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Tini a Tangaroa

Age composition of spawning orange roughy, Mid-East Coast, North Island, New Zealand, 2017

New Zealand Fisheries Assessment Report 2019/11

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ISSN 1179-5352 (online)
ISBN 978-1-98-859445-3 (online)

April 2019

New Zealand Government

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EXECUTIVE SUMMARY

Doonan, I.J.; Horn, P.L.; Ó Maolagáin, C.; Dutilloy, A. (2019). Age composition of spawning orange roughy, Mid-East Coast, North Island, New Zealand, 2017.

***New Zealand Fisheries Assessment Report 2019/11*. 15 p.**

Orange roughy otoliths were prepared and aged from two known spawning sites (Sea Valley and Rock Garden) on the Mid-East Coast (ORH 2A South, ORH 2B and ORH 3A). The otoliths (n = 900) were sampled from mark identification trawl tows made on the 2017 acoustic survey. Otoliths were prepared and read by one reader following the accepted ageing protocol. The aim was to develop age compositions for use in an assessment of this stock. Both sites had similar shaped age distributions but the Sea Valley had relatively more older fish (mode about 42 years), and Rock Garden was dominated by younger fish (mode about 35 years).

1. INTRODUCTION

This report partially fulfils the reporting requirements for Objective 1 of Project MID201701, "Routine age determination of middle depth and deepwater species from commercial fisheries and trawl surveys", funded by the Ministry for Primary Industries. The objective was: To determine catch-at-age for commercial catches and resource surveys of specified middle depth and deepwater fishstocks. The work identified under section D of Objective 1 was the otolith preparation and ageing of samples of orange roughy collected in 2017 from the Mid-East Coast (MEC).

A protocol for age interpretation of orange roughy was developed during an international workshop held at NIWA, Wellington, in 2007. In 2009, the new protocol was tested by two NIWA and two FAS (Fish Ageing Services Pty. Ltd., Victoria, Australia) readers by ageing the otolith pairs from 160 fish, i.e., potentially 8 age estimates per fish. The new protocol provided a consistent and documented method for the interpretation of growth zones in orange roughy otoliths (Horn et al. 2016).

Early growth of orange roughy was validated by examining the otolith marginal increment type and by length frequency analysis (Mace et al. 1990). Andrews et al. (2009) applied an improved lead-radium dating technique to otolith cores, grouped by growth-zone counts from thin sections. Results showed a high degree of correlation of the growth-zone counts to the expected lead-radium growth curve, and provided support for both a centenarian life span for orange roughy and for the age estimation procedures using thin otolith sectioning.

An acoustic survey was conducted on spawning aggregations located in the MEC in June 2017 using the FV *Amaltal Explorer* (Ryan et al. 2017). Trawling was conducted on the aggregations for biological data and species identification, and otoliths were sampled from orange roughy taken in these tows. We report age compositions for orange roughy from two spawning aggregations, Sea Valley and Rock Garden, following the methods described by Doonan et al. (2013). It is assumed that the samples from the aggregations can be used to estimate the age structure of the spawning stock biomass.

2. METHODS

2.1 Ageing of orange roughy

Otoliths were prepared using the NIWA preparation method (Horn et al. 2016). One otolith from each selected fish was individually embedded in resin and cured in an oven at 50 °C. A thin section was cut along a line from the primordium through the most uniform posterior-dorsal axis using a sectioning saw with dual diamond-impregnated wafering blades separated by a 380 µm spacer. The section was mounted on a glass microscope slide under a glass cover slip.

All otoliths were read once by one reader. Otolith interpretation and reading protocols followed those described in the Ageing Workshop Report (Horn et al. 2016). The data produced included counts of zones from the primordium to the transition zone (TZ), and from the TZ to the otolith margin, and readability codes for those readings (on a 5-stage scale). Data with a readability code of 5 (i.e., unreadable) for either the pre- or post-TZ readings were excluded. The presence of a transition zone was identified using the following three criteria: a clear reduction in zone width, a marked change in the optical density of the otolith from dark to light, and a change in curvature of the posterior arm of the otolith (Horn et al. 2016).

Transition Zones were classified using a 4-stage scale, i.e.:

- 0, not believed to have formed (not observed),
- 1, clear and unambiguous with all three criteria met,
- 2, a gradual transition with at least two criteria met,
- 3, a gradual transition with none or one of the criteria met.

For TZ classifications 0 and 3, only a total age was recorded.

2.2 Acoustic survey

An experimental voyage was conducted on 15–28 June 2017 on the Mid-East Coast using the FV *Amaltal Explorer* (Ryan et al. 2017). Acoustic surveys were completed on three spawning aggregations: Sea Valley (VA), Rock Garden (RG), and Tolaga Knoll (TK) on the Mid-East coast (Figure 1). The Sealord Acoustic Optical System (AOS) was used, which is equipped with 38 kHz and 120 kHz Simrad echosounders, a still camera, and video camera. A demersal trawl was used to collect samples for catch composition and mark identification, and to sample orange roughy for length, weight, sex, gonad stage and otoliths.

