

OREOS — OEO 3A BLACK OREO AND SMOOTH OREO

1. FISHERY SUMMARY

This is presented in the Fishery Summary section at the beginning of the Introduction – Oreos chapter.

2. BIOLOGY

This is presented in the Biology section at the beginning of the Introduction – Oreos chapter.

3. STOCKS AND AREAS

This is presented in the Stocks and Areas section at the beginning of the Introduction – Oreos chapter.

4. STOCK ASSESSMENT

The smooth oreo stock assessment is unchanged from 2009. The black oreo stock assessment for 2008 has been withdrawn but the CPUE series has been updated to 2012.

4.1 Introduction

The following assumptions were made in the stock assessment analyses to estimate biomasses and yields for black oreo and smooth oreo.

- (a) The acoustic abundance estimates were unbiased absolute values.
- (b) The CPUE analyses provided indices of abundance for either black oreo or smooth oreo in the whole of OEO 3A. Most of the oreo commercial catches came from the CPUE study areas. Research trawl surveys indicated that there was little habitat for, and biomass of, black oreo or smooth oreo outside those areas.
- (c) The ranges used for the biological values covered their true values.
- (d) The maximum fishing mortality (F_{MAX}) was assumed to be 0.9, varying this value from 0.5 to 3.5 altered B_0 for smooth oreo in OEO 3A by only about 6% in the 1996 assessment.
- (e) Recruitment was deterministic and followed a Beverton and Holt relationship with steepness of 0.75.
- (f) Catch overruns were 0% during the period of reported catch.
- (g) The populations of black oreo and smooth oreo in OEO 3A were discrete stocks or production units.
- (h) The catch histories were accurate.

4.1.1 Black oreo

The last accepted assessment was in 2008. A three-area population model was used to accommodate the structure of the catch and length data, with age-dependent migration between areas. However, new age data collected within each area suggest that, based on 2013 analyses, assumptions made by this model are incorrect. Specifically, differences in the size distribution between areas now seem likely to be due to differential growth rates, rather than to movement. The model applied in 2008 was therefore considered inadequate and has been withdrawn. No stock assessment is presented here; a new approach needs to be developed.

4.1.2 Smooth oreo

A new assessment of smooth oreo in OEO 3A was completed in 2009. This used a CASAL age-structured population model employing Bayesian methods. Input data included research and observer-collected length data, one absolute abundance estimate from a research acoustic survey carried out in 1997 (TAN9713), and three relative abundance indices from standardised catch per unit effort analyses.

4.2 Black oreo

Partition of the main fishery into 3 areas

The main fishery area was split into three areas: a northern area that contained small fish and was generally shallow (Area 1), a southern area that contained large fish in the period before 1993 and which was generally deeper (Area 3), and a transition area (Area 2) that lay between Areas 1 and 3 (Figure 1).

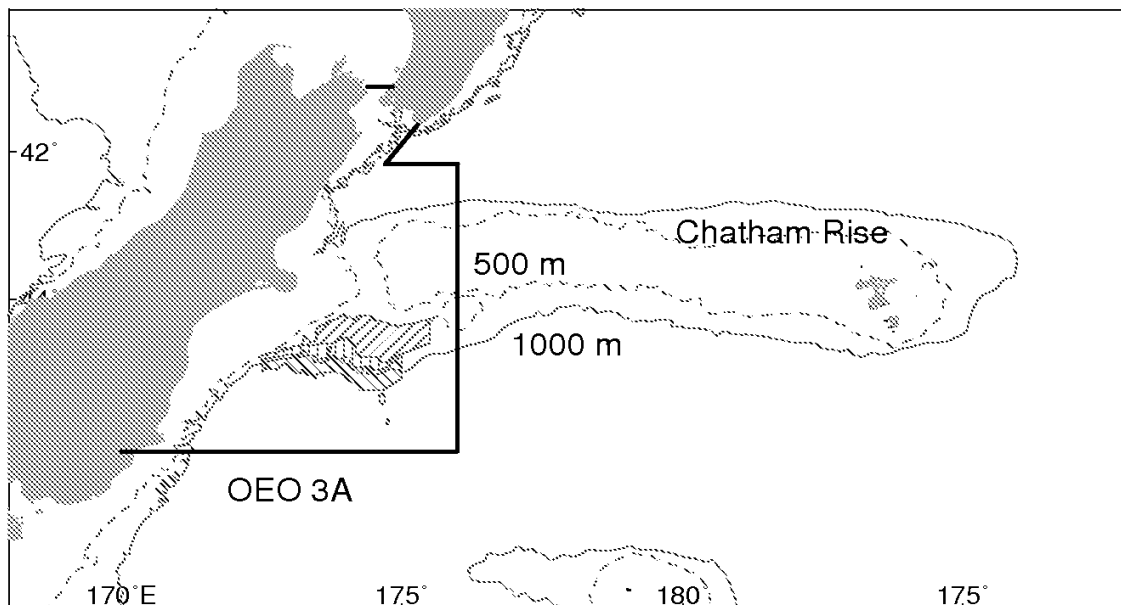


Figure 1: The three spatial areas used in the CASAL model and 2002 acoustic abundance survey. Area 1 at the top with right sloping shading; Area 2 in the middle with vertical shading; Area 3 at the bottom with left sloping shading. The thick dark line encloses management area OEO 3A.

The boundary between Areas 1 and 2 was defined in terms of the northern edge of the area that enclosed 90% of the total catch from the fishery. Areas 2 and 3 contained most of the fishery while Area 1 consisted of lightly fished and unfished ground. The boundary between Areas 2 and 3 was defined by the 32.5 cm contour in mean fish length for data before 1993 so that the fishery is split into an area containing smaller fish and another that has larger fish. The population outside the main fishery was assumed to follow the same relative dynamics.

Rejection of spatial model based on migration

The previous model reconciled the differences in commercial length distribution by using three areas. No age data were incorporated and instead lengths were used as a proxy for age. The dynamics were assumed to be recruitment in the shallow area (Area 1), with migration from Area 1 to Area 2, and also from Area 2 to Area 3, i.e., a one way movement to generally deeper water. The differences in the length distributions between areas drove the estimated migration rates by age. The stock assessment predicted that mature fish in the relatively unfished area (Area 1) comprised about 25% B_0 and so there were no sustainability concerns as this area was largely not fished.

To test the above migration hypothesis, otoliths sampled from acoustic survey mark identification trawls were aged and age distributions estimated for Area 1 and for the combined Areas 2 and 3 (Doonan, pers. comm.). The results showed deficiencies in the use of length data as a proxy for age in the stock assessment model. The age frequency in Area 1 was similar to that from Areas 2 and 3, but the model predicted them to be very different. Growth in Areas 2 and 3 appears to be faster than in Area 1 and this may drive the observed differences in length distributions. The migration model assumed the same growth in all areas. Maturity may be related to length rather than age, but it is age-based in the model. For these reasons, the Working Group rejected the stock assessment model in 2013. No formal stock assessment is presented here.

