OREOS – OEO 3A BLACK OREO AND SMOOTH OREO

1. FISHERY SUMMARY

This is presented in the Fishery Summary section at the beginning of the Oreos report.

2. BIOLOGY

This is presented in the Biology section at the beginning of the Oreos report.

3. STOCKS AND AREAS

This is presented in the Stocks and Areas section at the beginning of the Oreos report.

4. STOCK ASSESSMENT

The smooth oreo stock assessment is unchanged from 2009. The black oreo stock assessment is updated with the 2008 assessment.

4.1 Introduction

The following assumptions were made in the stock assessment analyses carried out by NIWA 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) Varying the maximum fishing mortality (F_{MAX}) from 0.5 to 3.5 altered B_0 for smooth oreo in OEO 3A by only about 6% in the 1996 assessment, so only one assumed value (0.9) was used in all the analysis of OEO 3A smooth oreo. Only one assumed value (0.67) for the maximum exploitation rate (E_{MAX}) was used in the NIWA OEO 3A black oreo analysis.
(e) Recruitment was deterministic and followed a Beverton & 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 assessment was updated in 2008 and used new absolute abundance estimates and length data from the 2006 acoustic survey, a revised maturity ogive, revised and updated catch history, relative abundance estimates from an updated and revised post-GPS standardised CPUE analyses, and revised observer length frequencies. This replaced the 2004 assessment.

The population was modelled using three spatial areas to cope with the spatial structure observed in the catch and length data. The three spatial areas included: a northern area that contained small fish and was generally shallow (Area 1), a southern area that contained large fish and was generally deeper (Area 3), and a transition area (Area 2) that lay between Areas 1 and 3. Age dependant migration was allowed in the model to move the fish between the areas.

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

NIWA CASAL spatial model

An age structured, CASAL model employing Bayesian statistical techniques was used, The model assumed Baranov fishing mortality, but had a maximum exploitation rate (0.80) instead of a maximum instantaneous fishing mortality. A revised maturity ogive was estimated outside the model. Deterministic recruitment was assumed. Fish recruit to the population at age one.

The model estimated initial recruitment (mid-water only), the c.v. of the length-at-age, migration parameters to move fish from mid-water to area 1, from Area 1 to 2, and from Area 2 to 3, and process errors on both the observer and acoustic survey length frequency data sets. Input data for each area for the 2008 stock assessment included: new absolute abundance estimates and length data from the 2006 acoustic survey and previous estimates from the 1997 and 2002 acoustic surveys; revised and updated catch history, unchanged relative abundance estimates from pre-GPS and revised and updated relative abundance estimates from post-GPS standardised CPUE analyses, revised and updated observer length frequencies, unchanged growth parameter estimates. Observed lengths in the commercial fishery were compiled for each area grouped over years (up to five) where enough data were available and the absolute abundance at length from the acoustic surveys was converted to a length frequency using fixed length-weight parameters.

The base case analysis excluded trawl survey relative abundance data and trawl survey length frequencies. Migration was assumed to be unidirectional, meaning fish could move from mid-water to Area 1, or from Area 1 to Area 2 or from Area 2 to Area 3 in one year, but not move back. The migration rate was dependent on age and in one run it was dependent on the current biomass of the area the fish were moving to.

Growth was defined by a mean length at each age class in the model (1 to 70 years) for both sexes combined, and an associated c.v. (estimated as 0.077 from the age-length data) and was assumed to be constant over the age classes. Growth data for black oreo split into two groups at about age five years corresponding to the pre- and post-settlement life stages. Mean length-at-age was calculated separately for pre-and post-settlement fish and linear interpolation was used to join the curves. For post-settlement fish a local regression with a width spanning 2/3 of the data was fitted to all fish greater than 20 cm and mean length at ages 7 to 70 years was calculated from this fit. For pre-settlement fish a straight line was taken through the origin and the mean length for fish less than 20 cm length. Linear interpolation was used to calculate the mean length at ages 1 to 4 years. Mean length for ages 5 and 6 years was calculated by linear interpolation between those at 4 and 7 years.

The base case model used all data inputs. Additional model runs investigated the effect of using the length data only, the length data and acoustic abundance estimates only, the length data and pre-GPS data only, the length data and the post-GPS data only, one length frequency only, no length data, fixed migration rates and values, and estimating the year class strength using 5 degrees of freedom.

