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Orange roughy age estimates for the Volcano seamount, Challenger Plateau (ORH 7A), for 2014

New Zealand Fisheries Assessment Report 2015/60

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EXECUTIVE SUMMARY

Doonan, I.J.; Horn, P.L.; Ó Maolagáin, C. (2015). Orange roughy age estimates for the Volcano seamount, Challenger Plateau (ORH 7A), for 2014.

***New Zealand Fisheries Assessment Report 2015/60*. 9 p.**

Orange roughy otoliths sampled from the Volcano seamount on the Challenger Plateau (ORH 7A) in 2014 were aged. Otoliths were prepared and read by one reader following the accepted ageing protocol. The aim was to develop age compositions for use in ORH 7A assessments because Volcano is a site of spawning orange roughy for this stock. Mean age from the scaled age frequency was 43.5 years, and 8.8% of fish were aged 60 years and over. There was a modest difference in the age distributions between Volcano orange roughy in 2014 and previous samples from the Challenger Plateau flats in 2009, suggesting that these two areas may be different stocks.

1. INTRODUCTION

This report fulfils the reporting requirements for Objective 8 of Project MID201001E, “Routine age determination of hoki and middle depth species from commercial fisheries and trawl surveys”, funded by the Ministry for Primary Industries. The objective was: “To age other species as required for validation of the ageing technique or for targeted studies to meet specific research requirements”. The work identified for 2014–15 was the otolith preparation and ageing of samples of orange roughy from a spawning plume on the feature known as Volcano on the Challenger Plateau, in the ORH 7A fishstock. The approximate location of the feature is 39° 48’ S, 167° 14.5’ E.

Before 2007, orange roughy age estimates produced by New Zealand and Australian readers had poor comparability (Francis 2006, Hicks 2005), which led to low confidence in the age-frequency data and resulted in age data being excluded from the stock assessments carried out in 2006. Francis (2006) suggested that a significant source of between-agency bias was the method used to identify the transition zone (TZ), a feature believed to be associated with the switch from somatic growth to gamete production.

In response, an Orange Roughy Ageing Workshop was held in 2007 to improve otolith preparation and interpretation between agencies, especially in relation to the TZ. A new protocol for age interpretation was developed during the workshop (Tracey et al. 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 (Tracey et al. 2009). The new protocol solved the inter-agency problems, and provided a consistent and documented method for the interpretation of growth zones in orange roughy otoliths.

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.

1.1 Challenger Plateau (ORH 7A) commercial fishery

This fishery commenced in 1981 on the southwest Challenger Plateau. The TACC peaked at 12 000 t in 1987–88, and was reduced in 1989–90 and several times after that until the fishery was effectively closed from 1 October 2000 (with a TACC of 1 t). As part of the research for this stock, a series of trawl surveys were carried out during the spawning season from 1987 to 1990 (Clark & Tracey 1994).

Starting in 2005, the Deepwater Group Ltd (previously the Orange Roughy Management Company Ltd) commissioned combined acoustic and stratified random trawl surveys for orange roughy to investigate the current state of the stock. These surveys were on spawning fish in the south-western part of the Challenger Plateau in 2005, 2006, 2009, 2010, 2011 and 2012 (Clark et al. 2005, 2006, Doonan et al. 2009, 2010, Hampton et al. 2013, 2014). These surveys used the same trawl gear design, core strata, and survey protocols (but a different vessel) as the earlier (1987 to 1990) trawl survey series. Ageing of orange roughy from the 1987, 2006, and 2009 surveys has been reported previously, and comparisons between these samples showed a clear dominance of younger fish in later years supporting the hypothesis that younger fish from Challenger Plateau have recruited to the spawning population (Doonan et al. 2014).

