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Age composition of black oreo samples from OEO 3A, Chatham Rise: 2007–08 and 2008–09 commercial catch.

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EXECUTIVE SUMMARY

Doonan, I.J.; McMillan, P.J.; Ó Maolagáin, C. (2019). Age composition of black oreo samples from OEO 3A, Chatham Rise: 2007–08 and 2008–09 commercial catch.

***New Zealand Fisheries Assessment Report 2019/10*. 13 p.**

Black oreo (*Allocyttus niger*) otoliths sampled by observers from the west Chatham Rise (OEO 3A) commercial fishery in 2007–08 and 2008–09 were prepared and aged. Otoliths (*n* = 600) from the two fishing years combined were read by one reader following the accepted ageing protocol. This is the first aged sample of black oreo otoliths collected from a New Zealand black oreo commercial fishery because previous analyses used only otoliths collected during research surveys. The aim was to develop an age composition for use in a stock assessment of the OEO 3A black oreo population. Age estimates were from 6 to 104 years, but most fish were 15–45 years. The smoothed age distribution had a mode at about 23 years.

1. INTRODUCTION

This report fulfils parts of the reporting requirements for Objective 1 of Project DEE2016-20, "Routine age determination of middle depth and deepwater species from commercial fisheries and resource surveys", funded by the Ministry for Primary Industries (MPI). That objective was:

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

This work aimed to provide age estimates for black oreo (*Allocyttus niger*) from OEO 3A to produce a numbers-at-age distribution for input into a stock assessment. This is the first age estimation of samples collected by observers from a New Zealand black oreo commercial fishery because previous age estimation work used only otoliths collected during research surveys. The last published black oreo stock assessment was that of Doonan et al. (2009), which used observer length frequency samples and the 1997, 2002, and 2006 acoustic survey length data, and the growth estimates from McMillan et al. (1997) to derive an age distribution. No direct age estimates were made. The Deepwater Fisheries Assessment Working Group rejected subsequent stock assessments (I. Doonan, pers. comm.) because an analysis of age estimates (Doonan et al. 2016) showed that the three-area model for growth, used in the 2009 stock assessment, was not appropriate. A new stock assessment model was required, but has not been developed at the time of writing.

In New Zealand, black oreo age determination methods were developed by Doonan et al. (1995) and refined by McMillan et al. (1997). Unvalidated age estimates obtained for Chatham Rise and Puysegur-Snares samples in 1995 and 1997 respectively used counts of the growth zones (assumed to be annual) observed in thin sections of otoliths. The results indicated that black oreo is slow growing and long lived. The maximum estimated age was 153 years (45.5 cm TL fish). Australian workers used the same methods, i.e., sections of otoliths, and reported similar results (Smith & Stewart 1994). No further age estimation work for stock assessment was completed for black oreo until 2010 when a study was carried out to investigate the proportions of mature fish from the unfished area (Area 1), and the fished area (Area 2&3) in OEO 3A (see definition of Areas 1, 2 and 3 in Doonan et al. (2009) and Figure 1 below). That work analysed age estimates from 1000 otoliths from the acoustic research surveys in 1997, 2002 and 2006, under MPI project DEE2010-08 (Doonan et al. 2016). Age estimation for black oreo continued when Doonan et al. (2017) reported age distributions for research samples collected from the 2014 acoustic survey mark identification tows for MPI project MID201501.

Validation of black oreo age estimates made using otolith zone counts is difficult because techniques such as tagging, and seasonal otolith marginal increment formation are impractical. Atomic weapon testing in the Pacific Ocean in the 1950s resulted in elevated environmental levels of C^{14} levels, and this was used by Kalish (1993) to develop a method for testing the age of long-lived fishes. A preliminary study of C^{14} levels in black oreo otoliths provided strong support for age estimates made using otolith zone counts (Neil et al. 2008), so the method is believed to be valid.