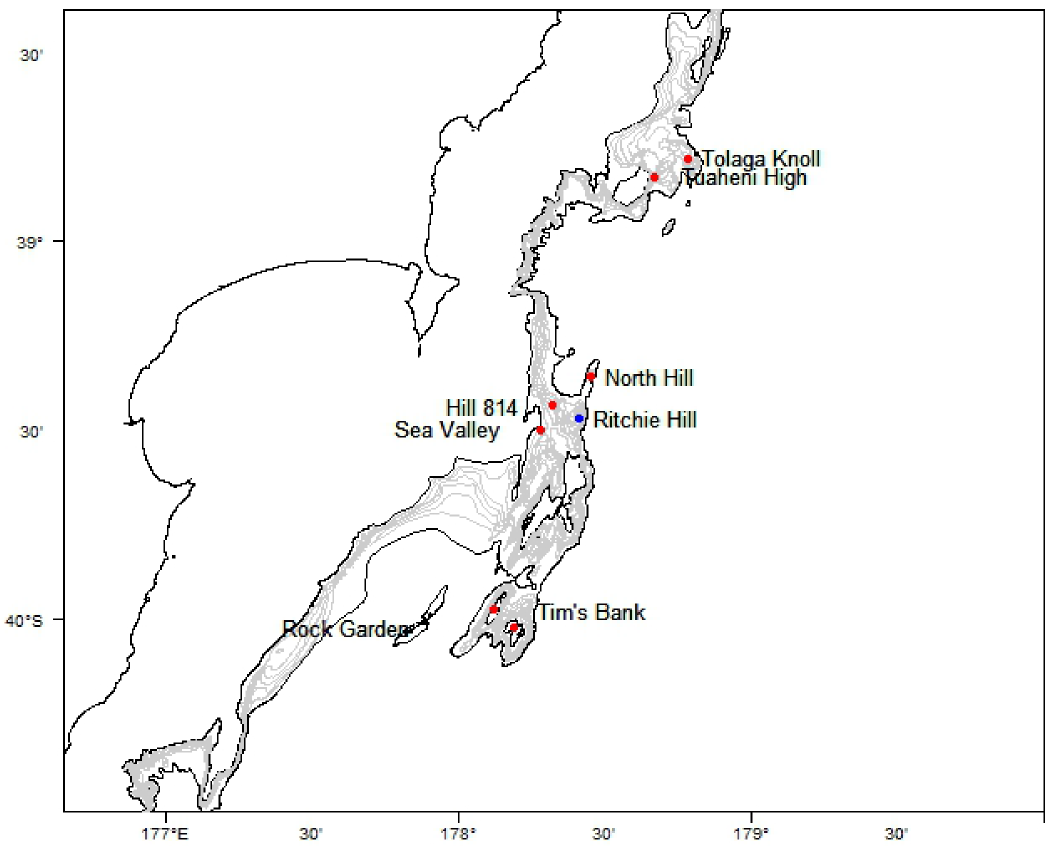

Figure 1: Mid-East Coast area showing the three sites where acoustic surveys of spawning aggregations were conducted: Sea Valley, Rock Garden, and Tolaga Knoll. Sites where spawning aggregations were recorded in the past, but have since disappeared, are also shown.

For Sea Valley, 10 tows were carried out over the period 15–28 June 2017. For Rock Garden, 7 tows were carried out from 18–25 June 2017. For Tolaga Knoll, 1 tow was carried out on 23 June 2017. In total, 1 237 otoliths were collected for the Sea Valley and the Rock Garden. Only 100 otoliths were collected from Tolaga Knoll.

This survey was conducted using a commercial fishing vessel, and the skipper was responsible for target fishing the aggregations. Since towing into and through the mark is likely to damage the fishing gear (as a consequence of an excessive catch), the tow is usually made towards the mark and pulled out when an adequate bag is thought to have been caught. Consequently, it is likely that the catch represents fish in the layer that surrounds these aggregations. It is not known whether these fish have the same age compositions as those in the central, densest parts of the aggregations.

2.3 Analytical methods

2.3.1 Otolith selection

The method of analysis followed that of Doonan et al. (2013) for ORH 7A orange roughy. The number of otoliths to prepare was n_{unique}. Otoliths were selected with replacement until the specified total number of unique otoliths, n_{unique}, was reached. The procedure was continued to provide a selection of spare otoliths which were used to replace damaged or lost samples. The spares were used in the order of their selection. The selection probabilities for individual otoliths are proportional to the numbers of fish caught in each tow (or total orange roughy catch from the tow, if mean fish weights are similar across all tows) divided by the number of otoliths in the tow. This selection probability was based on all otoliths that were available and assumed that the otolith sampling was random. If the same otolith was selected more than once, its age was repeated in estimating the mean age and age frequency. Since an age estimate may be used more than once, the number of ages, n_{ages}, is likely to be greater than the number of otoliths prepared, n_{unique}.