Revised maturity ogive

The previous maturity ogive was estimated in 2002 using von Bertalanffy growth parameters and it also did not take into account the length-at-age distribution. A new analysis used OEO 3A spawning season research trawl survey data from 1986 and 1987 to estimate the maturity rates by age by fitting the length ogive and length frequencies of mature and non-mature fish to that predicted by a simple population model (growth, constant recruitment, fixed M, and F). Maturity rates were represented by a capped logistic with parameters A_m (rates cap), a50L (age at 50% of A_m), and A50.95 (ages from 50% to 95% level). Errors were estimated by bootstrapping the trawl survey data within strata.

Simulations were used to evaluate the estimation procedure when assumptions were violated. The estimated parameters were (F=0): A_m = 1, A50 = 37.7 yr, and A50.96 = 0.5 yr. The age ogive was almost knife-edge at 38 yr.

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).

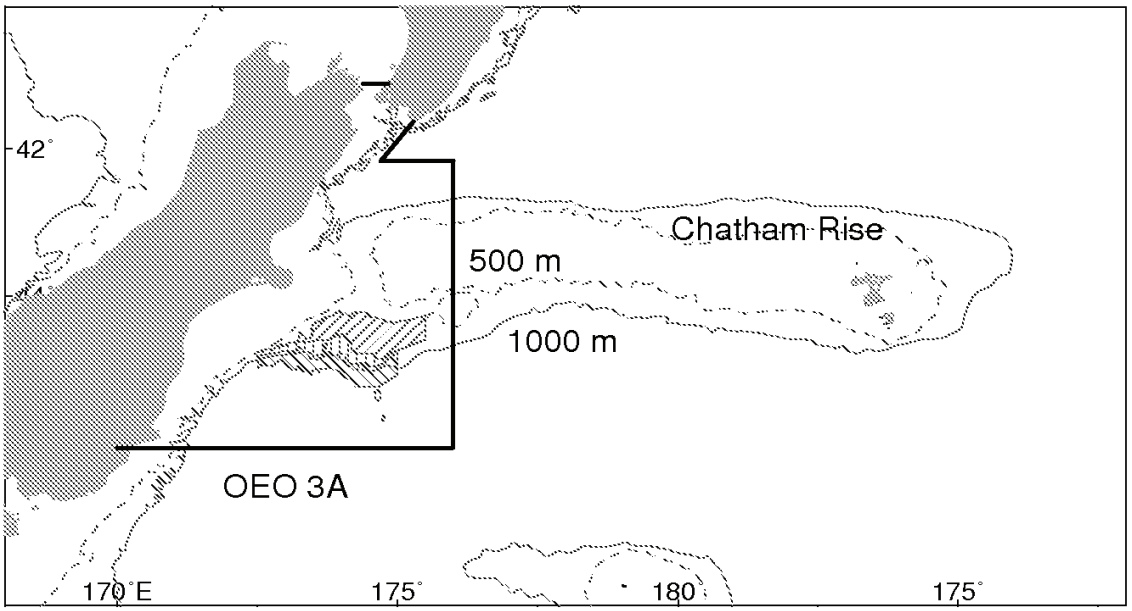


Figure 1: The three spatial areas used in the CASAL model and 2002 acoustic abundance survey. Area 1 at the top with right sloping shading; Area 2 in the middle with vertical shading; Area 3 at the bottom with left sloping shading. The thick dark line enclosed management area OEO 3A.

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.

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 Oreos report) and are given in Table 1.

Table 1: Black oreo catch (t) for each fishing year in the three spatial model areas, rounded to the nearest 10 t.