Substantial catch of black oreo from OEO 3A was first reported in 1979–80, and a TAC (10 000 t, for combined oreo species) was established in 1982–83. The catch of combined oreo species from OEO 3A was less than the TAC from 1992–93 to 1995–96, substantially so in 1994–95 and 1995–96. Consequently, the OEO 3A TAC was reduced from 10 106 t to 6600 t in 1996–97. Subsequently the OEO 3A TAC was reduced to 5900 t in 1999–00, 4400 in 2000–01, 4095 in 2001–02, and 3100 t in 2002–03 (Ministry for Primary Industries 2017). A small increase in 2009–10 resulted in the current

(2017) TAC of 3250 t. Estimated mean annual black oreo catch in OEO 3A from 1997–98 to 2007–08 was 2100 t (Ministry for Primary Industries 2017).

2. METHODS

2.1 Otolith selection

The work aimed to age 600 otoliths, with the sampled year(s) to be as near as possible to the last fishing year (2017) where data permitted, and where otoliths were collected from the oreo target fishery in OEO 3A. The fishery for, and distribution of, black oreo in OEO 3A is primarily on the southwest Chatham Rise (Figure 1), as determined by previous trawl surveys, e.g., McMillan & Hart (1994), and analysis of commercial catch, e.g., Coburn et al. (2005). The density and size distribution of black oreo differed in the three areas defined in Figure 1. Area 1 had shallower waters, with low densities of black oreo, smaller fish on average, and the area supported target fishing for hoki. The commercial oreo fishery, which targeted black oreo schools and caught larger fish, was carried out in Areas 2 and 3.

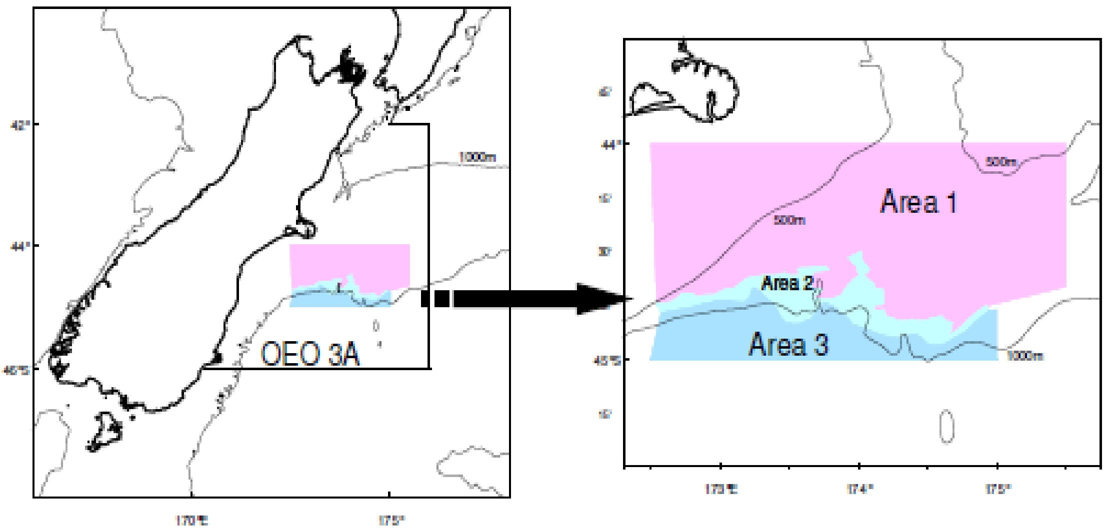

Figure 1: Black oreo management area OEO 3A showing Areas 1–3, used in previous stock assessment analysis (Doonan et al. 2009) and age distribution analyses (Doonan et al. 2016, 2017).

Observer Programme black oreo otolith sampling started in 2002–03 (Table 1) but the total number of samples collected each year was variable; about half the fishing years since 2002–03 had about 200 or fewer black oreo otoliths, and only 2005–06 had at least 600 otoliths available. This project aimed to estimate age from the best sampled year(s) closest to 2017. The best adjacent years with at least 600 otoliths were 2008–09 combined with either 2007–08 or 2009–10. In 2009–10, over half the sampled black oreo otoliths were from tows that had targeted either hoki or smooth oreo (Table 1). In 2007–08 and 2008–09, about two-thirds of the black oreo otoliths were from tows that targeted black oreo, so these were the years chosen by the MPI Deepwater Fisheries Working Group to produce the black oreo otolith sample for ageing.