2.3.2 Allocation of the number of otoliths to process from each spawning aggregation

The two sampled areas of orange roughy aggregation (VA and RG) were analysed separately, so the target of 900 otoliths to prepare and read was split between the aggregations by the ratio of the estimated orange roughy abundance in these areas. VA and RG were surveyed acoustically several times (several snapshots) but TK was surveyed only once. Preliminary orange roughy abundance estimates were derived by Ryan et al. (2017).

Table 1 shows the number of snapshots and mean abundances for the three aggregations. The data from Tolaga Knoll were ignored since the abundance estimate was low relative to that from the other two aggregations, and it was not possible to get a credible age frequency given the number of otoliths collected from the single tow conducted there.

Table 1: Acoustic abundance estimates for each spawning aggregation (preliminary estimates).

Stratum	No. of snapshots	Mean abundance (t)	Ratio of otoliths relative to 3600 t
VA	5	3 600	1
RG	5	2 540	0.71
TK	1	150	0.046

Using the ratio of 0.7 for RG, n_{unique} was 529 for the Sea Valley (1/1.7 × 900) and 371 for the Rock Garden, i.e. 900 in total.

2.3.3 Analysis

The data consisted of the age estimate from each otolith replicated by any repeat count. The mean age estimate was the sample mean. The age frequency was the fraction of data at each age over this age-otolith sample. Standard error was assessed using a bootstrap analysis where tows were resampled along with the ages within each selected tow.

For each aggregation, the age frequency was also estimated for each sex, and these were combined assuming a 50:50 sex ratio. For the male analysis, otoliths from males were used and the catch rates for each tow were converted into numbers of males per km using each tow sex ratio and mean weight from the length-weight relationship applied to the length distribution. Sex ratios varied widely between tows, and therefore the relative catch weights for males does not necessarily follow that for combined sex catch rates. Hence, the selection analysis was re-applied to the male otolith sample (i.e., prepared otoliths) to get the repeat counts. At RG, one tow had half the total combined catch for that aggregation and so to down-weight its influence, the square-root of catch rates was used in the analysis for both aggregations. Once the repeat counts were obtained, the age frequency and its CV were obtained as outlined above. The same analysis was applied to the female otoliths, but using the female sex ratio to split catches.

Kernel smoothing was used to show the results in the plots. It used one parameter, *width*, which is approximately the moving window width over which the average age was calculated. This procedure used the 'density' function from the R statistical package (R Core Team 2014). *Width* was set to 10.

3. RESULTS

Details of the stations used in the analysis are listed in Appendix A (Table A1). Details of the otolith samples from the two spawning areas are given in Table 2. Age-frequency data are listed in Appendix B (Table B1).

Table 2: Details of 2017 Mid-East Coast orange roughy otolith samples by location. *N*, initial number of otoliths selected; replacements, the number of otoliths replaced from the initial selected set (e.g., because they were missing or broken); rejects, number of preparations unable to be aged.

				Transition Zone classification code			
	N	Replacements	Rejects	0	1	2	3
Sea Valley	529	49	2	15	182	260	70
Rock Garden	371	26	0	33	102	194	42

3.1 Sea Valley

Many selected otoliths were damaged and needed a replacement. Some damaged otoliths could be used in a non-optimal way by cutting them on another, less preferred, axis to avoid the damaged tip. The result was that the usual selection procedures were abandoned and any otolith that could be used was. As the selection probabilities were incorrect, the selection analysis was re-run with just the prepared otoliths to get the repeat counts for the age frequency.

The mean sex ratio over all tows (10 tows) was 44% male (CV 79%, range 4–95%). The number of tows with ratios outside 25–75% was 7 (one ratio at 25%). Males were younger than females (Figure 2). The age frequencies by sex are shown in Figure 2, and the combined age frequency distribution, assuming a 50:50 sex ratio, is presented in Figure 3 along with a comparison of the age frequencies when sex was disregarded. The latter had a mean weighted CV of 40%, and 16% for the smoothed version.

