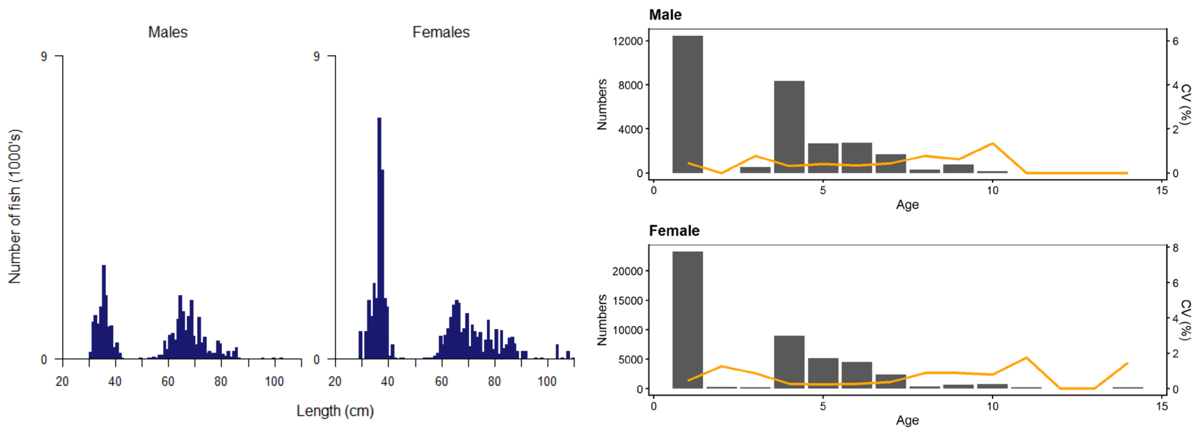

Figure 7: (left) Length frequency distribution (by sex) developed from the peak of the trawl fishery (Feb–Apr) and (right) proportions-at-age by sex for SKI 3 in the 2020–21 fishing year.

Table 6: Calculated numbers-at-age, separately by sex, with CVs, for gemfish (SKI 3 and SKI 7) sampled by observers during commercial trawl operations for the 2020–21 fishing year. Age is in years.

				SKI 3
Age	Male	CV	Female	CV
1	12 449	0.5	23 264	0.5
2	0	0.0	263	1.3
3	534	0.9	231	0.9
4	8 339	0.3	8 958	0.3
5	2 688	0.4	5 168	0.3
6	2 768	0.3	4 545	0.3
7	1 706	0.4	2 429	0.4
8	296	0.8	365	0.9
9	772	0.5	688	0.9
10	152	1.1	795	0.8
11	0	0.0	209	1.8
12	0	0.0	0	0.0
13	0	0.0	0	0.0
14	0	0.0	229	1.6
15+	196	2.5	1 827	1.1

				SKI 7
Age	Male	CV	Female	CV
0	989	1.1	0	0.0
1	0	0.0	1 329	1.0
2	1 801	0.9	0	0.0
3	0	0.0	0	0.0
4	770	0.9	261	1.0
5	5 486	0.5	4 922	0.3
6	7 747	0.3	3 426	0.2
7	6 145	0.3	3 684	0.2
8	3 610	0.4	2 721	0.2
9	4 387	0.5	1 421	0.4
10	1 003	0.7	1 278	0.3
11	873	0.8	639	0.6
12	8	2.3	137	1.1
13	0	0.0	418	0.8
14	48	3.3	0	0.0
15	1 527	1.3	0	0.0
16	0	0.0	0	0.0
17	0	0.0	0	0.0
18	107	2.5	0	0.0
19	0	0.0	0	0.0
20	777	1.3	47	1.5
21+	1 097	1.1	610	1.0

3.2.4 SKI 7

Proportion-at-age distributions were generated for from observer data for the bottom trawl fishery, where data were included if a tow occurred between 1 June and 30 September and if at least five gemfish were measured to ensure that tows had representative length data (see Table 5). The length frequencies used to generate the ALK had several modes and included many fish under 50 cm (Figure 8). Most of the gemfish in SKI 7 were ages 5–9, but a moderate number of ages 0–2 were also present; the CVs for were very low (Table 6, Figure 8).

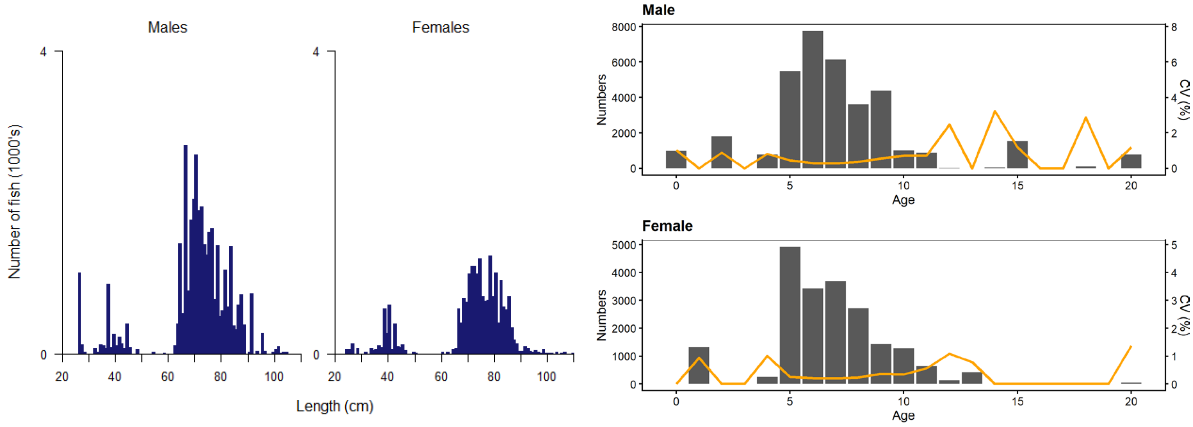

Figure 8: (left) Length frequency distribution (by sex) developed from the peak of the trawl fishery (Jun–Sep) and (right) proportions-at-age by sex for SKI 7 in the 2020–21 fishing year.

4. DISCUSSION

Horn (2002) found that barracouta may be underaged when using whole otoliths compared with thin sections for the older fish. Age readings from thin sections were compared with those from whole otoliths to determine if different readers would have a different result to that of Horn (2002) for barracouta, and to trial thin-section preparations for gemfish for the first time. Both species were aged older with whole otoliths, when compared with thin sections, for younger ages and aged younger for older ages. Zonation patterns from whole otoliths were less clear than when using thin sections. The Deepwater Working Group agreed that, given this discrepancy, that ageing with whole otoliths was still preferred.

An error was made in the selection of otoliths for barracouta, but it was agreed that too few data were collected from BAR 4 to generate an age-length key. The trawl fishery in BAR 5 was well covered by the observers and despite the error in otolith selection, enough otoliths were selected from the peak of the fishery to generate an age-length key. The CVs were generally good for ages 2–5, but it was agreed with the Deepwater Working Group that more large fish would be aged from 2019–20 and 2020–21, to be presented with the results of the 2021–22 fishing year.

Several of the age classes were poorly represented for gemfish. Gemfish of ages 2 and 3 are largely missing from the commercial trawl fishery in SKI 3, and ages 3 and 4 were not caught in SKI 7. If a catch-at-age distribution is to be developed, the sampling scheme should be modified to ensure sampling is representative. Otoliths are available from the west coast South Island trawl survey (306 in 2016, 481 in 2018, and 545 in 2021) and these could be used to augment the data collected by the observers.

5. ACKNOWLEDGEMENTS

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