Table 1: Summary of the black oreo otoliths collected by MPI observers from OEO 3A since 2002–03.

Fishing year	Number of tows per target species					Total otoliths	Number of sampled tows
	BOE	HOK	OEO	ORH	SSO		
2002–03	165	0	117	0	10	292	21
2003–04	0	103	20	0	19	142	14
2004–05	10	3	140	0	0	153	11
2005–06	261	10	335	0	76	682	45
2006–07	0	27	20	3	0	50	9
2007–08	150	35	0	0	37	222	29
2008–09	297	1	0	0	175	473	49
2009–10	99	35	0	0	70	204	30
2010–11	134	13	0	0	175	322	29
2011–12	0	58	146	0	0	204	24
2012–13	110	18	0	0	39	167	21
2013–14	96	24	0	0	48	168	33
2014–15	52	15	0	0	110	177	28

Fishery catch and effort data were selected from the commercial catch and effort database (CE) if they were derived from trawl tows that caught or targeted black oreo with start positions between latitudes 42 and 47 ºS, and longitudes 172 and 176 ºE. Observer data (from the *cod* database) were selected using the same criteria, but with an additional criterion that there were otoliths from black oreo available from each tow. There was variation between years in the geographical and temporal distribution of the sampled tows, and the target species, although most black oreo otoliths were sampled from tows that targeted oreos or orange roughy. The 2007–08 and 2008–09 samples comprehensively sampled the geographical and temporal distribution of the black oreo target fishery and included 640 otoliths, taken from 67 tows over 9 trips (Table 2). A plot of OEO 3A black oreo catch from 2007–08 and 2008–09 by 0.1 degree longitude bins was compared with catches for tows sampled by observers scaled-up to the CE catch, and showed that the observer coverage approximately matched the spatial distribution of the fishery (Figure 2).

The probability of an otolith being selected for ageing was proportional to the black oreo catch, and inversely proportional to the number of otoliths in each tow, i.e., more otoliths were selected from large catches if there were sampled otoliths available. Otoliths were selected with replacement until there were 600 unique otoliths. A summary of the otoliths available for selection is in Table 2. The method of otolith selection followed that of Doonan et al. (2013). The target 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 spare otoliths to replace any damaged or lost samples, and spares were used in the order of their selection. For otoliths collected by observer sampling of the commercial catch, selection probabilities are proportional to the numbers of fish caught in each tow (or to catch weight in the tow, if mean fish weights are similar across all tows) divided by the number of otoliths in the tow. The 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 prepared otoliths n_{unique}.

Table 2: Summary of the black oreo otoliths by observer trip collected from OEO 3A during 2007–08 and 2008–09, and used for otolith selection.

Trip code	2520	2650	2699	2710	2744	2832	2862	2911	2920	Total
No. of tows	14	3	15	16	3	1	5	2	8	67
No. of otoliths	107	27	150	102	45	10	116	20	63	640