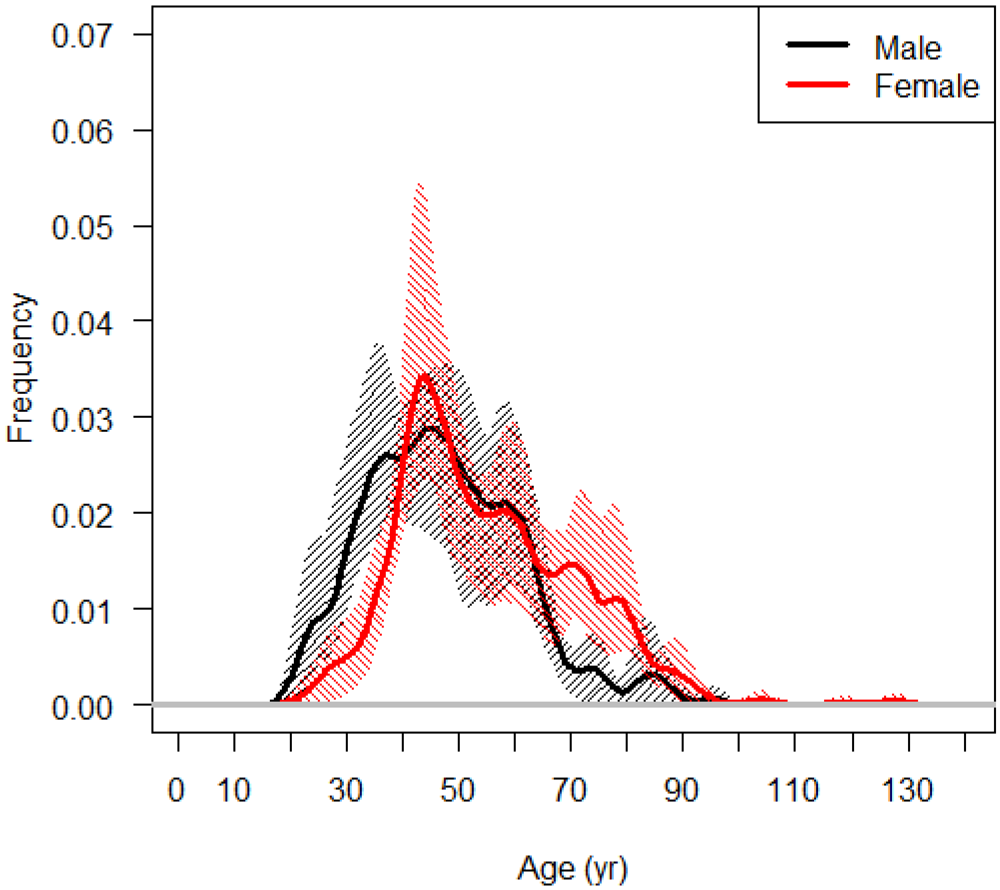

Figure 2: 2017 Sea Valley smoothed orange roughy age frequency distribution and pairwise 95% CI for males (black) and females (red).

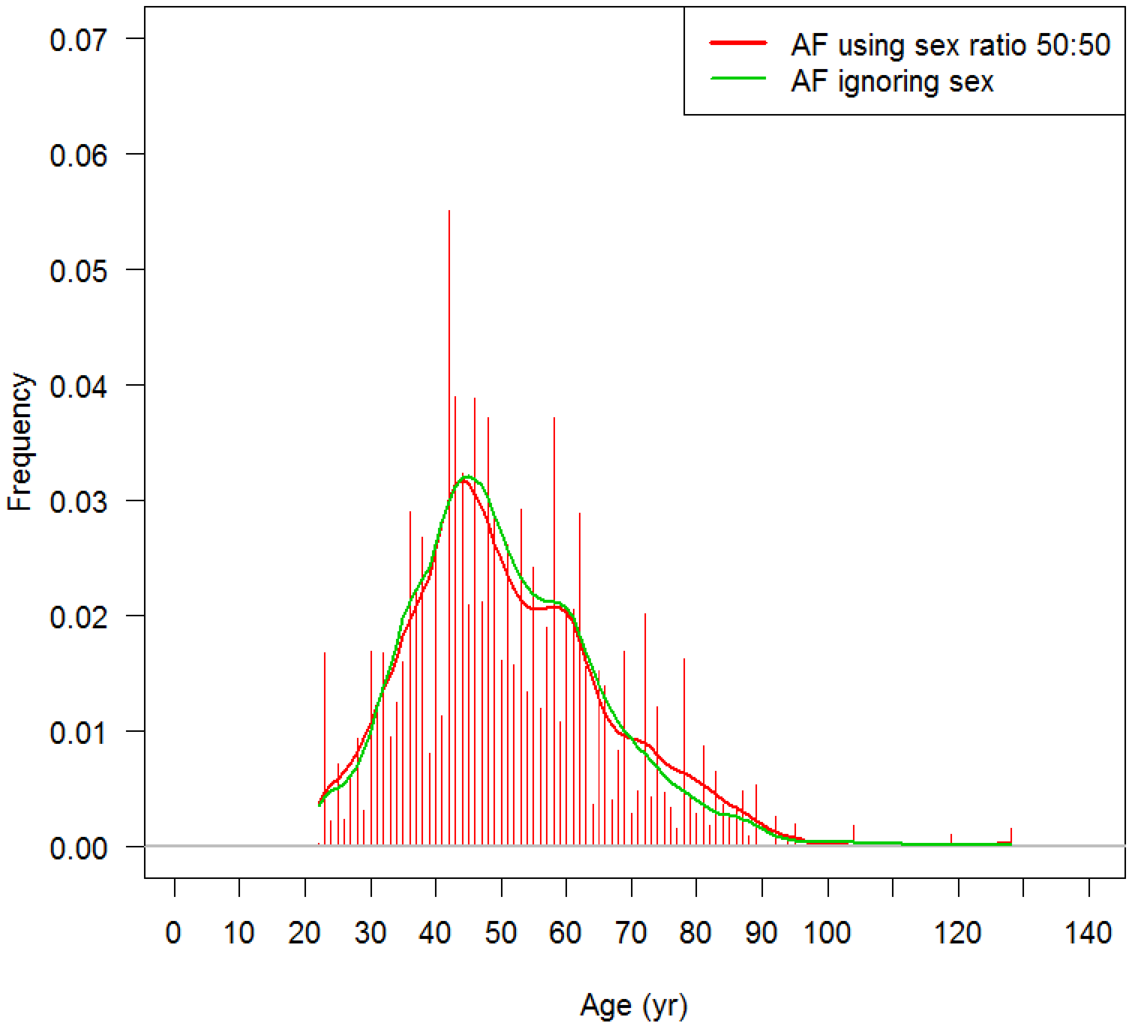

Figure 3: 2017 Sea Valley estimated orange roughy age frequency distribution (red bars) assuming a sex ratio of 50:50 with a smoothed density through the age estimates (red curve). The age frequency distribution without regard for sex is the green curve.