Year	Total	Area 1	Area 2	Area 3	Year	Total	Area 1	Area 2	Area 3
1972–73	†3 440	110	2 010	1 320	1990–91	4 770	890	2 310	1 580
1973–74	†3 800	130	2 220	1 460	1991–92	3 450	300	1 290	1 870
1974–75	†5 100	170	2 970	1 960	1992–93	4 960	230	2 810	1 920
1975–76	†1 260	40	730	480	1993–94	4 160	340	2 510	1 320
1976–77	†3 880	130	2 260	1 490	1994–95	2 400	120	1 560	720
1977–78	†5 750	190	3 350	2 210	1995–96	3 760	200	2 530	1 030
1978–79	720	20	420	270	1996–97	3 750	450	2 190	1 110
1979–80	5 740	430	2 670	2 650	1997–98	1 600	170	590	840
1980–81	12 640	80	8 260	4 300	1998–99	3 290	160	2 450	680
1981–82	11 460	100	6 400	4 960	1999–00	4 070	160	2 780	1 120
1982–83	8 290	510	4 940	2 840	2000–01	2 960	100	2 010	850
1983–84	7 410	300	4 200	2 910	2001–02	2 250	60	1 530	660
1984–85	3 930	150	1 510	2 270	2002–03	1 660	100	1 260	300
1985–86	2 190	10	920	1 260	2003–04	1 600	250	840	500
1986–87	4 030	30	1 970	2 020	2004–05	1 600	80	1 040	490
1987–88	3 140	40	1 940	1 160	2005–06	1 890	60	1 480	350
1988–89	3 230	170	2 490	570	2006–07	1 770	50	970	740
1989–90	2 830	620	1 050	1 160					

† 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. Within each area, groups of years were identified where each group spanned no more than five years. This procedure aimed to get adequate sample sizes to derive combined length frequencies and to use as much of the data as possible. Only one sample, from Area 1 in 1995–96, was not included (Table 2). Derived length frequencies for each group were calculated from the sample length frequencies weighted by the catch weight of each sample.

Research acoustic survey length frequencies by area

The 1997, 2002 and new 2006 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. Lengths below 25 cm and greater than 38 were pooled, Table 3.

Table 2: Number of observer commercial tows where black oreo was measured for length frequency. Excluded tows had less than 30 fish measured (13), extreme mean lengths (2) and missing catch information (3). –, no data.

Year	Number of tows in the length frequency					
	Area 1	Group no.	Area 2	Group no.	Area 3	Group no.
1978–79	–		–		–	
1979–80	–		9	1	35	1
1980–81	–		–		–	
1981–82	–		–		–	
1982–83	–		–		–	
1983–84	–		–		–	
1984–85	–		–		–	
1985–86	–		–		1	2
1986–87	–		2	2	6	2
1987–88	–		3	2	6	2
1988–89	3	1	32	2	7	2
1989–90	8	1	9	2	2	3
1990–91	1	1	5	2	8	3
1991–92	–		–		11	3
1992–93	–		–		–	
1993–94	–		22	3	4	4
1994–95	–		–	3	6	4
1995–96	1		3	3	3	4
1996–97	–		1	3	1	4
1997–98	13	2	–		7	4
1998–99	2	2	–		1	5
1999–00	2	2	52	4	57	5
2000–01	1	2	83	4	47	5
2001–02	–		18	4	14	5
2002–03	–		12	4	–	
2003–04	2	3	18		–	
2004–05	9	3	1	5	–	
2005–06	1	3	7	5	–	
2006–07	4	3	32	5	–	

Table 3: Research length frequency proportions for the model area for the 1997, 2002, and 2006 acoustic surveys.

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

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

Absolute estimates of abundance for black oreo are available from three acoustic surveys of oreos carried out from 10 November to 19 December 1997 (TAN9713), 25 September to 7 October 2002 (TAN0213), and 17–30 October 2006 (TAN0615). 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 survey was very similar to the 2002 survey and covered the flat with 78 transects and 22 tows. The estimated total abundance (immature plus mature) for each area is shown in Table 4.

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

Abundance (c.v. %)	Area 1	Area 2	Area 3	Total
1997	148 000 (29)	10 000 (26)	5240 (25)	163 000 (26)
2002	43 300 (31)	15 400 (27)	4710 (38)	64 000 (22)
2006	56 400 (37)	16 400 (30)	5880 (34)	78 700 (30)

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 are no new pre-GPS data or analyses so the indices used in the 2004 assessment are unchanged. There were 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) so two new post-GPS series were developed. The first of these was from 1992–93 to 1997–98 (early series) and the second was from 2002–03 to 2006–07 (late series) with data from the intervening years ignored. The catch and effort data were restricted to all tows that targeted or caught black oreo in OEO 3A up to and including the 2006–07 fishing year. Data were restricted to the spatial analysis study area and were included in the analyses if there were at least three years with more than 50 catches of black oreo. Data were excluded if only one vessel caught 80% or more of the black oreo catch in a year.