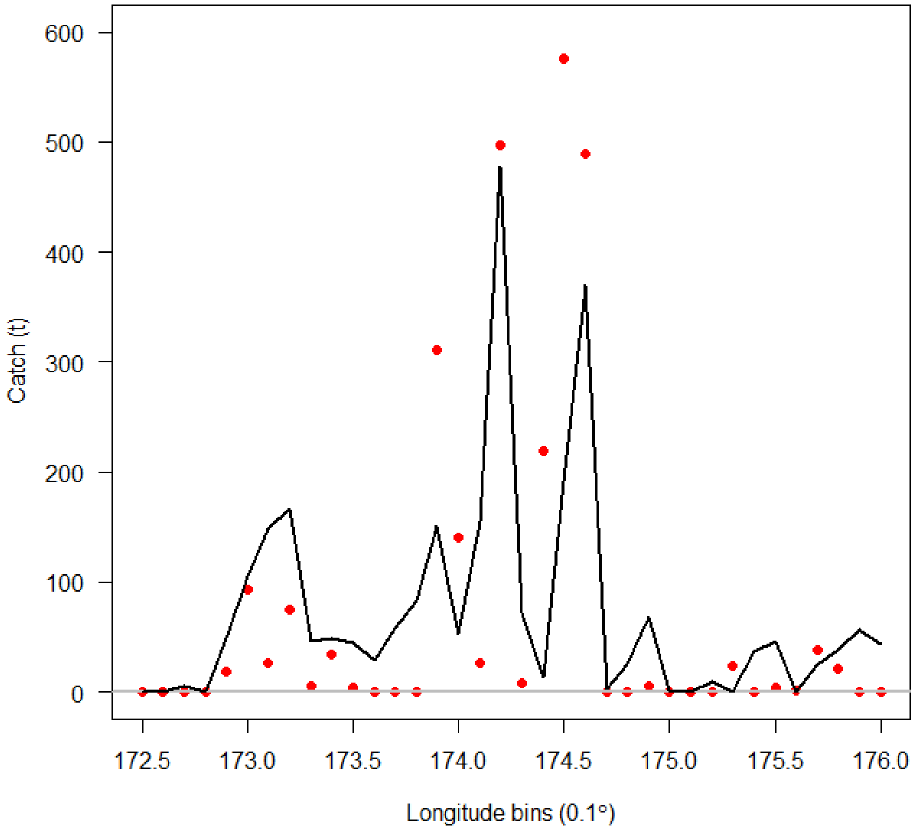

Figure 2: Black oreo catch (t) in 2007–08 and 2008–09 by 0.1 degree bins from OEO 3A CE data (black line) and the scaled-up catch sampled by observers (red dots). Scaling made the sum of observer catch the same as that for the CE data.

Procedures for preparation and reading of black oreo otoliths in this study follow those described in Horn et al. (2018). Briefly, otoliths were marked along the dorso-ventral cutting axis, embedded in resin, three to a block, and cured in an oven. A thin section was cut and the section was mounted on a glass microscope slide under a glass cover slip. All otoliths were read once by one reader, without knowledge of size or sex of the fish, and the data produced were zone counts and readability scores (5-stage scale) for each section.

2.2 Analytical methods

Otoliths with a readability score of 5 (i.e., unreadable) were excluded from the 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 proportions at age for the sample. The coefficient of variation (CV) for the sample was calculated using a bootstrapping procedure, sampling with replacement for tows.

Kernel smoothing was used to show the density of the age estimates in the resulting plots. The smoothing method 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) and *width* was set to 10.

3. RESULTS

3.1 Otolith samples selected and read

Details of the trawl tows used in the analysis are listed in Appendix A (Table A1). To obtain 600 otolith preparations, it was necessary to use 27 replacement otoliths because that many of the initial 600 were missing or broken. Twelve of the 600 successful preparations were rejected because they were unreadable (i.e., readability code 5). Age frequencies are presented for the 2007–08 and 2008–09 commercial fishery in Figure 3, and age-frequency data are listed in Appendix B. Age estimates were from 6 to 104 years, but most fish were 15–45 years. The smoothed age distribution had a mode at about 23 years.