4.2.1 Estimates of fishery parameters and abundance

Catches by area

Catches were partitioned into the three areas by scaling up the estimated catch of black oreo from each area to the total reported catch (see tables 2 and 3 in the Fishery Summary section at the beginning of the Introduction – Oreos chapter) and are given in Table 1.

Table 1: Estimated black oreo catch (tonnes) for each fishing year in the three spatial model areas.

| Year | Area 1 | Area 2 | Area 3 | Total |
|---------|--------|--------|--------|--------|
| 1972–73 | 110 | 2 010 | 1 320 | †3 440 |
| 1973–74 | 130 | 2 214 | 1 456 | †3 800 |
| 1974–75 | 170 | 2 970 | 1 960 | †5 100 |
| 1975–76 | 40 | 736 | 484 | †1 260 |
| 1976–77 | 130 | 2 260 | 1 490 | †3 880 |
| 1977–78 | 190 | 3 350 | 2 210 | †5 750 |
| 1978–79 | 27 | 750 | 30 | 806 |
| 1979–80 | 39 | 2 189 | 4 762 | 6 990 |
| 1980–81 | 793 | 7 813 | 4 090 | 12 696 |
| 1981–82 | 12 | 7 616 | 3 851 | 11 479 |
| 1982–83 | 57 | 3 384 | 2 577 | 6 018 |
| 1983–84 | 682 | 5 925 | 3 192 | 9 800 |
| 1984–85 | 148 | 1 478 | 2 218 | 3 844 |
| 1985–86 | 13 | 814 | 1 112 | 1 938 |
| 1986–87 | 33 | 1 863 | 1 908 | 3 805 |
| 1987–88 | 49 | 2 399 | 1 439 | 3 888 |
| 1988–89 | 244 | 3 532 | 811 | 4 588 |
| 1989–90 | 696 | 1 164 | 1 288 | 3 148 |
| 1990–91 | 753 | 1 947 | 1 330 | 4 030 |
| 1991–92 | 289 | 1 250 | 1 816 | 3 355 |
| 1992–93 | 180 | 2 221 | 1 717 | 4 117 |
| 1993–94 | 339 | 2 509 | 1 353 | 4 200 |
| 1994–95 | 139 | 1 894 | 845 | 2 878 |
| 1995–96 | 231 | 2 744 | 1 099 | 4 074 |
| 1996–97 | 418 | 2 095 | 1 035 | 3 548 |
| 1997–98 | 257 | 874 | 1 267 | 2 397 |
| 1998–99 | 138 | 2 047 | 572 | 2 756 |
| 1999–00 | 133 | 2 246 | 906 | 3 285 |
| 2000–01 | 89 | 1 804 | 761 | 2 653 |
| 2001–02 | 58 | 1 447 | 620 | 2 126 |
| 2002–03 | 82 | 997 | 236 | 1 314 |
| 2003–04 | 233 | 775 | 464 | 1 471 |
| 2004–05 | 61 | 766 | 360 | 1 187 |
| 2005–06 | 55 | 1 315 | 312 | 1 682 |
| 2006–07 | 48 | 914 | 698 | 1 659 |
| 2007–08 | 53 | 926 | 629 | 1 607 |
| 2008–09 | 59 | 920 | 671 | 1 649 |
| 2009–10 | 115 | 973 | 885 | 1 973 |
| 2010–11 | 38 | 859 | 762 | 1 659 |
| 2011–12 | 31 | 534 | 910 | 1 475 |

† Soviet catch, assumed to be mostly from OEO 3A and to be 50:50 black oreo: smooth oreo.

Observer length frequencies by area

Catch at length data collected by observers in Areas 1, 2, and 3 were extracted from the *obs_lfs* database (Table 2). Derived length frequencies for each group were calculated from the sample length frequencies weighted by the catch weight of each sample.

Table 2: Number of observed commercial tows where black oreo was measured for length frequency. A total of 60 tows were excluded because they had fewer than 30 fish measured, extreme mean lengths or missing catch information.

| Year | Area 1 | Area 2 | Area 3 | Other |
|---------|--------|--------|--------|-------|
| 1985–86 | 0 | 1 | 0 | 0 |
| 1986–87 | 0 | 2 | 6 | 0 |
| 1987–88 | 0 | 6 | 3 | 0 |
| 1988–89 | 30 | 8 | 4 | 2 |
| 1989–90 | 12 | 6 | 1 | 0 |
| 1990–91 | 2 | 5 | 7 | 1 |
| 1991–92 | 0 | 10 | 1 | 0 |
| 1992–93 | 0 | 0 | 0 | 0 |
| 1993–94 | 8 | 16 | 2 | 5 |
| 1994–95 | 0 | 4 | 2 | 2 |
| 1995–96 | 2 | 3 | 2 | 6 |
| 1996–97 | 0 | 1 | 1 | 2 |
| 1997–98 | 13 | 2 | 5 | 0 |
| 1998–99 | 2 | 1 | 0 | 3 |
| 1999–00 | 7 | 94 | 11 | 6 |
| 2000–01 | 3 | 110 | 22 | 2 |
| 2001–02 | 8 | 23 | 8 | 5 |
| 2002–03 | 3 | 17 | 4 | 4 |
| 2003–04 | 9 | 1 | 2 | 3 |
| 2004–05 | 3 | 5 | 3 | 1 |
| 2005–06 | 0 | 38 | 7 | 7 |
| 2006–07 | 6 | 1 | 2 | 5 |
| 2007–08 | 0 | 9 | 5 | 7 |
| 2008–09 | 4 | 16 | 9 | 3 |
| 2009–10 | 4 | 14 | 4 | 2 |
| 2010–11 | 1 | 15 | 7 | 2 |
| 2011–12 | 3 | 6 | 1 | 0 |

Research acoustic survey length frequencies by area

The 1997, 2002, 2006 and 2011 acoustic survey abundance at length data were converted to a length frequency using the combined sexes fixed length-weight relationship (“unsexed” in table 1, Biology section above) to convert the abundance to numbers at length (Table 3).

Absolute abundance estimates from the 1997, 2002, 2006 and 2011 acoustic surveys

Absolute estimates of abundance for black oreo are available from four acoustic surveys of oreos carried out from 10 November to 19 December 1997 (TAN9713), 25 September to 7 October 2002 (TAN0213), 17–30 October 2006 (TAN0615) and 17 November to 1 December 2011 (SWA1102). The 1997 survey covered the “flat” with a series of random north-south transects over six strata at depths of 600–1200 m. Seamounts were also sampled using parallel and “starburst” transects. Targeted and some random (background) trawling was carried out to identify targets and to determine species composition. The 2002 survey was limited to flat ground with 77 acoustic transect and 21 mark identification tows completed. The 2006 (78 transects and 22 tows) and 2011 (72 transects and 25 tows) surveys were very similar to the 2002 survey and covered the main area of the black oreo fishery. The estimated total abundance (immature plus mature) for each survey by area is shown in Table 4.