Previously, acoustic estimates on hills have not been considered in any stock assessments because of an ambiguous interpretation of species composition and so the Deepwater Working Group (DWWG) decided to leave them out of the assessment until more definite information was available. In July 2014, Sealord commissioned experimental work on orange roughy spawning aggregations off the west coast of North Island, i.e., the Westpac Bank area of Challenger Plateau in ORH 7A, and the Kaipara Flat and Tauroa Knoll west of Northland in ORH 1 (Ryan et al. 2015). This work concluded that fish aggregations above one of the Westpac hills, Volcano, were likely to be orange roughy based on multi-frequency acoustics, which can categorise non-swimbladder species from those with swimbladders, and trawl catches (99% orange roughy). Gonad staging showed that the fish were in the phase leading up to active spawning. Otoliths were collected from samples of orange roughy on Volcano and these were used in this study. The aim was to see if there were major differences between the age distributions of Volcano fish and those in aggregations on the flat. The distributions would also be useful in stock assessments.

2. METHODS

2.1 Ageing of orange roughy

Orange roughy otoliths were prepared using NIWA's preparation method as reported by Tracey et al. (2007). Briefly, one complete otolith from each of the pairs was individually embedded in resin and cured in an oven. 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.

To estimate ages of orange roughy, all otoliths were read once by one reader. Otolith interpretation and reading protocols followed those described in the Ageing Workshop Report (Tracey et al. 2007). The data produced include counts of zones from the primordium to the 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 is identified, ideally, by 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 (Tracey et al. 2007). TZs were classified using a 4-stage scale, i.e.: 0, not believed to have yet been formed; 1, clear and unambiguous with all three criteria met; 2, a gradual transition with at least two criteria met; and 3, a gradual transition with none or one of the criteria met. For TZ classification 3, only a total age was recorded.

2.2 Analytical method

Survey

The research used the FV *Thomas Harrison* which had specialist acoustic gear (an Acoustic Optical System (AOS) attached to the headline of the trawl net) aboard to survey the aggregations acoustically. Our interest, however, was in the trawling and the collection of otolith samples, which was part of the biological sampling programme. Sampling details are as in Ryan et al. (2014).

The net used was a four-panel wingless ‘Otakau mother’ trawl with a 100 mm codend mesh, a 22 m ground-rope, rigged with 140 m sweeps and 28 m bridles. Headline height was about 4.5 m, wingspread about 11 m, and doorspread ranged between 164 and 197 m. Ground-gear varied depending on whether the AOS was attached or not; with the AOS attached rock-hopper ground-gear was used, otherwise a bobbin rig was used.

Orange roughy catches were estimated from factory processing figures and conversion weights. All bycatch species in the catch were identified and weighed to the nearest 0.1 kg on motion-compensated Marel scales. A random sample of about 200 orange roughy was weighed, measured for length, and dissected for sex identification and macroscopic gonad staging. For catches exceeding 10 t, multiple samples of orange roughy were taken: 200 fish were sampled from each 10 t of catch (e.g., a 31 t catch would require measurement of three samples each of 200 fish.

More detailed biological data including individual fish weight, gonad weight, stomach content description, and otoliths were collected from about 60 orange roughy in each random length frequency sample of size of 200.

Six trawls were attempted on Volcano, but one station (5) has been excluded from this analysis as it produced a total catch of only 1.7 kg with no orange roughy. The catches from the tows used in the analysis are shown in Table 1.

Table 1: Trawls used in the analysis, their total catch weight, the percentage weight of orange roughy, and number of orange roughy otoliths collected (Ryan et al. 2014).

Station	AOS attached	Date	Total catch (kg)	ORH (%)	Number of otoliths
1	No	4 Jul	5 572.5	99.3	56
2	Yes	4 Jul	8 558.9	99.6	60
3	Yes	4 Jul	879.7	96.9	53
4	No	5 Jul	48 577.9	99.8	245
6	Yes	6 Jul	1 299.7	99.0	56

Otolith selection

All otoliths were used except those with a total count readability code of 5.