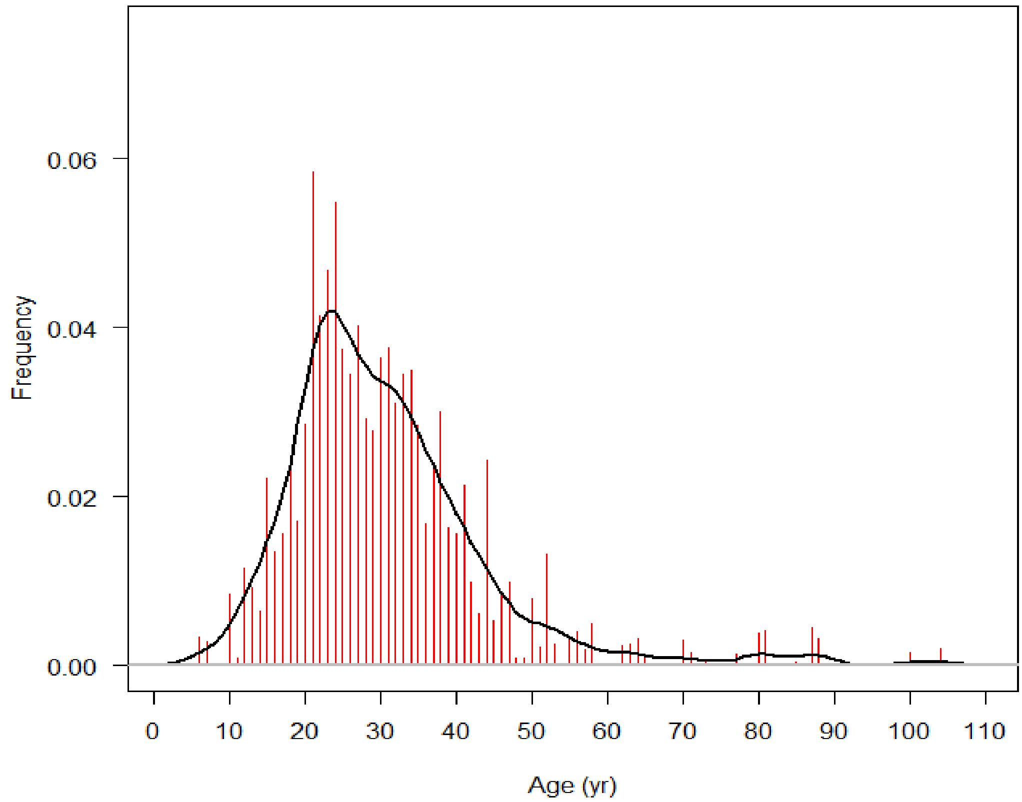

Figure 3: Estimated age frequency (red bars) for the 2007–08 and 2008–09 commercial fishery black oreo otolith sample (n = 588) with a smoothed density through the age estimates (black curve).

4. DISCUSSION

An age distribution for the black oreo (OEO 3A) commercial trawl fishery was produced from data sampled in 2007–08 and 2008–09. These data were from the most recent contiguous pair of years that provided sufficient otoliths to comprehensively represent the main black oreo fishery. This age distribution should be suitable for use in a stock assessment.

The commercial catch age distribution estimated for 2007–09 was compared with age distributions estimated from otoliths collected during acoustic research survey tows in Areas 2&3 from 1997–2006 and 2014, reported in Doonan et al. (2016, 2017) (Figure 4). The main mode of all three distributions was similar at 23–25 years, but the 2014 research survey distribution had a secondary mode of young fish at around 5 years old, and the 1997–2006 distribution had relatively high proportions of fish younger than about 23 years. Some of these research tows clearly sampled parts of the black oreo population that were not sampled by the commercial tows. This suggests that the mark-type classification for some of the research tows were problematic. The research tows used in the age estimation analysis were chosen because they were believed to have sampled marks that comprised mainly adult schooling fish, but the age results suggested that was not always correct.

An examination of the right-hand limbs of the distributions showed that the 2007–09 commercial catch distribution contained more older fish (30–60 years old) than either of the research survey distributions, but this was mainly due to the preponderance of younger fish in the research survey samples. When ages younger than 23 years were excluded from the research data, and the curves re-normalised, the right-hand limb of the 2014 research distribution was similar to the 2007–09 commercial data distribution, and had only slightly fewer older fish.