Relative abundance estimates from standardised CPUE analysis

Standardised CPUE indices were obtained for each area. Because of the apparent changes in fishing practice attributable to the introduction of GPS, the data were split into pre- and post-GPS series. There were also major changes in the fishery from 1998–99 to 2001–02 when there were TACC reductions and the start of a voluntary industry catch limit on smooth oreo (1998–99). Two post-GPS series were therefore developed. The first of these was from 1992–93 to 1997–98 (early series) and the second was from 2002–03 onwards (late series) with data from the intervening years ignored. Since there are no new data for either the pre-GPS series or the post-GPS early series, these are left unchanged from previous standardisation results. Only the post-GPS late series is updated here, using data that extends from 2002–03 to 2011–12.

Table 3: Research length frequency proportions for the model area for the 1997, 2002, 2006 and 2011 acoustic surveys. - no data for 1997 to 2006, lengths below 25 cm and greater than 38 were pooled.

| Length (cm) | 1997 | | | 2002 | | | 2006 | | | 2011 | | |
|-------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| | Area 1 | Area 2 | Area 3 | Area 1 | Area 2 | Area 3 | Area 1 | Area 2 | Area 3 | Area 1 | Area 2 | Area 3 |
| 22 | - | - | - | - | - | - | - | - | - | 0.001 | 0.001 | 0.000 |
| 23 | - | - | - | - | - | - | - | - | - | 0.007 | 0.008 | 0.002 |
| 24 | - | - | - | - | - | - | - | - | - | 0.021 | 0.019 | 0.007 |
| 25 | 0.015 | 0.013 | 0.009 | 0.022 | 0.016 | 0.008 | 0.009 | 0.017 | 0.015 | 0.031 | 0.029 | 0.010 |
| 26 | 0.035 | 0.027 | 0.019 | 0.039 | 0.030 | 0.013 | 0.026 | 0.035 | 0.032 | 0.027 | 0.027 | 0.019 |
| 27 | 0.113 | 0.061 | 0.029 | 0.051 | 0.038 | 0.018 | 0.066 | 0.073 | 0.055 | 0.044 | 0.047 | 0.032 |
| 28 | 0.165 | 0.090 | 0.038 | 0.085 | 0.062 | 0.029 | 0.118 | 0.105 | 0.077 | 0.083 | 0.086 | 0.055 |
| 29 | 0.153 | 0.104 | 0.064 | 0.117 | 0.091 | 0.044 | 0.152 | 0.143 | 0.113 | 0.112 | 0.114 | 0.072 |
| 30 | 0.143 | 0.105 | 0.065 | 0.139 | 0.119 | 0.060 | 0.175 | 0.153 | 0.132 | 0.153 | 0.154 | 0.107 |
| 31 | 0.131 | 0.119 | 0.089 | 0.123 | 0.122 | 0.086 | 0.156 | 0.157 | 0.154 | 0.159 | 0.157 | 0.125 |
| 32 | 0.102 | 0.121 | 0.105 | 0.137 | 0.133 | 0.127 | 0.117 | 0.136 | 0.169 | 0.121 | 0.119 | 0.153 |
| 33 | 0.046 | 0.094 | 0.098 | 0.112 | 0.123 | 0.141 | 0.073 | 0.089 | 0.119 | 0.121 | 0.118 | 0.175 |
| 34 | 0.041 | 0.086 | 0.097 | 0.065 | 0.084 | 0.138 | 0.059 | 0.056 | 0.076 | 0.069 | 0.067 | 0.126 |
| 35 | 0.029 | 0.058 | 0.083 | 0.054 | 0.064 | 0.100 | 0.032 | 0.026 | 0.037 | 0.026 | 0.029 | 0.057 |
| 36 | 0.015 | 0.043 | 0.091 | 0.021 | 0.052 | 0.104 | 0.014 | 0.009 | 0.014 | 0.018 | 0.018 | 0.034 |
| 37 | 0.006 | 0.037 | 0.080 | 0.015 | 0.025 | 0.049 | 0.001 | 0.001 | 0.004 | 0.005 | 0.005 | 0.018 |
| 38 | 0.006 | 0.042 | 0.131 | 0.020 | 0.041 | 0.083 | 0.003 | 0.001 | 0.003 | 0.002 | 0.002 | 0.005 |
| 39 | - | - | - | - | - | - | - | - | - | 0.000 | 0.000 | 0.002 |
| 40 | - | - | - | - | - | - | - | - | - | 0.000 | 0.000 | 0.000 |
| 41 | - | - | - | - | - | - | - | - | - | 0.000 | 0.000 | 0.000 |
| 42 | - | - | - | - | - | - | - | - | - | 0.000 | 0.000 | 0.000 |

Table 4: Total (immature plus mature) black oreo abundance estimates (t) and CVs for the 1997, 2002, 2006 and 2011 acoustic surveys for the three model areas in OEO 3A.

| Acoustic survey | Area 1 | Area 2 | Area 3 | Total |
|-----------------|--------------|-------------|------------|--------------|
| 1997 | 148 000 (29) | 10 000 (26) | 5 240 (25) | 163 000 (26) |
| 2002 | 43 300 (31) | 15 400 (27) | 4 710 (38) | 64 000 (22) |
| 2006 | 56 400 (37) | 16 400 (30) | 5 880 (34) | 78 700 (30) |
| 2011 | 138 100 (27) | 36 800 (30) | 7 400 (34) | 182 300 (25) |

Only data within a pre-defined spatial area were considered useful for assessing abundance (Figure 2).

Quota management area: OEO3A

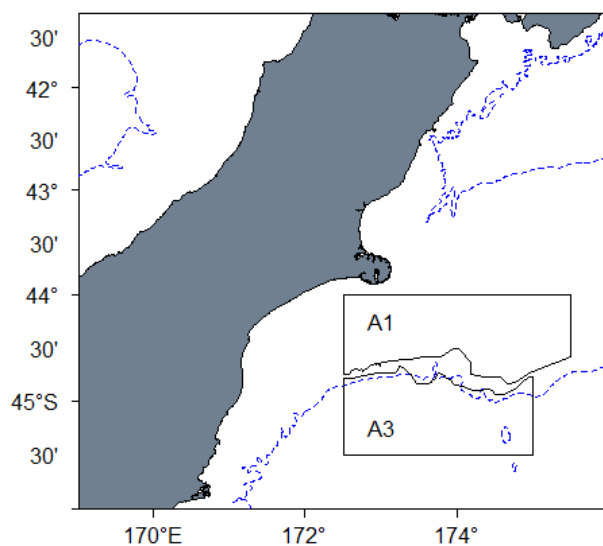


Figure 2: Spatial areas from which CPUE data were collected for inclusion in the standardisation. Areas A1 and A3 are shown, with A2 being the area between the two.