Analysis

The age frequency from each station was weighted by the catch weight of orange roughy at that station, then the weighted frequencies were summed and renormalized to get the population frequency. CV was estimated by bootstrapping the stations only; bootstrapping the fish within stations will overestimate the CV (Thorson 2014).

For plotting, kernel smoothing was used to give more stable results. It used one parameter, *width*, which is approximately the moving window width over which the average age was calculated. The function used density from the R statistical package (R Development Core Team 2010). *Width* was set to 10.

3. RESULTS

The number of otoliths prepared and read was 470; age readings from two of these were excluded because they had total count readability codes of 5. Numbers of otoliths by readability code for the TZ were:

Code	0	1	2	3
Number of otoliths	15	156	249	48

Age frequencies are presented in Figure 1 and Table 2.

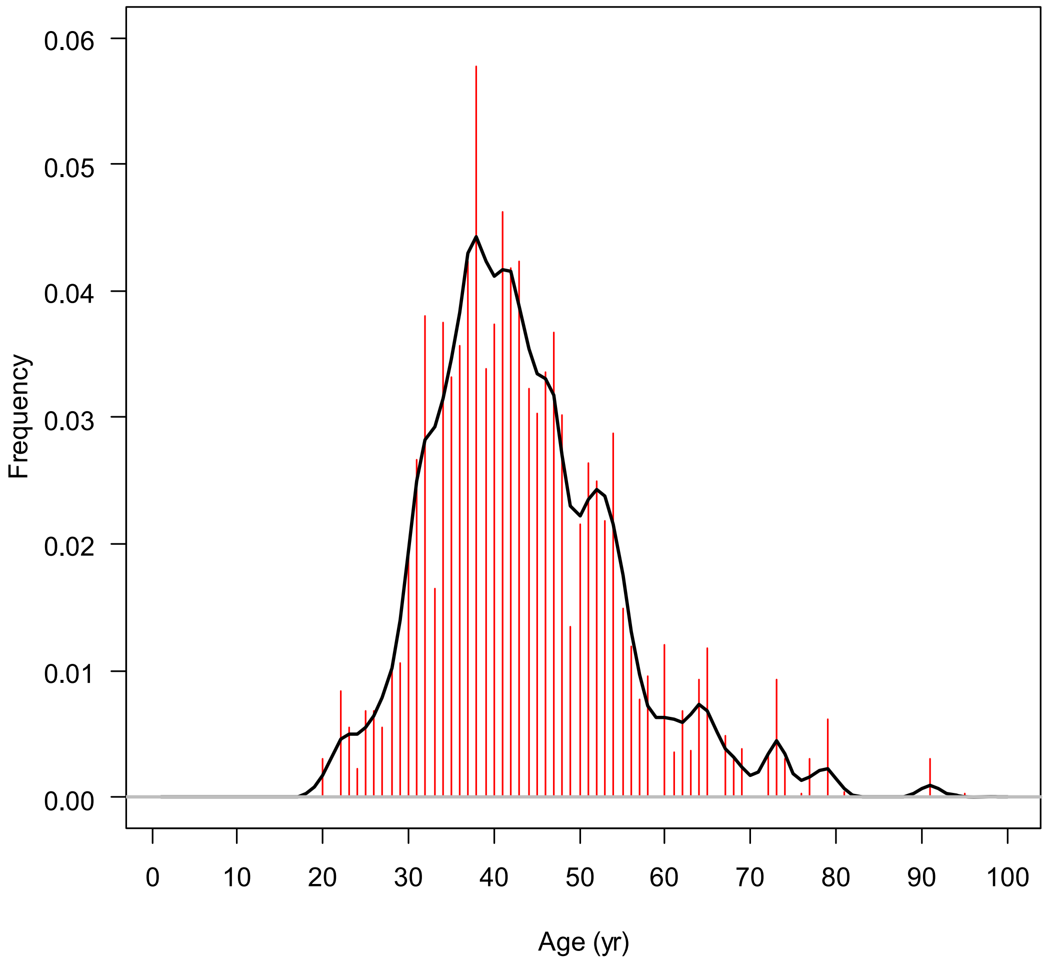

Figure 1: Estimated age frequency distribution (red bars) for Volcano orange roughy in 2014, with a smoothed density line through the age estimates (black curve).