The basic analysis used a two-part model which separately analysed the tows that caught black oreo using a linear regression applied to log-transformed data, termed the log-linear regression (positive catch regression), and a binomial part which used a Generalised Linear Model with a logit link for the proportion of successful tows (zero catch regression). The log-linear and binomial index values for each year were multiplied together to give a combined index. The variables considered in the analyses included year, latitude, longitude, depth, season, time, target species, vessel, sun altitude and moon phase. The modified model incorporated an interaction term for year and area that enabled the CPUE from each of the three areas to be analysed. The method gave a unique index for each year by taking the means of the model predicted values for each combination of year and area for the model with a fishing year-area interaction term.

The following analyses were performed:

1. Analysis for area 1 used a single part model only (log-linear regression). No binomial model analysis was required because there were very few zero tows.
2. Analysis with year/area interaction was applied to Areas 2 and 3 for pre- and post-GPS data separately. Two part (log-linear and binomial) models were employed for the pre-GPS series. The single part (log-linear) model was used for the post-GPS series because there was very little post-GPS target fishing for black oreo and therefore very few zero catch tows.

The indices and CV estimates are in Table 5.

Table 5: OEO 3A black oreo pre-GPS and post-GPS time series of standardised catch per unit effort indices and jack-knife c.v. estimates (%) that were used in the base case.. –, no estimate.

Fishing	Pre-GPS						Post-GPS					
	Area1		Area2		Area3		Area1		Area2		Area3	
	Index	c.v.	Index	c.v.	Index	c.v.	Index	c.v.	Index	c.v.	Index	c.v.
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	–	–	–	–	–	–	–	–	Early series			
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	–	–	–	–	–	–	–	–	–	–	–	–
1999–0	–	–	–	–	–	–	–	–	–	–	–	–
2000–1	–	–	–	–	–	–	–	–	–	–	–	–
2001–2	–	–	–	–	–	–	Late series					
2002–3	–	–	–	–	–	–	0.72	42	1.05	21	0.91	44
2003–4	–	–	–	–	–	–	1.06	31	1.19	19	1.05	27
2004–5	–	–	–	–	–	–	1.71	38	0.83	27	0.88	25
2005–6	–	–	–	–	–	–	1.23	37	1.11	22	0.88	41
2006–7	–	–	–	–	–	–	0.63	83	0.86	22	1.34	25

4.2.2 Biomass estimates

A MCMC chain of 1500 was used which was derived from systematically sub-sampling every 1000th point after a burn-in of 500 iterations. The chain appeared to have converged for the main parameters, but a second chain gave a shift in the distribution of the virgin biomass of about 3000 t. However, this difference is only about 4 % of the estimated median. The process errors in the acoustic and observer length frequencies were also set to their MPD values. Base case biomass estimates (medians of the posterior distribution) are in Table 6. The vulnerable biomass estimates are the same as the total biomass estimates in Areas 2 plus 3.

Table 6: Base case biomass estimates (rounded to nearest 100 t). Vulnerable biomass is the sum of the total biomass in Areas 2 and 3. All estimates are mid-year. – not estimated.

	Area 1			Area 2			Area 3			Total		
Biomass	B_0	B_{2007}	B_{2007}/B_0	B_0	B_{2007}	B_{2007}/B_0	B_0	B_{2007}	B_{2007}/B_0	B_0	B_{2007}	B_{2007}/B_0
Mature	20 200	18 700	92	24 100	5 180	22	42 900	1 190	3	87 400	25 200	29
Vulnerable	–	–	–	–	–	–	–	–	–	86 600	15 000	17
Total	79 500	74 100	93	39 200	12 800	33	47 300	2 130	5	166 000	89 200	54

The fits of the abundance estimates to the MPD solution of the base case are generally good (Figure 2), but they do not fit to the last two acoustic estimates in Area 3 or the first two in Area 1.