This area corresponds to the main fishing area and overlaps with the acoustic survey area (Figure 1). Tows were initially selected for inclusion in the CPUE standardisation if they targeted or caught black oreo within this area.

Uncertainty was assessed by bootstrapping the data, re-estimating the indices for each iteration, and estimating the coefficient of variation (CV) for each year/area from this distribution. The indices and CV estimates are listed in Table 5 and shown in Figure 3.

Table 5: OEO 3A black oreo pre-GPS and post-GPS time series of standardised catch per unit effort indices and bootstrapped CV estimates (%). Values for each series have been renormalized to a geometric mean of one. -, no estimate.

| Fishing Year | Pre-GPS | | | | | | Post-GPS | | | | | |
|-----------------|---------|----|-------|----|-------|-----|----------|----|-------|----|-------|----|
| | Area1 | | Area2 | | Area3 | | Area1 | | Area2 | | Area3 | |
| | Index | CV | Index | CV | Index | CV | Index | CV | Index | CV | Index | CV |
| 1979–80 | - | - | 1.45 | 39 | 1.52 | 125 | - | - | - | - | - | - |
| 1980–81 | - | - | 1.84 | 17 | 2.55 | 15 | - | - | - | - | - | - |
| 1981–82 | - | - | 1.71 | 22 | 2.15 | 9 | - | - | - | - | - | - |
| 1982–83 | - | - | 1.41 | 8 | 1.80 | 14 | - | - | - | - | - | - |
| 1983–84 | - | - | 0.99 | 8 | 1.04 | 19 | - | - | - | - | - | - |
| 1984–85 | - | - | 0.95 | 27 | 0.99 | 12 | - | - | - | - | - | - |
| 1985–86 | - | - | 0.63 | 31 | 0.66 | 33 | - | - | - | - | - | - |
| 1986–87 | - | - | 0.81 | 22 | 0.88 | 36 | - | - | - | - | - | - |
| 1987–88 | - | - | 0.45 | 20 | 0.49 | 23 | - | - | - | - | - | - |
| 1988–89 | - | - | 0.72 | 21 | 0.23 | 44 | - | - | - | - | - | - |
| 1989–90 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1990–91 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1991–92 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1992–93 | - | - | - | - | - | - | - | - | 1.62 | 14 | 2.46 | 20 |
| 1993–94 | - | - | - | - | - | - | - | - | 1.17 | 17 | 1.20 | 15 |
| 1994–95 | - | - | - | - | - | - | - | - | 0.96 | 13 | 0.82 | 17 |
| 1995–96 | - | - | - | - | - | - | - | - | 0.89 | 15 | 0.68 | 22 |
| 1996–97 | - | - | - | - | - | - | - | - | 1.06 | 18 | 0.96 | 17 |
| 1997–98 | - | - | - | - | - | - | - | - | 0.58 | 47 | 0.64 | 63 |
| 1998–99 | - | - | - | - | - | - | - | - | - | - | - | - |
| 1999–00 | - | - | - | - | - | - | - | - | - | - | - | - |
| 2000–01 | - | - | - | - | - | - | - | - | - | - | - | - |
| 2001–02 | - | - | - | - | - | - | - | - | - | - | - | - |
| 2002–03 | - | - | - | - | - | - | 0.62 | 90 | 1.11 | 24 | 0.9 | 38 |
| 2003–04 | - | - | - | - | - | - | 0.99 | 45 | 1.15 | 27 | 1.05 | 37 |
| 2004–05 | - | - | - | - | - | - | 1.33 | 63 | 0.85 | 32 | 0.8 | 56 |
| 2005–06 | - | - | - | - | - | - | 1.1 | 63 | 1.34 | 23 | 0.99 | 31 |
| 2006–07 | - | - | - | - | - | - | 0.51 | 78 | 1.05 | 27 | 1.49 | 24 |
| 2007–08 | - | - | - | - | - | - | 1.52 | 44 | 0.67 | 66 | 0.84 | 33 |
| 2008–09 | - | - | - | - | - | - | 0.65 | 73 | 0.84 | 44 | 0.75 | 30 |
| 2009–10 | - | - | - | - | - | - | 1.17 | 29 | 1.02 | 26 | 1.06 | 30 |
| 2010–11 | - | - | - | - | - | - | 1.38 | 52 | 0.89 | 30 | 0.9 | 22 |
| 2011–12 | - | - | - | - | - | - | 1.37 | 44 | 1.28 | 24 | 1.49 | 18 |

4.3 Smooth oreo

2009 assessment

The stock assessment analyses were conducted using the CASAL age-structured population model employing Bayesian statistical techniques. The 2005 assessment was updated by including five more years of catch, CPUE and observer length data, and used two new series of post-GPS standardised CPUE, one before and the second after major TACC and catch limit changes. The modelling took account of the sex and maturity status of the fish and treated OEO 3A as a single smooth oreo fishery, i.e., no sub-areas were recognised. The base case model used the 1997 absolute acoustic abundance estimate, pre-GPS and early and late post-GPS series of standardised CPUE indices, and the mean natural mortality estimate (0.063 yr⁻¹). Acoustic and observer length frequencies were used in a preliminary model run to estimate selectivity and the base case fixed these selectivity estimates but did not use the length frequencies. Other cases investigated the sensitivity of the model to data sources including:

- Use of the upper and lower 95% confidence interval values for estimates of natural mortality (0.042–0.099 yr⁻¹);
- Use of only the left hand limb of the 1994 observer length frequency (plus the 1997 acoustic survey length frequency) with growth not estimated by the model.