3.2 Rock Garden

For the sexed age frequencies, five fish were excluded (ages 20–39, i.e., young fish) as they had no recorded sex or gonad stage. The mean sex ratio over all tows (7 tows) was 53% male (CV 41%, range 32–88%). The age frequencies by sex are shown in Figure 4. The age frequency without regard for sex and assuming a sex ratio of 50:50 is shown in Figure 5. The mean weighted CV was 45%, and 17% for the smoothed version.

There were two clear groups of tows: those with a younger main mode at about 30 years, and those with an older mode at about 45 years. For males, the total catch from tows with the younger mode was like that from those with the older mode, which resulted in a modal peak at the younger age (Figure 4). In contrast, female data had more catch in tows with the older mode and so their age frequencies had a main mode at 45 years (Figure 4).

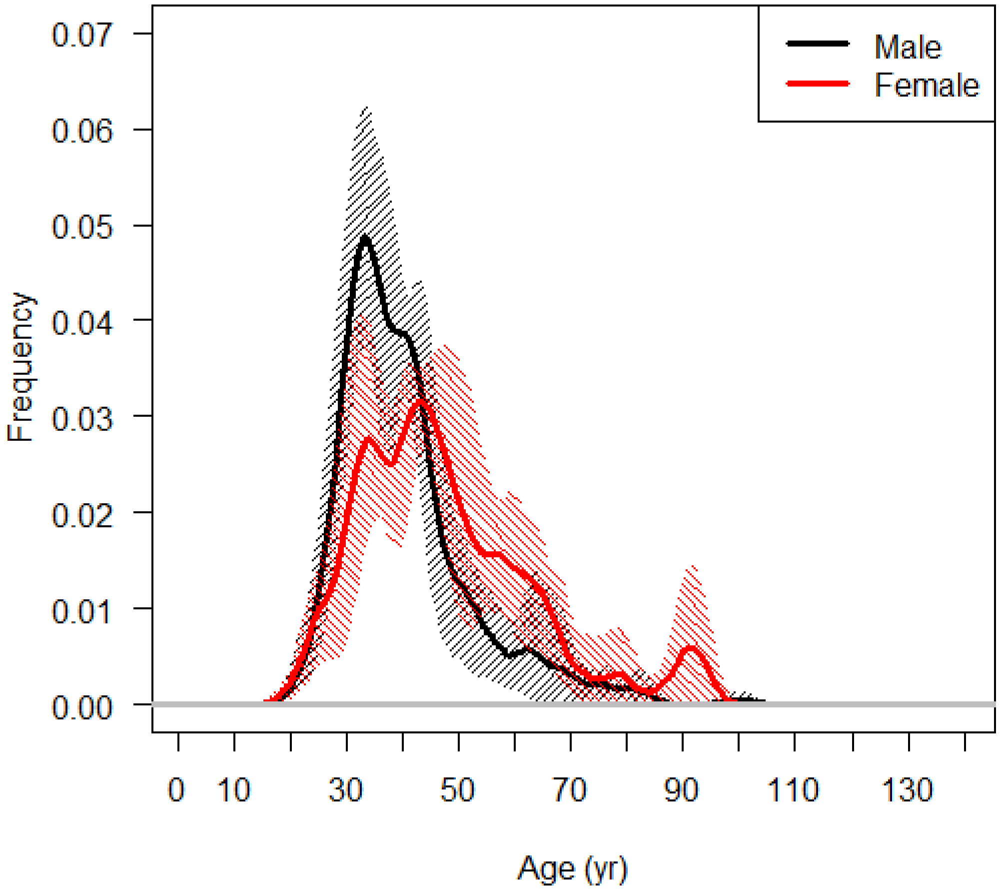

Figure 4: 2017 Rock Garden smoothed orange roughy age frequency distribution and pairwise 95% CI for males (black) and females (red).