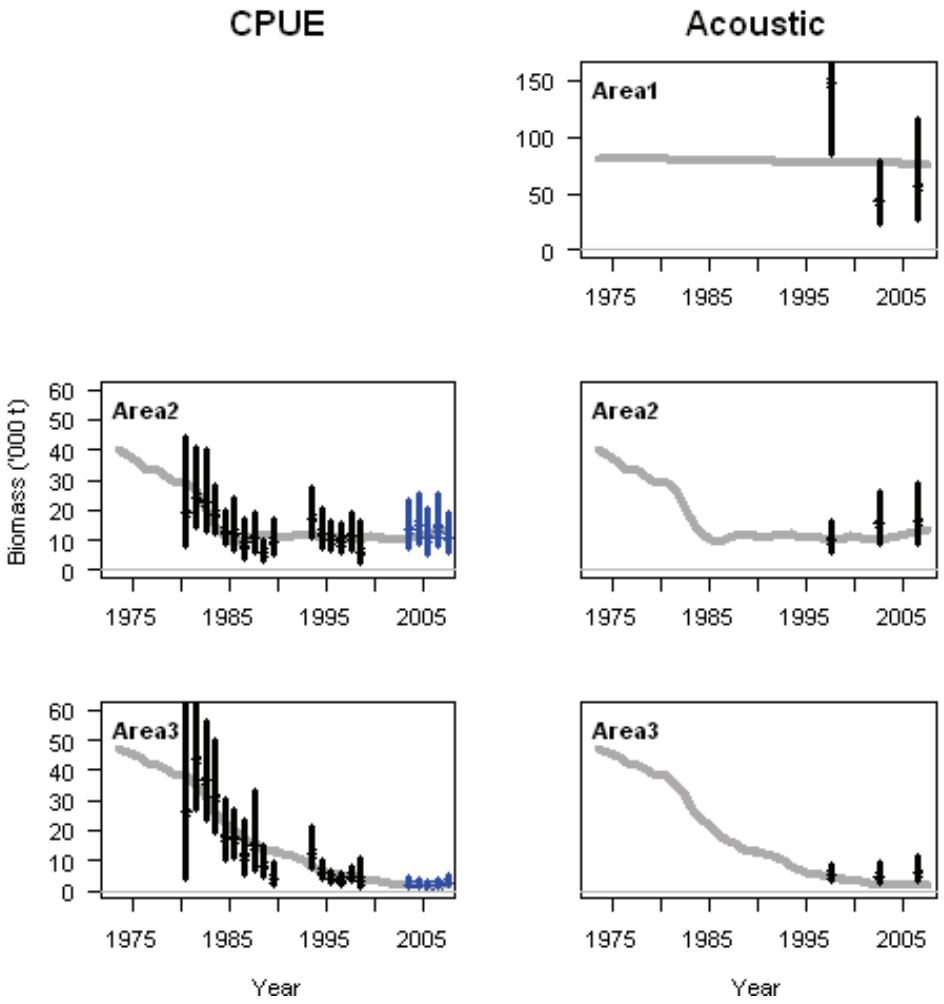


Figure 2: The fit of the abundance observations (CPUE and the absolute acoustic estimates) for each area to the predicted total biomass trajectories for the 2008 assessment of black oreo in OEO 3A (MPD solution, base case). The vertical lines are the 95% confidence intervals. The CPUE series were adjusted by their estimated catchability so that they are in absolute biomass units.

Sensitivity of the model to data sources

Except when no LF data were used, biomass estimates from all the sensitivity runs were not substantially different from the base case, Table 7.

Table 7: Estimated mature $B_{2001–02}/B_0$ (%) and $B_{2006–07}/B_0$ (%) for the MPD sensitivity runs. Base case in bold.

RUN1	Post-GPS CPUE series are not split into two
RUN2 (Base case)	**All data**
RUN3	Density dependent migration allowed
ACO.only	Data restricted to acoustic abundances + all LF data
preCPUE.only	Data restricted to pre-GPS CPUE series + all LF data
postCPUE.only	Data restricted to post-GPS CPUE + all LF data
LFs.only	Data restricted to LF data only
Recruits	Estimate recruit deviates
OneLF	Restrict LF data to one year
No LF	No LF data used
FixMig	No LF data used, but migration and selectivities fixed to their estimates from the base case
RUN1 OLD MATURITY	Run1 using previous maturity ogive.