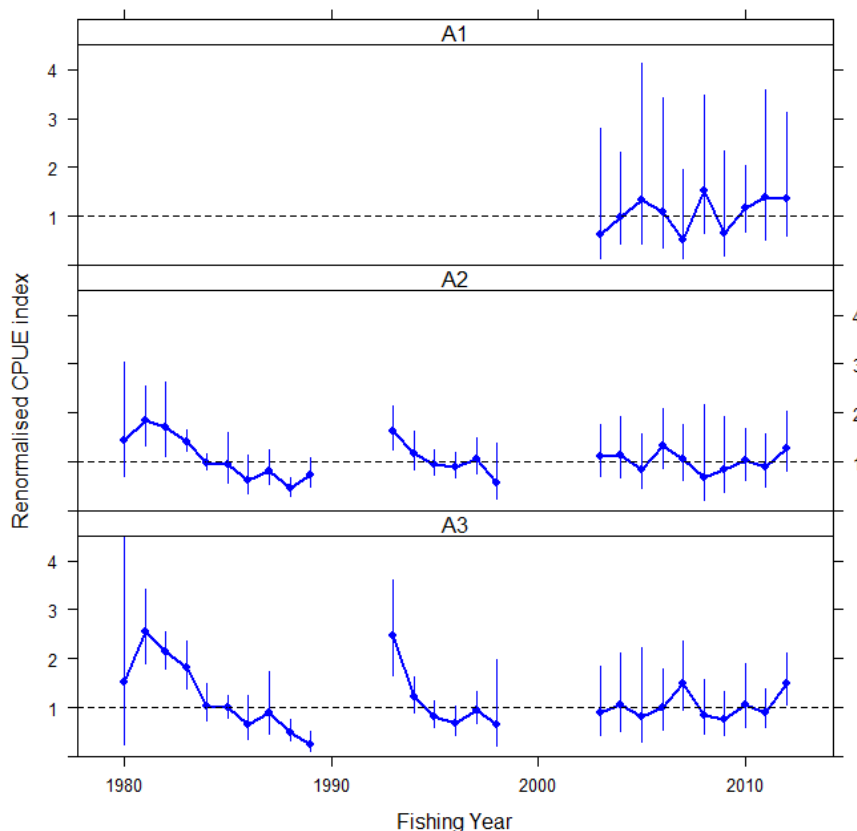


Figure 3: Standardised commercial CPUE series for black oreo in each area within OEO 3A. Pre-GPS and post-GPS (early and late) series are shown, each renormalized to a geometric mean of one. Error bars represent the 95% confidence intervals assuming a lognormal error distribution and using the CVs listed in Table 5.

4.3.1 Estimates of fishery parameters and abundance

Catch history

The estimated catches were scaled up to the total reported catch (see tables 2 and 3 in the Fishery Summary section at the beginning of the Introduction – Oreos chapter) and are given in Table 6.

Table 6: Reconstructed catch history (t)

| Year | Catch | Year | Catch | Year | Catch | Year | Catch |
|---------|--------|---------|-------|---------|-------|---------|-------|
| 1972–73 | †3 440 | 1981–82 | 1 288 | 1990–91 | 5 054 | 1999–00 | 1 789 |
| 1973–74 | †3 800 | 1982–83 | 2 495 | 1991–92 | 6 622 | 2000–01 | 1 621 |
| 1974–75 | †5 100 | 1983–84 | 3 979 | 1992–93 | 4 334 | 2001–02 | 1 673 |
| 1975–76 | †1 260 | 1984–85 | 4 351 | 1993–94 | 4 942 | 2002–03 | 1 412 |
| 1976–77 | †3 880 | 1985–86 | 3 142 | 1994–95 | 4 199 | 2003–04 | 1 254 |
| 1977–78 | †5 750 | 1986–87 | 3 190 | 1995–96 | 4 022 | 2004–05 | 1 457 |
| 1978–79 | 650 | 1987–88 | 5 905 | 1996–97 | 3 239 | 2005–06 | 1 445 |
| 1979–80 | 5 215 | 1988–89 | 6 963 | 1997–98 | 4 733 | 2006–07 | 1 306 |
| 1980–81 | 2 196 | 1989–90 | 6 459 | 1998–99 | 2 474 | 2007–08 | 1 526 |

† Soviet catch, assumed to be mostly from OEO 3A and to be 50:50 black oreo:smooth oreo.

Observer length frequencies

Observer length data were extracted from the observer database. These data represent proportional catch at length and sex. All length samples were from the CPUE study area (see Figure 4). Only samples where 30 or more fish were measured, and the catch weight and a valid depth were recorded, were included in the analysis. Data from adjacent years were pooled because of the paucity of data in some years. The pooled length frequencies were applied in the model at the year that the median observation of the grouped samples was taken (Table 7).

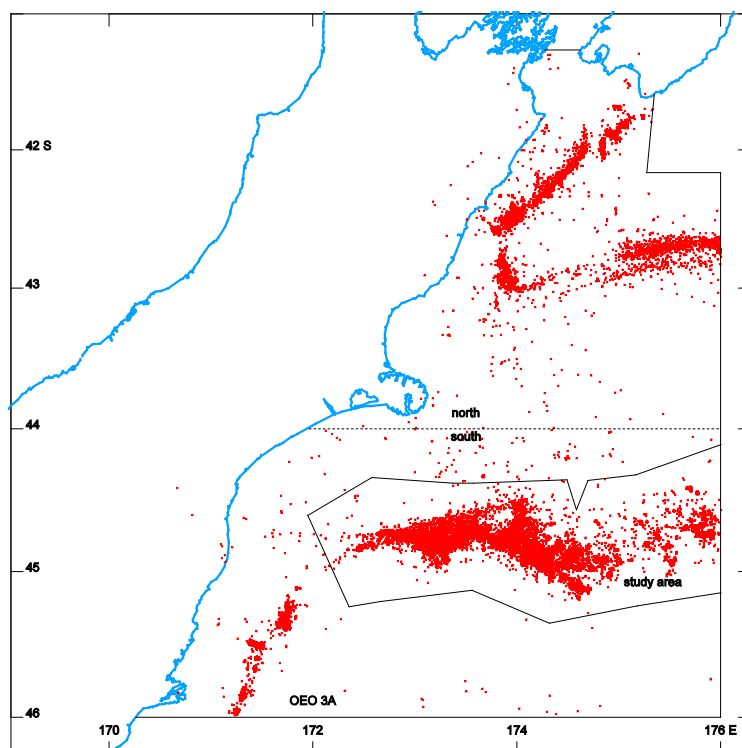


Figure 4: Locations of all tows in OEO 3A with a reported catch of smooth oreo from 1979–80 to 2002–03 (dots). The study area is shown along with the line chosen to split north from south Chatham rise catches.

Table 7: Observer length frequencies; numbers of length samples (tows sampled), number of fish measured, groups of pooled years, and the year that the length data were applied in the stock assessment model. -, not applicable.

| Year | Number of length samples | Number of fish measured | Year group code | Year the grouped data were applied |
|---------|--------------------------|-------------------------|-----------------|------------------------------------|
| 1979–80 | 32 | 3 499 | 1 | Applied |
| 1980–81 | 0 | 0 | - | - |
| 1981–82 | 0 | 0 | - | - |
| 1982–83 | 0 | 0 | - | - |
| 1983–84 | 0 | 0 | - | - |
| 1984–85 | 0 | 0 | - | - |
| 1985–86 | 1 | 106 | 2 | - |
| 1986–87 | 4 | 387 | 2 | - |
| 1987–88 | 10 | 1 300 | 2 | Applied |
| 1988–89 | 14 | 1 512 | 2 | - |
| 1989–90 | 0 | 0 | - | - |
| 1991–92 | 9 | 919 | 3 | - |
| 1992–93 | 0 | 0 | - | - |
| 1993–94 | 13 | 1 365 | 4 | Applied |
| 1994–95 | 7 | 752 | 4 | - |
| 1995–96 | 2 | 207 | 4 | - |
| 1996–97 | 3 | 365 | 5 | - |
| 1997–98 | 13 | 1 720 | 5 | - |
| 1998–99 | 5 | 770 | 5 | - |
| 1999–00 | 77 | 7 595 | 5 | Applied |
| 2000–01 | 93 | 9 389 | 6 | Applied |
| 2001–02 | 20 | 3 030 | 7 | Applied |
| 2002–03 | 14 | 1 427 | 8 | Applied |
| 2003–04 | 4 | 321 | 8 | - |
| 2004–05 | 9 | 840 | 8 | - |
| 2005–06 | 26 | 3 207 | 9 | Applied |
| 2006–07 | 2 | 205 | 9 | - |
| 2007–08 | 8 | 816 | 9 | - |

