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AGE DISTRIBUTION OF ORANGE ROUGHY HARVESTED FROM THE SLEEPING BEAUTY SEAMOUNT, SOUTHERN INDIAN OCEAN.

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Delegation of SIODFA

Paper provides results of analysis of orange roughy otoliths.

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Southern Indian Ocean
Deepsea Fishers Association

AGE DISTRIBUTION OF ORANGE ROUGHY HARVESTED FROM THE SLEEPING BEAUTY SEAMOUNT, SOUTHERN INDIAN OCEAN.

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SUMMARY

Otoliths of orange roughy (*Hoplostethus atlanticus*) from the Sleeping Beauty seamount in the Southern Indian Ocean were prepared and read by one reader following the accepted NIWA ageing protocol. The goal was to identify their age composition for use in their stock assessment. A sample of 400 orange roughy otoliths collected in 2017 was analysed. The results showed a range in age from 21 to 140 years, with a mode from around 32 to 45 years.

1. INTRODUCTION

This work prepared and aged the otoliths from a sample of orange roughy taken from the Sleeping Beauty feature in the Southern Indian Ocean. Sleeping Beauty is a rocky bank covering over 100 square miles on Walter's Shoal (≈ 32°30' S, 44° E). This area was mapped by sidescan sonar in 2000. It has a habitat common in this region - a very small proportion can be fished with bottom trawls as there are having only three trawl paths.

The area has been surveyed acoustically on many occasions since 2004, including multi-frequency AOS acoustic surveys (G. Patchell, Sealord Group, pers. comm.). Orange roughy otoliths have been collected from this area since 2006, and in 2017 the Scientific Committee of the Southern Indian Ocean Fisheries Agreement (SIOFA) recommended an assessment of this stock be done because of the extensive data series (SIOFA 2017) that was available. In recent years the orange roughy stock assessments in New Zealand and Australia have highlighted the need for good age distribution data to support assessments, and hence a large otolith sample was collected in July 2017 during commercial fishing operations by F.T. *Will Watch*.

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). Later, 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.

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2. METHODS

2.1 Ageing of Orange Roughy

Otoliths were prepared using the NIWA preparation method (Horn *et al*. 2016). One otolith from each of the pairs was individually embedded in resin and cured by heating 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.

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 and from the transition zone 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- transition zone 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 formed (i.e., 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 transition zone classification 3, only a total age was recorded.

2.2 Analystical Methods

It was initially intended (and preferable) that the method of otolith selection and analysis would follow that of Doonan *et al*. (2013) for orange roughy taken from the management zone ORH 7A in New Zealand. This method assigns a selection probability to each otolith collected that represented the contribution that the sampled orange roughy catch (in the tow the otolith came from) made to the total abundance (in numbers). However, owing to the method of collection and storage of the available otoliths, about one-third were found to be broken or incomplete. Incomplete otoliths were generally missing the tip of the posterior-dorsal axis — that section contains the growth zones formed after the transition zone. Consequently, otoliths for preparation were chosen roughly randomly in proportion to the size of the orange roughy catch from each tow. The intention was to more intensively sample larger catches. This process was continued until there were 400 otoliths believed to be suitable for preparation. All usable otoliths from six of the seven largest tows were prepared. Details of the stations and otoliths used in the analysis are listed in Table 1.

Table 1
Stations (sorted by orange roughy catch weight), catch, number of otoliths collected, number of otoliths prepared, and the remaining number of otoliths that appear to be complete and so would be available for future examination (Residual). Tow dates are also listed.

Tow	ORH	Number of otoliths			Date of sampling
number	catch (t)	Collected	Prepared	Residual	
102	55	40	33	0	2017-07-05
92	30	40	34	0	2017-07-03
114	30	40	32	0	2017-07-08
86	25	98	58	15	2017-07-01
82	18	40	26	0	2017-07-01
94	11	40	28	0	2017-07-03
96	10	40	28	0	2017-07-03
110	7	40	26	2	2017-07-07
127	7	40	20	2	2017-07-10
85	6	102	30	44	2017-07-01
91	6	40	31	2	2017-07-02
84	4	100	25	38	2017-07-01
107	4	40	19	0	2017-07-06
118	1	40	10	13	2017-07-08
Totals		740	400	116	

For each tow, an age frequency was formed. The combined age frequency was the weighted mean age frequency over the tow age frequencies, where the weight was the square-root of the tow's catch. The CV was estimated by bootstrapping the tows 500 times.