Table 2: Estimated age frequency and bootstrap CV for Volcano orange roughy in 2014.

Age	Frequency	CV	Age	Frequency	CV
20	0.003	69.2	58	0.009	58.2
21	0	–	59	0	–
22	0.008	36.0	60	0.012	24.1
23	0.006	95.2	61	0.004	47.1
24	0.002	120.8	62	0.007	49.7
25	0.007	49.0	63	0.004	45.8
26	0.007	49.7	64	0.009	69.2
27	0.006	53.4	65	0.012	27.0
28	0.010	41.9	66	0	–
29	0.011	56.4	67	0.005	59.0
30	0.019	51.2	68	0.003	69.2
31	0.027	14.8	69	0.004	64.6
32	0.038	43.5	70	0	–
33	0.016	37.2	71	0	–
34	0.037	30.1	72	0.003	46.3
35	0.033	18.2	73	0.009	69.2
36	0.036	9.6	74	0.003	69.2
37	0.042	12.5	75	0	–
38	0.058	12.2	76	0	159.5
39	0.034	18.0	77	0.003	69.2
40	0.037	34.7	78	0	–
41	0.046	11.0	79	0.006	69.2
42	0.042	20.1	80	0	–
43	0.042	18.4	81	0	183.4
44	0.032	19.3	82	0	–
45	0.030	31.3	83	0	–
46	0.034	19.4	84	0	–
47	0.037	22.3	85	0	–
48	0.030	7.9	86	0	–
49	0.013	59.4	87	0	–
50	0.022	15.7	88	0	–
51	0.026	47.1	89	0	–
52	0.025	27.4	90	0	–
53	0.022	64.0	91	0.003	69.2
54	0.029	34.6	92	0	–
55	0.015	28.6	93	0	–
56	0.012	74.5	94	0	–
57	0.008	41.4	95	0	159.5

4. DISCUSSION

A comparison of the 2014 Volcano age distribution with that estimated for the "flats" in 2009 (Doonan et al. 2014) is shown in Figure 2. The level of recruitment to the flats in the intervening 5 years is unknown, so two comparisons between 2014 and 2009 are provided. The first compares the 2014 frequency and the frequency as at 2009, which assumes recruitment at a similar rate to that which generated the 2009 distribution. The second compares the 2014 frequency and the 2009 distribution with 5 years added to the ages, which assumes no recruitment for the 5 years from 2009 to 2014. The latter represents one extreme and so the true state for the flats is somewhere to the left of it. Mean age is 35.4 for the flats in 2009, and 43.5 for Volcano in 2014, a difference of 8 years. The percentage of fish aged 60 years and over is 3.7% for the flats in 2009, and 8.8% for Volcano in 2014. There appears to be, at least, a modest difference in the age distributions of from 3 to 8 years (or more if another strong recruitment has occurred). There is a need for contemporary age frequencies from the flats to be more certain, but clearly recruitment differs between the two areas and so, potentially, they are different stocks.