Area	RUN1	**RUN2**	RUN3	ACO.only	preCPUE.only	postCPUE.only	LFs.only	Recruits	OneLF	No LF	FixMig	RUN1 OLD MATURITY
TOTAL 2001–02	31	**30**	29	29	28	31	31	30	30	14	32	48
TOTAL 2006–07	32	**31**	30	31	29	32	32	32	31	17	34	50
Area 1 2001–02	93	**93**	89	93	93	93	93	94	93	93	93	95
Area 1 2006–07	93	**93**	88	93	92	93	93	94	93	93	93	95
Area 2 2001–02	17	**16**	18	15	14	10	10	23	18	19	18	25
Area 2 2006–07	22	**21**	23	21	20	17	17	30	25	25	23	32
Area 3 2001–02	4	**3**	3	3	1	1	1	2	5	6	5	6
Area 3 2006–07	4	**3**	4	3	1	1	1	4	5	6	5	6

4.2.4 Other factors

Yield estimates would be under-estimated if reported catch was less than the actual catch. Low reported catch could be caused by discarding of unwanted and small fish, particularly black oreo in the early days of the fishery and also by lost bags. Estimates of discards of oreos were made for 1994–95 and 1995–96 from MFish observer data and were 207 and 270 t, respectively. Estimates of discards at other times were not made but may have been substantial for black oreo in the mid 1980s. Yield estimates may also be under-estimated if there was a change over time in the proportion of oreo catch that was not reported.

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.

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 Oreos report) and are given in Table 11.

Table 11: 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 12).

Table 12: 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	–	–
1990–91	26	2 978	3	Applied
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 c.v. for each length class was given by the regression, log(c.v.) = 0.86 + 8.75/log(proportion). This regression was estimated from the c.v.s obtained by bootstrapping the data and provides a smoothed estimate of the c.v.s. The estimated length frequency is in Figure 3.

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 c.v. of 23% (1999 estimate was 35 100 t with c.v. 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.

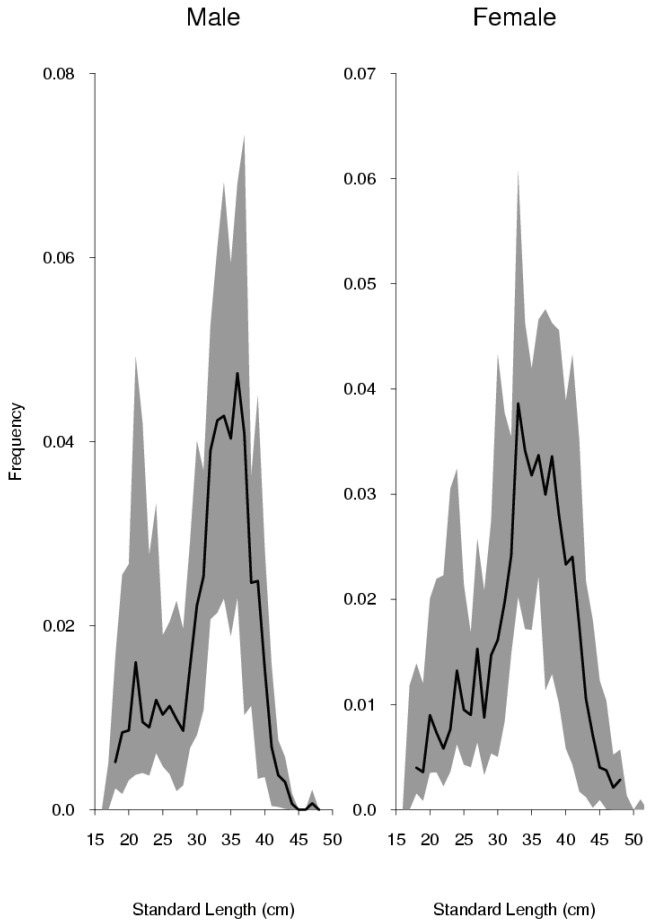


Figure 3: Population length frequency derived from the 1997 acoustic survey data. The bold line is the estimated value and the shaded area is the spread from 300 bootstraps.

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 new 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 of catch limit (1400 t) was introduced and substantial oreo TACC reductions were made during that time (6600 to 3100 t). The pre-GPS series trends down, and declines to approximately a third of the initial level over the nine-year period. The early post-GPS trends down but the late post-GPS series trends up and flattens. The base case stock assessment used all three indices (Table 13).

Table 13: CPUE indices by year and jackknife c.v. (%) estimates from the pre-GPS and the two post-GPS analyses.

Pre-GPS						Post-GPS		
Year	Index	c.v.	Year	Index	c.v.	Year	Index	c.v.
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						

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.