Length frequency data from the 1997 acoustic survey

Length data collected during the 1997 survey were used to generate a population length frequency by sex. A length frequency was generated from the trawls in each mark-type and also for the seamounts. These frequencies were combined using the fraction of smooth oreo abundance in each mark-type. The overall frequency was normalised over both male and female frequencies so that the sum of the frequencies over both sexes was 100%. The CV for each length class was given by the regression, $\log(\text{CV}) = 0.86 + 8.75/\log(\text{proportion})$. This regression was estimated from the CVs obtained by

bootstrapping the data and provides a smoothed estimate of the CVs. The estimated length frequency is in Figure 5.

Absolute abundance estimates from the 1997 acoustic survey

Absolute estimates of abundance for smooth oreo are available from the acoustic survey on oreos carried out from 10 November to 19 December 1997 (TAN9713) using the same approach as described for OEO 3A black oreo. The abundance estimates used in the 1999 OEO 3A smooth oreo assessment were revised in 2005 using new target strength estimates for smooth oreo, black oreo and a number of bycatch species. The revised estimate was 25 200 t with a CV of 23% (the 1999 estimate was 35 100 t with a CV of 27%). There is uncertainty in the estimates of biomass because the acoustic estimate includes smooth oreo in layers that are a mixture of species for which the acoustic method has potential bias problems.

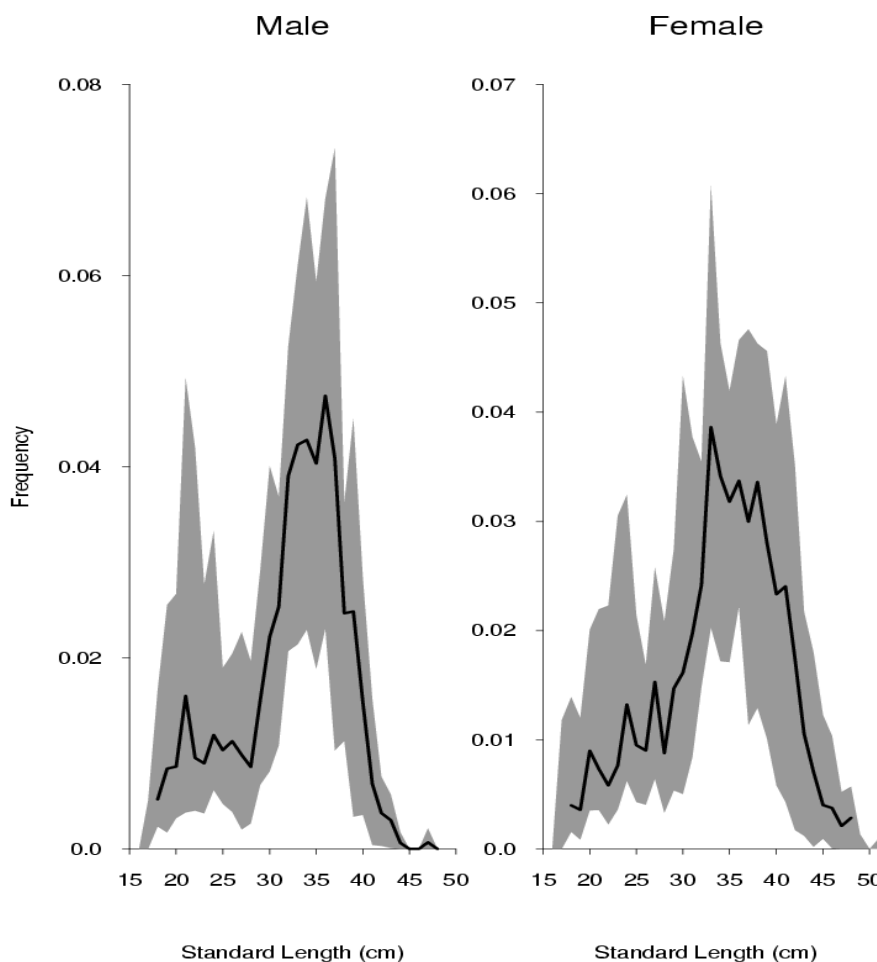


Figure 5: Population length frequency derived from the 1997 acoustic survey data. The bold line is the estimated value and the shaded area is the spread from 300 bootstraps.

Relative abundance estimates from standardised CPUE analysis

The CPUE study area is shown in Figure 4. Three analyses were carried out; a pre-GPS analysis (unchanged from 2005) that included data from 1980–81 to 1988–89 and two post-GPS analyses that included data from 1992–93 to 1997–98 and 2002–03 to 2007–08. The years from 1998–99 to 2001–02 were not included because a voluntary smooth oreo catch limit (1400 t) was introduced and substantial oreo TACC reductions were made during that time (6600 down to 3100 t). The pre-GPS series shows a downward trend, and declines to approximately a third of the initial level over the nine-year period. The early post-GPS also has a downward trend but the late post-GPS series has an upward trend and then flattens out. The base case stock assessment used all three indices (Table 8).

Fishing Industry members of the Deepwater Fishery Assessment Working Group expressed concern about the accuracy of the historical Soviet catch and effort data (pre-GPS series) and felt that it was inappropriate to use those data in the stock assessment.

Table 8: CPUE indices by year and jackknife CV (%) estimates from the pre-GPS and the two post-GPS analyses.

| Year | Pre-GPS | | | Year | Index | CV | Post-GPS | | |
|---------|---------|----|---------|------|-------|---------|----------|----|--|
| | Index | CV | Year | | | | Index | CV | |
| 1980–81 | 1.00 | 27 | 1992–93 | 1.00 | 24 | 2002–03 | 0.55 | 23 | |
| 1981–82 | 0.82 | 26 | 1993–94 | 0.88 | 11 | 2003–04 | 0.77 | 22 | |
| 1982–83 | 0.72 | 62 | 1994–95 | 0.74 | 14 | 2004–05 | 0.99 | 22 | |
| 1983–84 | 0.59 | 61 | 1995–96 | 0.48 | 17 | 2005–06 | 0.96 | 31 | |
| 1984–85 | 0.72 | 22 | 1996–97 | 0.56 | 15 | 2006–07 | 1.00 | 20 | |
| 1985–86 | 0.61 | 19 | 1997–98 | 0.50 | 19 | 2007–08 | 0.92 | 21 | |
| 1986–87 | 0.46 | 16 | | | | | | | |
| 1987–88 | 0.42 | 16 | | | | | | | |
| 1988–89 | 0.26 | 28 | | | | | | | |

4.3.2 Biomass estimates

The posterior distributions from the MCMC on the base case are shown in Figure 6. The probability that the current mature biomass (2008–09) and the biomass 5 years out (2013–14) are above 20% B_0 is 1 for both.