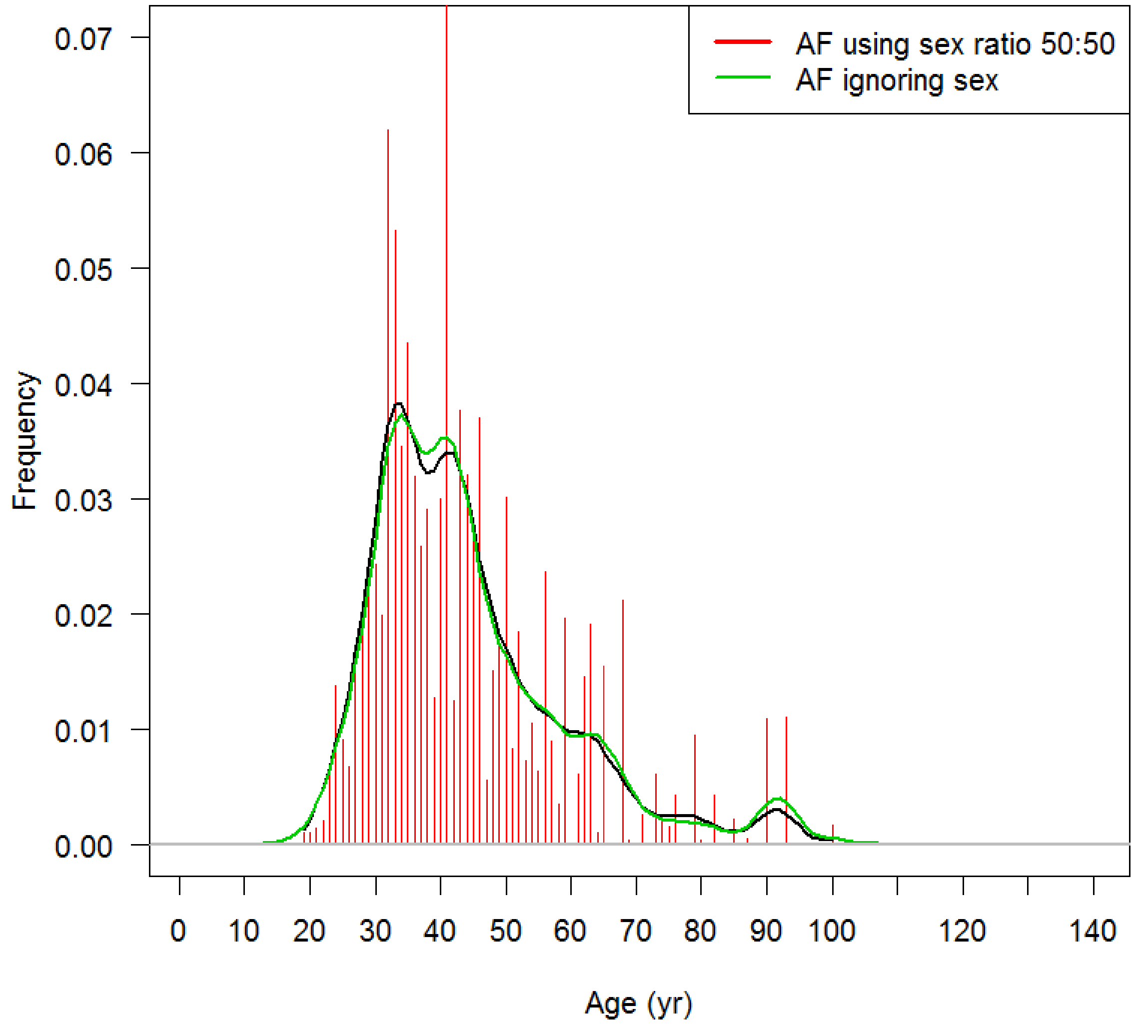

Figure 5: 2017 Rock Garden estimated orange roughy age frequency distribution red bars) assuming a sex ratio of 50:50 with a smoothed density through the age estimates (black curve). The age frequency without regard for sex is the green curve.

4. DISCUSSION

A comparison of the age frequency distributions from the two Mid-East Coast areas (Sea Valley and Rock Garden), as well as the distribution for both areas, is shown in Figure 6. The Rock Garden had relatively more younger fish, with a main mode at 35 years. The Sea Valley had a main mode at 42 years, i.e., it had slightly older fish than Rock Garden.