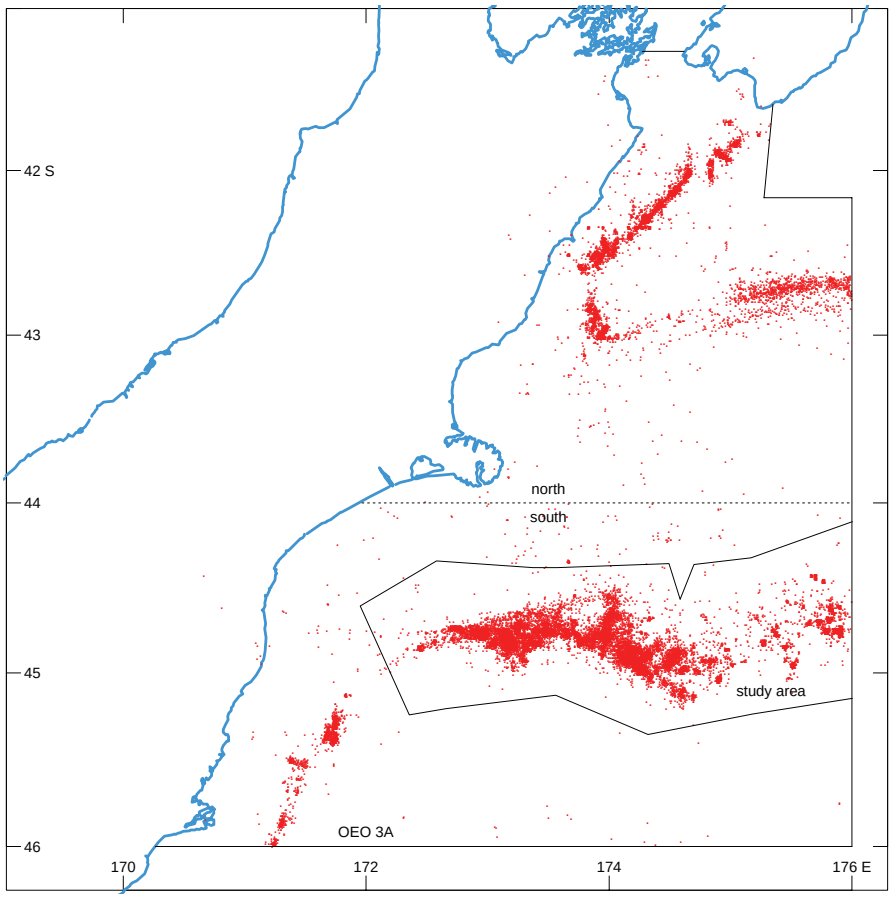


Figure 4: Locations of all tows in OEO 3A with a reported catch of smooth oreo from 1979–80 to 2002–03 (dots). The study area is shown along with the line chosen to split north from south Chatham rise catches.

4.3.2 Biomass estimates

The posterior distributions from the MCMC on the base case are shown in Figure 5. 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.

Biomass estimates derived from the MCMC are in Table 14. 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 current biomass between 12% and 59% of B_0.

Projections were carried out for 5 years with the current catch limit of 1400 t. The trajectory shows increasing biomass (Figure 5).