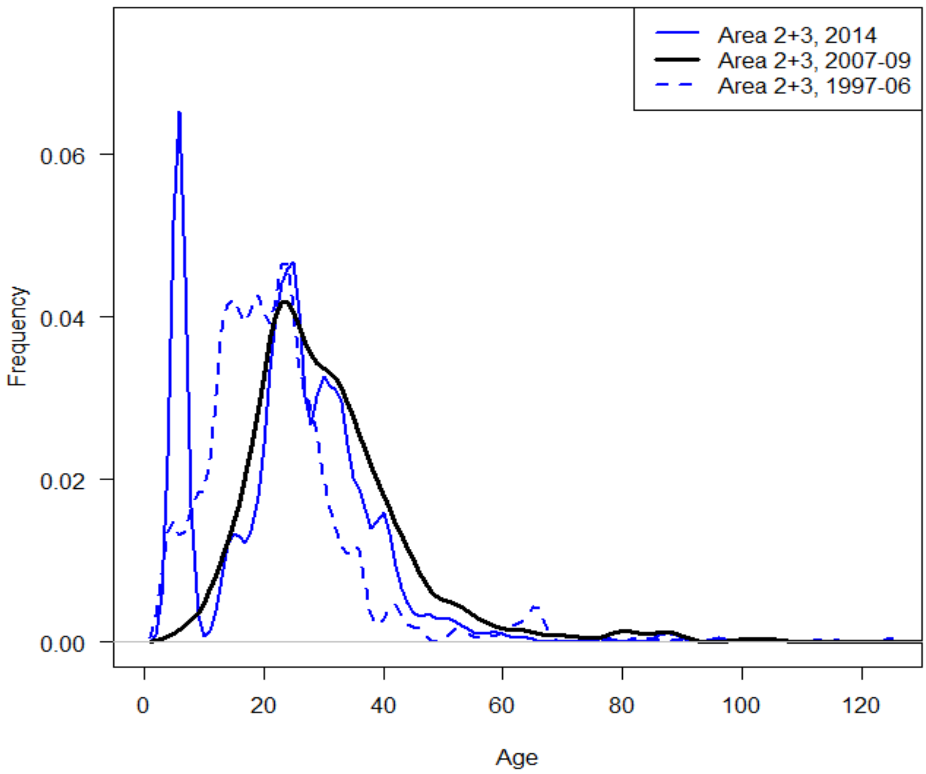

Figure 4: A comparison of the estimated black oreo age frequency distribution for the 2007–08 and 2008–09 commercial fishery (black lines) with previous age distributions derived from acoustic surveys.

5. ACKNOWLEDGMENTS

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APPENDIX A: STATION WEIGHT AND OTOLITH SELECTION PROBABILITIES

Table A1: 2007–08 and 2008–09 commercial fishery station data: trip and tow numbers, black oreo catch, relative weight by station used to randomly sample otoliths, number of otoliths collected, and probability of selecting one otolith, i.e., relative station weight divided by the number of otoliths sampled at the station.

Trip	Tow no	Catch (kg)	Station weight	Number of otoliths	Otolith probability
2520	006	4 500	0.0055	2	0.00274
2520	010	18 000	0.0219	10	0.00219
2520	011	40 500	0.0493	10	0.00493
2520	012	8 750	0.0107	2	0.00533
2520	013	6 000	0.0073	3	0.00244
2520	014	29 700	0.0362	12	0.00302
2520	015	38 000	0.0463	10	0.00463
2520	016	19 000	0.0232	11	0.00210
2520	017	25 532	0.0311	10	0.00311
2520	020	2 000	0.0024	3	0.00081
2520	023	2 400	0.0029	10	0.00029
2520	024	1 400	0.0017	3	0.00057
2520	027	7 513	0.0092	11	0.00083
2520	028	29 100	0.0355	10	0.00355
2650	102	24 670	0.0301	16	0.00188
2650	104	29 000	0.0353	5	0.00707
2650	108	1 000	0.0012	6	0.00020
2699	001	11 258	0.0137	10	0.00137
2699	002	19 500	0.0238	12	0.00198
2699	003	25 222	0.0307	10	0.00307
2699	004	12 000	0.0146	11	0.00133
2699	006	15 000	0.0183	10	0.00183
2699	175	9 600	0.0117	12	0.00097
2699	176	13 800	0.0168	10	0.00168
2699	179	21 000	0.0256	10	0.00256
2699	180	30 000	0.0366	12	0.00305
2699	181	23 000	0.0280	10	0.00280
2699	182	14 000	0.0171	12	0.00142
2699	184	14 000	0.0171	5	0.00341
2699	185	6 000	0.0073	10	0.00073
2699	186	10 000	0.0122	11	0.00111
2699	188	2 000	0.0024	5	0.00049
2710	006	8 400	0.0102	5	0.00205
2710	008	2 000	0.0024	5	0.00049
2710	016	1 200	0.0015	5	0.00029
2710	020	21 000	0.0256	10	0.00256
2710	022	200	0.0002	5	0.00005
2710	024	2 000	0.0024	5	0.00049
2710	027	8 000	0.0097	5	0.00195
2710	028	6 000	0.0073	10	0.00073
2710	032	1 750	0.0021	2	0.00107
2710	033	6 000	0.0073	10	0.00073
2710	035	2 500	0.0030	5	0.00061
2710	040	1 250	0.0015	5	0.00030