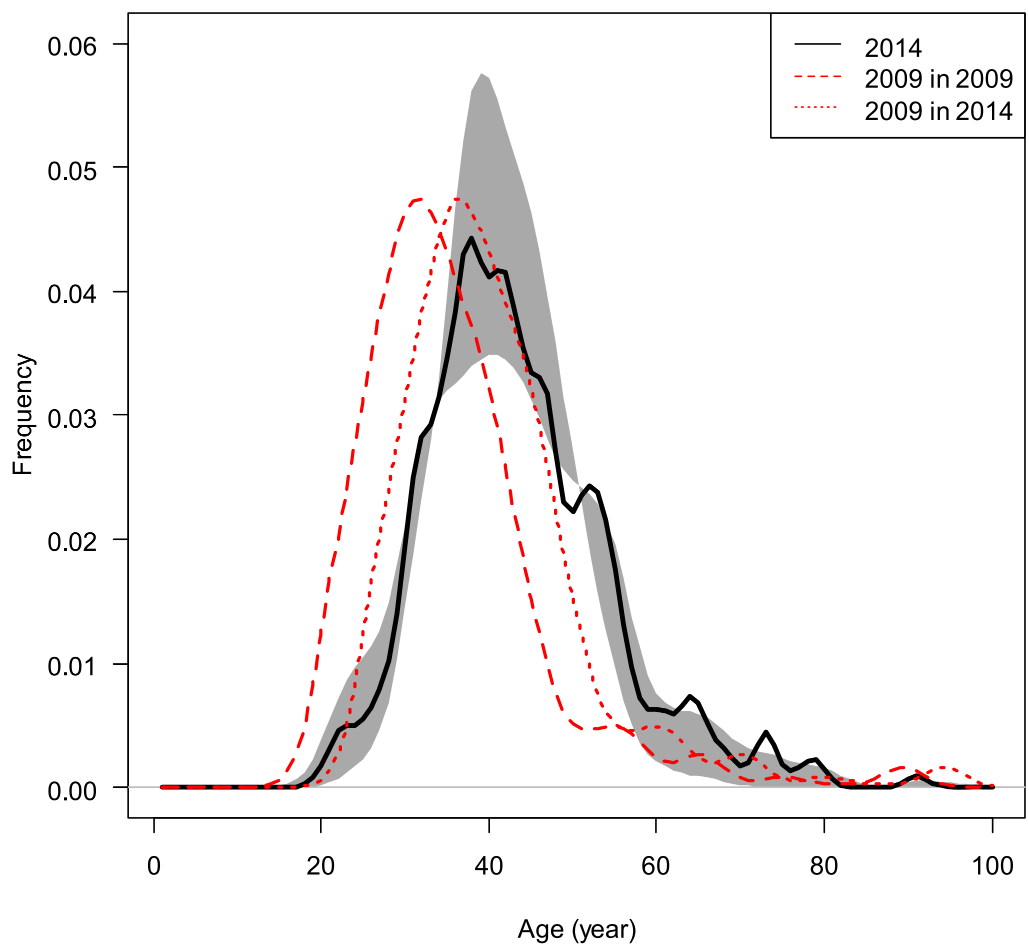

Figure 2: Smoothed age frequency distributions for Volcano, showing the 2014 distribution (black line) and the pairwise 95% CI for this distribution (grey shading), and two frequency distributions from the 2009 age analysis (red lines), one as estimated for 2009, and the other adjusted to be in 2014 and assuming no recruitment since 2009. In this instance, the smoothing of the 2014 distribution did not work well as the black line sometimes extends outside the 95% CI.

5. ACKNOWLEDGMENTS

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6. REFERENCES

Andrews, A.H.; Tracey, D.M.; Dunn, M.R. (2009). Lead-radium dating of orange roughy (*Hoplostethus atlanticus*): validation of a centenarian life span. *Canadian Journal of Fisheries and Aquatic Sciences 66*: 1130–1140.

Clark, M.R.; O'Driscoll, R.L.; Macaulay, G. (2005). Distribution, abundance, and biology of orange roughy on the Challenger Plateau: results of a trawl and acoustic survey, June-July 2005 (THH0501). NIWA Client Report WLG2005-64.

Clark, M.R.; O'Driscoll, R.L.; Macaulay, G.; Bagley, N.W.; Gauthier, S. (2006). Distribution, abundance, and biology of orange roughy on the Challenger Plateau: results of a trawl and acoustic survey, June-July 2006. NIWA Client Report WLG2006-83.