Kernel smoothing was used to show the plotted results. 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 aged otolith sample from the Sleeping Beauty feature are listed in Table 2, and the age-frequency is presented in Figure 1. Age-frequency data are listed in Table 3.

Table 2
Details of 2017 Sleeping Beauty orange roughy otolith sample. *N*, initial number of otoliths selected; Rejects (i.e., preparations unable to be aged); numbers of aged otoliths by transition zone classification (see Section 2).

		Transition zone classification code			
N	**Rejects**	**0**	**1**	**2**	**3**
400	1	54	55	259	31

4. CONCLUSIONS

The structure of the otoliths examined in this study exhibited some general differences to those from New Zealand stocks. The Indian Ocean otoliths generally appeared to be longer indicating either a longer period of pre-transition zone growth or a faster growth rate of the otolith. Also, one criterion used to define the location of the transition zone (i.e., a change in curvature of the posterior arm of the otolith) was often not met, resulting in a relatively high proportion (65%) of transition zone classifications of 2 (see Table 2). New Zealand samples generally have about 20–45% of transition zone classifications of 2 (e.g., Doonan *et al*. 2014). This indicates a post-transition zone fish growth rate that would be faster than that for New Zealand orange roughy. These characteristics were not further investigated.

Orange roughy from the Sleeping Beauty sea floor feature had an age frequency comprised of older fish than is generally seen in New Zealand fisheries; the range was from 21 to 140 years, with a broad mode from around 32 to 45 years. The proportion of fish older than 90 years was estimated to be 7%; in New Zealand fisheries it is rare for more than 3% of fish to be in this age range (e.g., Doonan *et al*. 2014).

5. REFERENCES

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Table 3
Estimated age frequencies for orange roughy from the 2017 Sleeping Beauty fishery

Age	Frequency	% CV	Age	Frequency	% CV	Age	Frequency	% CV
21	0.002	97.1	61	0.008	51.6	101	0.011	45.2
22	0.002	95.8	62	0.007	59.7	102	0	0
23	0.005	63.8	63	0.019	35.9	103	0.006	68.3
24	0.002	95.4	64	0.002	97.1	104	0	0
25	0.018	37.2	65	0.014	48.3	105	0	0
26	0.013	45.6	66	0.011	47.0	106	0.005	75.8
27	0.023	33.5	67	0.010	47.2	107	0	0
28	0.018	28.2	68	0.006	52.2	108	0	0
29	0.017	26.5	69	0.015	35.0	109	0	0
30	0.013	39.9	70	0.011	43.1	110	0	0
31	0.018	55.3	71	0.014	32.8	111	0.005	68.0
32	0.028	24.3	72	0.010	47.5	112	0.002	97.1
33	0.009	45.0	73	0.008	48.2	113	0	0
34	0.042	23.0	74	0.010	48.1	114	0	0
35	0.017	29.3	75	0	0	115	0.003	106.7
36	0.036	40.2	76	0.004	65.6	116	0.002	108.9
37	0.025	45.3	77	0.005	67.7	117	0	0
38	0.022	34.5	78	0.007	53.8	118	0	0
39	0.024	19.6	79	0.005	75.8	119	0	0
40	0.040	23.7	80	0.009	70.7	120	0	0
41	0.011	60.9	81	0.007	54.0	121	0	0
42	0.029	33.8	82	0.005	89.2	122	0	0
43	0.038	21.8	83	0.009	51.6	123	0	0
44	0.013	46.1	84	0.006	68.3	124	0	0
45	0.014	39.8	85	0.007	54.3	125	0	0
46	0.012	58.4	86	0.014	49.9	126	0.002	95.1
47	0.013	36.5	87	0	0	127	0	0
48	0.017	43.7	88	0.006	66.4	128	0	0
49	0.019	39.6	89	0.002	97.5	129	0	0
50	0.009	47.0	90	0.002	108.1	130	0	0
51	0.016	48.7	91	0.012	60.0	131	0	0
52	0.014	32.8	92	0.002	97.5	132	0	0
53	0.018	33.8	93	0	0	133	0	0
54	0.018	40.4	94	0.002	108.1	134	0	0
55	0.010	57.3	95	0	0	135	0	0
56	0.009	47.9	96	0.009	50.7	136	0	0
57	0.022	42.1	97	0.002	95.8	137	0	0
58	0.016	35.2	98	0	0	138	0	0
59	0.015	32.5	99	0.003	97.2	139	0	0
60	0.011	40.6	100	0	0	140	0.003	106.7

Figure 1
Results of analysis of the 2017 estimated age frequency (red bars) with a smoothed density through the age estimates (black curve).