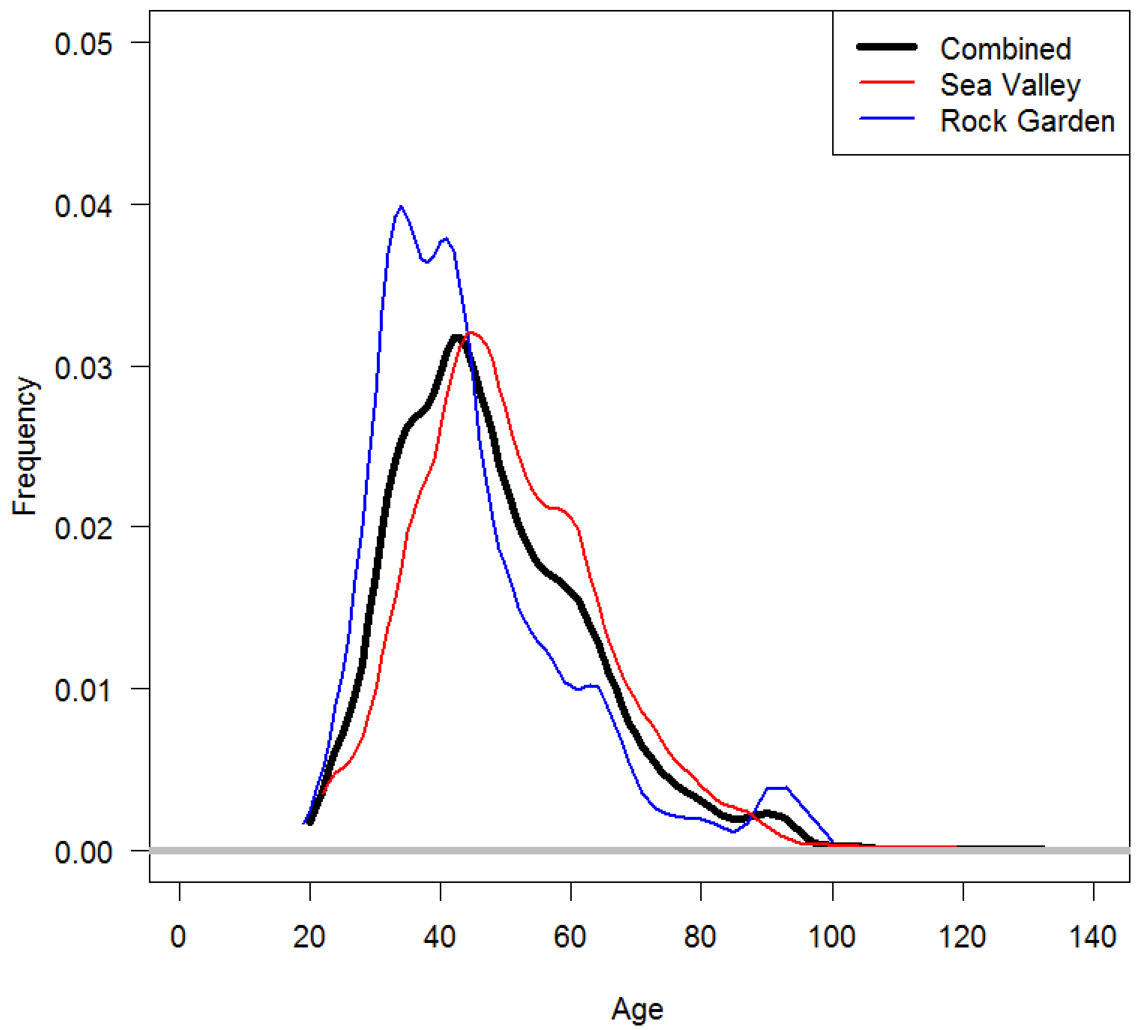

Figure 6: 2017 smoothed orange roughy age frequency distributions for Sea Valley (red), Rock Garden (blue), and both strata combined (black).

Ignoring sex gave age frequencies that were quite similar to the male or female frequencies when smoothed despite the variation in sex ratios by tow and the dominance of males in the younger age classes. There were differences in the non-smoothed distributions at various ages, but these appeared to be random, and given the MWCV for the frequencies and the reader error (about 8%), much less reliance should be placed on these age frequencies relative to the smoothed versions.

5. ACKNOWLEDGMENTS

This work was funded by the New Zealand Ministry for Primary Industries under Project MID201701. Thanks to Peter McMillan and Richard O’Driscoll for useful reviews of the document.

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APPENDIX A: STATIONS USED IN THE 2017 MID-EAST COAST ORANGE ROUGHY AGE ANALYSIS

Table A1: Mid-East Coast spawning aggregations: stations, orange roughy catch, relative population by station used to randomly sample otoliths, number of otoliths collected, and the probability of selecting one otolith (i.e., relative station population number divided by the number of otoliths sampled at the station). For the Sea Valley, the total number of otoliths was 529, i.e., those prepared, not those collected.

Station	Catch (kg)	Relative station population	Number of otoliths	Probability of selecting one otolith
Sea Valley				
1	9378	0.1683	75	2.24E-03
2	213	0.0038	82	4.66E-05
3	8692	0.1560	86	1.81E-03
10	10556	0.1895	98	1.93E-03
11	6080	0.1092	99	1.10E-03
12	855	0.0153	20	7.67E-04
13	8075	0.1450	16	9.06E-03
15	5123	0.0920	19	4.84E-03
16	2991	0.0537	14	3.84E-03
18	3741	0.0672	20	3.36E-03
Rock Garden				
4	2973	0.1159	75	0.001546
5	1668	0.0650	74	0.000879
6	4685	0.1827	50	0.003654
7	317	0.0124	69	0.000179
8	4843	0.1889	67	0.002819
9	7125	0.2779	20	0.013893
17	4033	0.1573	16	0.009829

APPENDIX B: ESTIMATED 2017 MID-EAST COAST ORANGE ROUGHY AGE FREQUENCIES

Table B1: Estimated age frequencies for the Mid-East Coast orange roughy for the Sea Valley and Rock Garden, in 2017. – no data. Combined sex age frequencies using a 50:50 sex ratio.