Clark, M.R.; Tracey, D.M. (1994). Population changes of *Hoplostethus atlanticus* on the Challenger Plateau. *Fishery Bulletin 92*: 236.

Doonan, I.J.; Horn, P.L.; Ó Maolagáin, C. (2014). Age composition of orange roughy from ORH 3B (Chatham Rise: northwest, 1994, and northeast, 2013), and from ORH 7A (Challenger Plateau in 1987, 2006 and 2009). *New Zealand Fisheries Assessment Report 2014/59*. 33 p.

Doonan, I.; Macaulay, G.J.; Parkinson, D.; Hampton, I.; Boyer, D.C.; Nelson, J.C. (2009). Abundance, distribution, and biology of orange roughy on the southwest Challenger Plateau (area ORH7A): results of a trawl and acoustic survey, June-July 2009. NIWA Client Report: 2009-58, FRS Client Report 05809/SL.

Doonan, I.J.; Parkinson, D.; Gauthier, S. (2010). Abundance, distribution, and biology of orange roughy on the southwest Challenger Plateau (area ORH 7A): results of a trawl and acoustic survey, June-July 2010. NIWA Client Report WLG2010-63.

Francis, R.I.C.C. (2006). Some recent problems in New Zealand orange roughy assessments. *New Zealand Fisheries Assessment Report 2006/43*. 65 p.

Hampton, I.; Boyer, D.C.; Leslie. R.W.; Nelson, J.C.; Soule, M.A.; Tilney, R.L. (2013). Acoustic and trawl estimates of orange roughy (*Hoplostethus atlanticus*) biomass on the southwest Challenger Plateau, June/July 2011. *New Zealand Fisheries Assessment Report 2013/48.* 44 p.

Hampton, I.; Boyer, D.C.; Leslie, R.W.; Nelson, J.C. (2014). Acoustic and trawl estimates of orange roughy (*Hoplostethus atlanticus*) biomass on the southwest Challenger Plateau, June/July 2012. *New Zealand Fisheries Assessment Report 2014/15. 43* p.

Hicks, A. (2005). Between-reader and between-lab ageing errors for orange roughy otoliths aged at NIWA and CAF. Document WG-DW-05/23(revised). 18 p. (Unpublished report held by the Ministry for Primary Industries, Wellington.)

Mace, P.M.; Fenaughty, J.M.; Coburn, R.P.; Doonan, I.J. (1990). Growth and productivity of orange roughy (*Hoplostethus atlanticus*) on the north Chatham Rise. *New Zealand Journal of Marine and Freshwater Research 24*: 105–119.

R Development Core Team (2010). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

Ryan, T.E.; O'Driscoll, R.L.; Downie, R.A. (2015). Estimates of biomass of orange roughy on ORH1, ORH7A and selected Tasman Sea high seas region using a net attached acoustic optical system. Voyage report to Sealord New Zealand. Unpublished client report available from CSIRO Marine and Atmospheric Research, Hobart, Tasmania 7001, Australia.

Thorson, J.T. (2014). Standardizing compositional data for stock assessment. *ICES Journal of Marine Science 71*: 1117–1128. doi:10.1093/icesjms/fst224.

Tracey, D.M.; Horn, P.L.; Marriott, P.M.; Krusic-Golub, K.; Green, C.; Gili, R.; Cid Mieres, L. (2007). Orange roughy ageing workshop: otolith preparation and interpretation. Report to the Deepwater Fisheries Assessment Working Group, 7–9 February 2007, Wellington, New Zealand. 26 p. (Unpublished report held by the Ministry for Primary Industries, Wellington.)

Tracey, D.M.; Horn, P.L.; Doonan, I.J.; Krusic-Golub, K.; Robertson, S. (2009). Orange roughy ageing study: application of otolith reading protocol and analysis of between-agency age data. Final Research Report for Ministry of Fisheries Research Project SAP200716, Objective 1. 18 p. (Unpublished report held by the Ministry for Primary Industries, Wellington.)