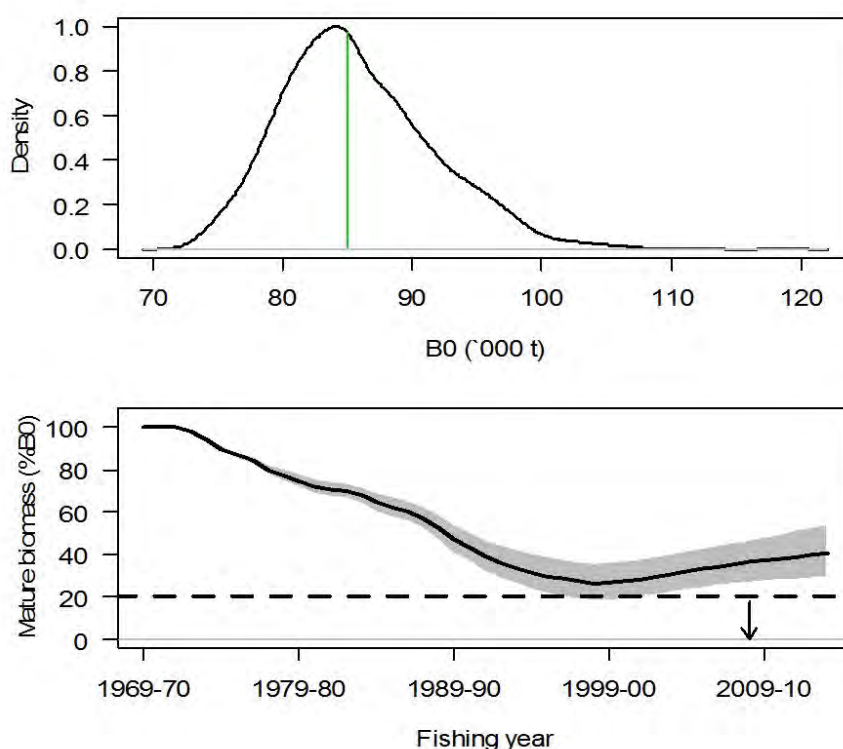


Figure 6: Smooth oreo OEO 3A: posterior distribution for the virgin biomass (top plot) and the mature biomass trajectories as a percentage of virgin biomass (bottom plot) from the MCMC analysis of the “NoLF” case with $M = 0.063$ (base case). In the top plot, the vertical line is the median of the distribution. In the bottom plot, the grey area is the point-wise 95% confidence intervals of the trajectories and the solid line is the median.

Biomass estimates derived from the MCMC are in Table 9. Total mature biomass for 2008–09 was estimated to be 36% of the initial biomass (B_0). Sensitivity case results for the base case using the lower and upper 95% confidence interval value estimates for M gave estimates of current biomass between 26% and 49% of B_0 . The sensitivity case that used the left hand limb of the 1994 observer length frequency (plus the 1997 acoustic survey length frequency) with growth not estimated by the model gave estimates of current biomass for the mean estimate of M (0.063 yr^{-1}) of 30 % of B_0 while estimates using the lower and upper 95% confidence interval value estimates for M gave estimates of 2008 biomass between 12% and 59% of B_0 .

Projections were carried out for five years with the current catch limit of 1400 t. The trajectory shows increasing biomass (Figure 6).

Table 9 (a): Base case (in bold) and sensitivity to M values (biomass estimates). Bcurr is 2008.

| | <i>M</i> = 0.063 | | | <i>M</i> = 0.042 | | | <i>M</i> = 0.099 | | |
|--|-------------------------|---------------|---------------|-------------------------|--------|---------|-------------------------|--------|--------|
| | Median | CI.05 | CI.95 | Median | CI.05 | CI.95 | Median | CI.05 | CI.95 |
| <i>B₀</i> | 85 000 | 77 300 | 96 500 | 97 700 | 90 100 | 110 000 | 68 500 | 60 300 | 79 600 |
| <i>B_{cur}</i> | 30 900 | 22 400 | 43 000 | 26 300 | 18 000 | 38 800 | 33 800 | 25 000 | 45 500 |
| <i>B_{cur}</i> (% <i>B₀</i>) | 36 | 29 | 45 | 27 | 20 | 35 | 49 | 41 | 57 |

(b) Sensitivity (biomass estimates). In these runs the left hand limb of the 1994 observer length was fitted, the 1997 acoustic survey length frequency was included and growth was not estimated by the model:

| | <i>M</i> = 0.063 | | | <i>M</i> = 0.042 | | | <i>M</i> = 0.099 | | |
|--|-------------------------|--------|--------|-------------------------|--------|--------|-------------------------|--------|--------|
| | Median | CI.05 | CI.95 | Median | CI.05 | CI.95 | Median | CI.05 | CI.95 |
| <i>B₀</i> | 77 400 | 74 800 | 80 200 | 82 800 | 81 600 | 84 200 | 82 300 | 76 700 | 89 200 |
| <i>B_{cur}</i> | 23 100 | 19 900 | 26 400 | 10 200 | 8 480 | 12 100 | 48 800 | 42 900 | 56 200 |
| <i>B_{cur}</i> (% <i>B₀</i>) | 30 | 27 | 33 | 12 | 10 | 14 | 59 | 56 | 63 |

4.3.3 Other factors

Because of differences in biological parameters between the species, it would be appropriate to split the current TACC for black oreo and smooth oreo. The WG noted that separate species catch limits are in place to reduce the risk of over- or under-fishing either smooth oreo or black oreo.

The model estimates of uncertainty are unrealistically low. Uncertainties that are not included in the model include:

- the assumption that recruitment is deterministic;
- that the acoustic index is assumed to be an absolute estimate of abundance;
- the selectivity in the base case is fixed at the MPD estimate from the preliminary case where all length data is used;
- uncertainty in the estimate of *M*.

In addition, the growth is fixed and known. The WG has previously noted the impact of the different ages of maturity for males and females. Due to the fact that males mature at a much smaller size than females (age at 50% maturity is 18–19 years for males and 25–26 for females), the sex ratio needs to be taken into account when assessing the sustainability of any particular catch level.

5. STATUS OF THE STOCKS

The smooth oreo stock assessment is unchanged from 2009. The black oreo stock assessment is updated using CPUE data up to 2011–12.

Stock Structure Assumptions

The two oreo stocks in FMA 3A are assessed separately but managed as a single stock. For both the black oreo and smooth oreo stocks it is assumed that there is potential mixing with stocks outside of the OEO 3A area.