	Sea Valley		Rock Garden	
Age (yr)	Frequency	CV	Frequency	CV
19	0	–	0.001001	0.969568
20	0	–	0.000928	0.993132
21	0	–	0.001377	0.969568
22	0.000261	0.973914	0.002054	0.716958
23	0.016767	0.676822	0.006030	0.612717
24	0.002184	0.702437	0.013727	0.724825
25	0.007122	0.467883	0.009096	0.638076
26	0.002265	0.961846	0.006770	0.448152
27	0.005824	0.966383	0.015667	0.445702
28	0.009369	0.708581	0.019440	0.359846
29	0.003042	0.961237	0.023688	0.479992
30	0.016872	0.780311	0.024317	0.439318
31	0.011754	0.437679	0.019801	0.427747
32	0.016757	0.400647	0.062034	0.206856
33	0.009460	0.562618	0.053218	0.461229
34	0.012437	0.680273	0.034580	0.325507
35	0.015880	0.448950	0.043584	0.373997
36	0.028954	0.263229	0.031952	0.394040
37	0.022324	0.373761	0.025812	0.435115
38	0.026684	0.293653	0.029125	0.286521
39	0.008042	0.534644	0.012722	0.341444
40	0.026079	0.403738	0.029975	0.346635
41	0.011261	0.406826	0.079048	0.209481
42	0.055060	0.275899	0.012424	0.382379
43	0.038962	0.653193	0.037683	0.380795
44	0.032398	0.399731	0.032014	0.326948
45	0.020886	0.408075	0.026629	0.526529
46	0.038866	0.364623	0.037057	0.244051
47	0.021164	0.274169	0.005496	0.576873
48	0.037137	0.454576	0.015008	0.473249
49	0.028857	0.377309	0.017607	0.478494
50	0.016085	0.470195	0.030145	0.481321
51	0.026076	0.293398	0.008246	0.440458
52	0.015641	0.294600	0.018464	0.625851
53	0.029163	0.479852	0.007219	0.705500
54	0.013322	0.414942	0.010499	0.515794
55	0.024121	0.394092	0.006354	0.403678
56	0.011934	0.440119	0.023614	0.495024
57	0.018903	0.372369	0.008912	0.580523
58	0.037097	0.441955	0.003427	0.535187
59	0.010762	0.446191	0.019576	0.435906

	Sea Valley		Rock Garden	
Age (yr)	Frequency	CV	Frequency	CV
60	0.020034	0.421350	0	–
61	0.020523	0.393333	0.006008	0.865990
62	0.028837	0.321779	0.014467	0.492704
63	0.015586	0.498828	0.019020	0.637362
64	0.003564	0.528063	0.001001	1.102039
65	0.015131	0.416406	0.015394	0.461474
66	0.013911	0.552360	0	–
67	0.003999	0.402889	0	–
68	0.008304	0.449270	0.021185	0.600570
69	0.016887	0.398396	0.000375	1.102039
70	0.002760	0.663268	0	–
71	0.004781	0.535952	0.002551	0.689410
72	0.020080	0.609615	0	–
73	0.004250	0.437982	0.006008	0.973521
74	0.011980	0.502284	0.001855	0.881001
75	0.004642	0.523430	0.001502	0.969568
76	0.003275	0.638710	0.004174	0.889579
77	0.001478	0.536061	0	–
78	0.016255	0.759579	0	–
79	0.004520	0.564203	0.009438	0.725726
80	0.002869	0.535537	0.000375	1.102039
81	0.008606	0.605180	0	–
82	0.001739	0.846697	0.004174	0.881001
83	0.006406	0.860857	0	–
84	0.003599	0.668523	0	–
85	0.002445	0.865509	0.002128	0.970963
86	0.003042	0.571355	0	–
87	0.004812	0.484514	0.000501	0.970963
88	0.000869	0.893346	0	–
89	0.005278	0.872725	0	–
90	0	–	0.010889	0.844248
91	0	–	0	–
92	0.002521	0.667686	0	–
93	0	–	0.011014	0.829274
94	0.001043	0.893346	0	–
95	0.001941	0.961846	0	–
96	0	–	0	–
97	0	–	0	–
98	0	–	0	–
99	0	–	0	–
100	0	–	0.001623	0.881001
101	0	–	0	–
102	0	–	0	–
103	0	–	0	–
104	0.001825	0.966383	0	–
105	0	–	0	–
106	0	–	0	–

	Sea Valley		Rock Garden	
Age (yr)	Frequency	CV	Frequency	CV
107	0	–	0	–
108	0	–	0	–
109	0	–	0	–
110	0	–	0	–
111	0	–	0	–
112	0	–	0	–
113	0	–	0	–
114	0	–	0	–
115	0	–	0	–
116	0	–	0	–
117	0	–	0	–
118	0	–	0	–
119	0.000956	0.893346	0	–
120	0	–	0	–
121	0	–	0	–
122	0	–	0	–
123	0	–	0	–
124	0	–	0	–
125	0	–	0	–
126	0	–	0	–
127	0	–	0	–
128	0.001478	0.925092	0	–