2710	042	200	0.0002	5	0.00005
2710	043	3 500	0.0043	5	0.00085
2710	044	2 500	0.0030	10	0.00030
2710	048	5 000	0.0061	10	0.00061
2744	003	17 680	0.0215	20	0.00108
2744	009	15 000	0.0183	5	0.00366
2744	010	45 000	0.0548	20	0.00274
2832	063	7 800	0.0095	10	0.00095
2862	001	25 000	0.0305	25	0.00122
2862	002	2 750	0.0034	11	0.00030
2862	003	16 652	0.0203	25	0.00081
2862	004	29 543	0.0360	28	0.00129
2862	005	18 000	0.0219	27	0.00081
2911	089	1 500	0.0018	10	0.00018
2911	091	1 980	0.0024	10	0.00024
2920	012	5 950	0.0072	10	0.00072
2920	015	11 900	0.0145	10	0.00145
2920	019	5 476	0.0067	5	0.00133
2920	021	9 032	0.0110	4	0.00275
2920	022	7 546	0.0092	4	0.00230
2920	027	3 600	0.0044	10	0.00044
2920	033	7 131	0.0087	10	0.00087
2920	037	4 228	0.0052	10	0.00052

APPENDIX B: ESTIMATED AGE FREQUENCIES

Table B1: Estimated age frequencies for OEO 3A Chatham Rise black oreo from the 2007–08 and 2008–09 commercial fishery.

Age (yr)	Frequency	CV
6	0.0033	0.94
7	0.0029	0.98
9	0.0001	0.98
10	0.0083	0.62
11	0.0008	0.99
12	0.0115	0.46
13	0.0091	0.49
14	0.0065	0.53
15	0.0222	0.39
16	0.0135	0.51
17	0.0157	0.37
18	0.0240	0.43
19	0.0170	0.33
20	0.0286	0.27
21	0.0583	0.25
22	0.0413	0.22
23	0.0468	0.20
24	0.0548	0.17
25	0.0374	0.24
26	0.0345	0.27
27	0.0401	0.20
28	0.0291	0.26
29	0.0277	0.24
30	0.0364	0.22
31	0.0376	0.31
32	0.0311	0.27
33	0.0344	0.25
34	0.0349	0.28
35	0.0283	0.27
36	0.0167	0.30
37	0.0235	0.31
38	0.0301	0.26
39	0.0163	0.34
40	0.0157	0.36
41	0.0214	0.39
42	0.0098	0.50
43	0.0061	0.46
44	0.0242	0.30
45	0.0053	0.52
46	0.0086	0.60

Age (yr)	Frequency	CV
47	0.0098	0.48
48	0.0009	0.87
49	0.0009	0.68
50	0.0079	0.47
51	0.0022	0.87
52	0.0131	0.49
53	0.0025	0.79
54	0.0001	0.87
55	0.0030	0.60
56	0.0040	0.75
57	0.0018	0.79
58	0.0050	0.95
62	0.0023	0.79
63	0.0025	0.81
64	0.0031	0.91
65	0.0014	1.04
70	0.0030	0.91
71	0.0016	0.98
73	0.0003	0.99
77	0.0014	0.87
80	0.0038	0.98
81	0.0041	0.86
85	0.0003	0.96
87	0.0045	0.91
88	0.0031	0.98
100	0.0016	1.03
104	0.0019	1.03