- **OEO 3A (Black Oreo)**

| Stock Status | |
|-----------------------------------|--|
| Year of Most Recent Assessment | 2013 |
| Assessment Runs Presented | Age-structured CASAL spatial assessment model rejected by the Working Group; CPUE accepted |
| Reference Points | Target: 40% <i>B₀</i> Soft Limit: 20% <i>B₀</i> Hard Limit: 10% <i>B₀</i> Overfishing threshold: <i>F_{40%B₀}</i> |
| Status in relation to Target | Unknown |
| Status in relation to Limits | Unknown |
| Status in relation to Overfishing | Unknown |

| |
|--|
| Historical Stock Status Trajectory and Current Status |
| - |

| | |
|--|---|
| Fishery and Stock Trends | |
| Recent Trend in Biomass or Proxy | Unknown |
| Recent Trend in Fishing Intensity or Proxy | Catch has decreased with TACC since the early 1990s and remained low and relatively constant over the last 10 years. |
| Other Abundance Indices | CPUE since 2002–03 has stabilised in all three areas after significant declines in the two deeper areas in the 1980s and 1990s. |
| Trends in Other Relevant Indicators or Variables | - |

| | |
|---|--|
| Projections and Prognosis | |
| Stock Projections or Prognosis | - |
| Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits | Soft Limit: Unknown Hard Limit: Unknown |
| Probability of Current Catch or TACC causing Overfishing to continue or to commence | Unknown |

| | |
|--|---|
| Assessment Methodology and Evaluation | |
| Assessment Type | Level 2 – Partial Quantitative Stock Assessment |
| Assessment Method | CPUE |
| Assessment Dates | Latest assessment: 2013 Next assessment: 2019 |
| Overall assessment quality rank | 1 – High Quality |
| Main data inputs (rank) | CPUE abundance 1 – High Quality |
| Data not used (rank) | |
| Changes to Model Structure and Assumptions | The three area model with migration based on age is thought to be flawed and the previous model has been withdrawn. |
| Major Sources of Uncertainty | - |

| |
|----------------------------|
| Qualifying Comments |
| - |

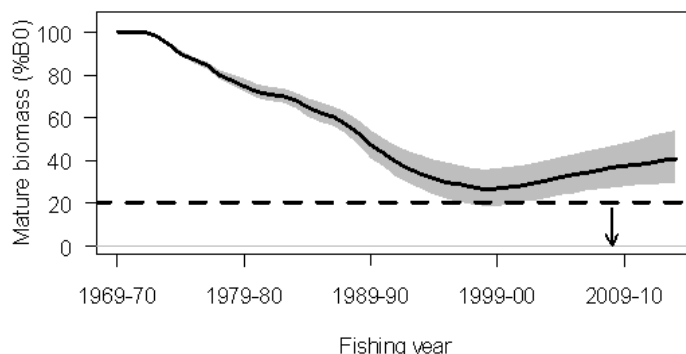
| |
|--|
| Fishery Interactions |
| Both species of oreo are sometimes taken as bycatch in orange roughy target fisheries, mostly in other areas e.g. OEO 4. The main bycatch species in the OEO 3A black oreo target fishery include smooth oreo, hoki, javelinfish, Baxter’s dogfish, pale ghost shark, ridge scaled rattail, and basketwork eel. Bycatch species that may be vulnerable to overfishing include deepwater sharks and rays. Protected species catches include seabirds and deepwater corals. Oreos are caught using bottom trawl gear. Bottom trawling interacts with benthic habitats. |

- **OEO 3A (Smooth Oreos)**

| | |
|--------------------------------|---|
| Stock Status | |
| Year of Most Recent Assessment | 2009 |
| Assessment Runs Presented | One base case and 5 sensitivity runs |
| Reference Points | Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0 Overfishing threshold: |

| | |
|------------------------------|--|
| Status in relation to Target | For the base case, B_{2009} was estimated at 36% B_0 , About as Likely as Not (40–60%) to be at or above the target. |
| Status in relation to Limits | B_{2009} is Unlikely (< 40%) to be below the Soft Limit and Very Unlikely (< 10%) to be below the Hard Limit. |

Historical Stock Status Trajectory and Current Status



Mature biomass trajectories as a percentage of virgin biomass from the base case. The grey area is the point-wise 95% confidence intervals of the trajectories and the solid line is the median.

| Fishery and Stock Trends | |
|--|--|
| Recent Trend in Biomass or Proxy | Biomass is projected to have been increasing since the late 1990s. |
| Recent Trend in Fishing Mortality or Proxy | Unknown |
| Other Abundance Indices | - |
| Trends in Other Relevant Indicators or Variables | - |

| Projections and Prognosis (2009) | |
|---|--|
| Stock Projections or Prognosis | The biomass is expected to increase over the next 5 years given the current catch limit of 1400 t. |
| Probability of Current Catch or TACC causing Biomass to remain below or to decline below Limits | Soft Limit: Very Unlikely (< 10%) Hard Limit: Very Unlikely (< 10%) |
| Probability of Current Catch or TACC causing Overfishing to continue or to commence | - |

| Assessment Methodology | |
|--|--|
| Assessment Type | Level 1 - Quantitative stock assessment |
| Assessment Method | Age-structured CASAL model with Bayesian estimation of posterior distributions |
| Assessment dates | Latest assessment: 2009 Next assessment: Unknown |
| Overall assessment quality rank | - |
| Main data inputs (rank) | - One acoustic absolute abundance estimate (1997) - three standardised CPUE indices (1981–82 to 1988–89, 1992–93 to 1997–98, 2002–03 to 2007–08) - Natural mortality estimate (0.063) - Selectivity estimated from acoustic and observer length frequencies New information from previous (2005) assessment: - Updated with additional catch, CPUE, observer length data collected since last assessment - two new standardised post-GPS CPUE series |
| Changes to Model Structure and Assumptions | - |

| | |
|------------------------------|--|
| Major Sources of Uncertainty | <ul style="list-style-type: none"> - The single acoustic index (1997) is assumed to be an absolute estimate of abundance - Sex ratio needs to be taken into account, as males mature at a much smaller size than females. - Recruitment is assumed to be deterministic. - Uncertainty in the estimates of natural mortality (M) - Selectivity is fixed in the base case at the MPD estimate from the preliminary study |
|------------------------------|--|

| | |
|----------------------------|---|
| Qualifying Comments | |
| | - |

| | |
|-----------------------------|---|
| Fishery Interactions | <p>Both species of oreo are sometimes taken as bycatch in orange roughy target fisheries, mostly in other areas e.g. OEO 4. The main bycatch species in the OEO 3A smooth oreo target fishery include black oreo, hoki, javelinfish, Baxter’s dogfish, pale ghost shark, ridge scaled rattail and basketwork eel. Low productivity bycatch species include deepwater sharks and rays. Protected species catches include seabirds and deepwater corals. Oreos are caught using bottom trawl gear. Bottom trawling interacts with benthic habitats.</p> |
|-----------------------------|---|

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