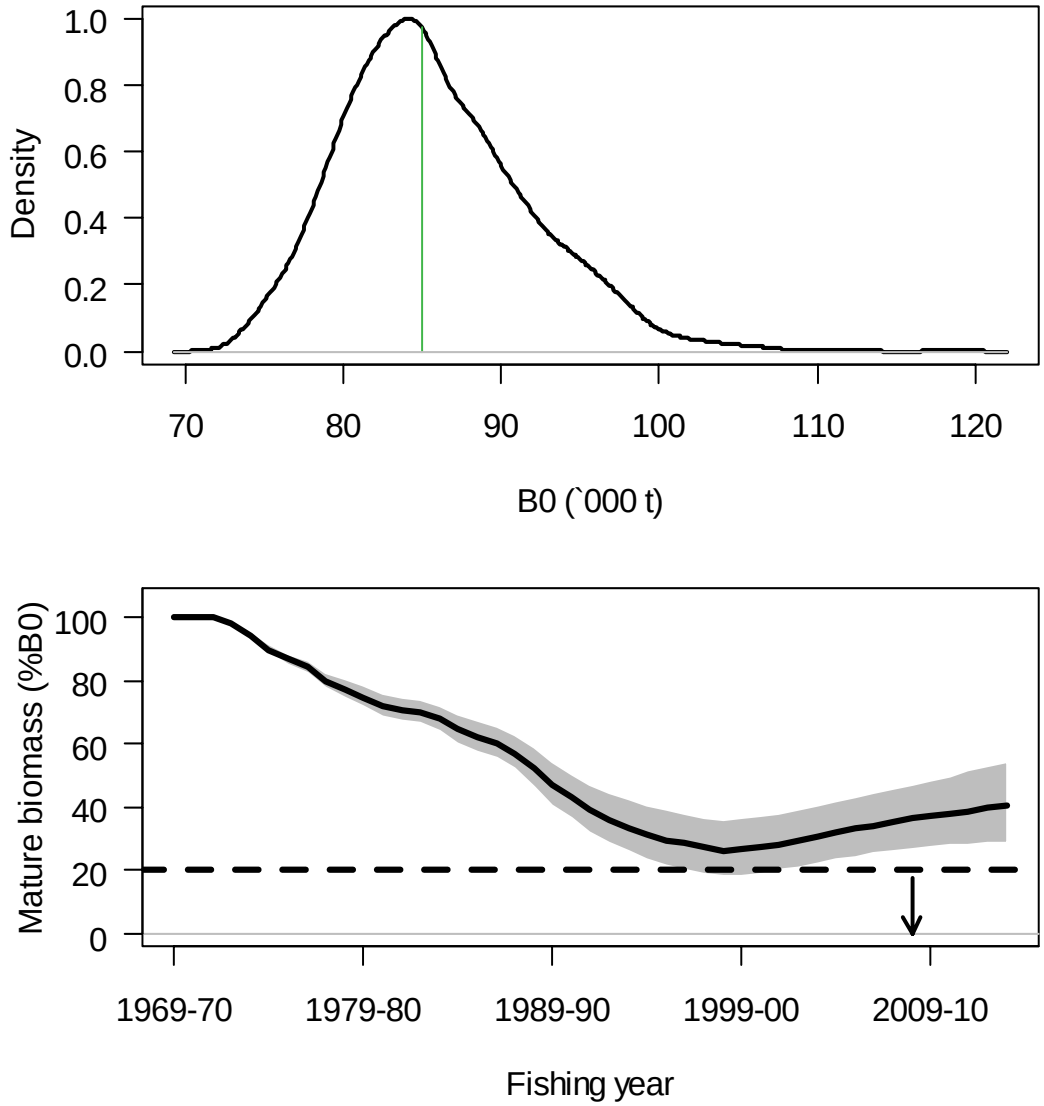


Figure 5: Smooth oreo OEO 3A: posterior distribution for the virgin biomass (top plot) and the mature biomass trajectories as a percentage of virgin biomass (bottom plot) from the MCMC analysis of the "NoLF" case with M = 0.063 (base case). In the top plot, the vertical line is the median of the distribution. In the bottom plot, the grey area is the point-wise 95% confidence intervals of the trajectories and the solid line is the median.

Table 14: Base case (bold) and sensitivity (†) case biomass estimates.

	M=0.063			†M=0.042			†M=0.099		
	Median	**CI.05**	**CI.95**	Median	CI.05	CI.95	Median	CI.05	CI.95
B_0	**85 000**	**77 300**	**96 500**	97 700	90 100	110 000	68 500	60 300	79 600
B_cur	**30 900**	**22 400**	**43 000**	26 300	18 000	38 800	33 800	25 000	45 500
B_cur($\%B_0$)	**36**	**29**	**45**	27	20	35	49	41	57

Left hand limb of the 1994 observer length frequency (plus the 1997 acoustic survey length frequency) with growth not estimated by the model:

	†M=0.063			†M=0.042			†M=0.099		
	Median	CI.05	CI.95	Median	CI.05	CI.95	Median	CI.05	CI.95
B_0	77 400	74 800	80 200	82 800	81 600	84 200	82 300	76 700	89 200
B_cur	23 100	19 900	26 400	10 200	8 480	12 100	48 800	42 900	56 200
B_cur($\%B_0$)	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
- 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

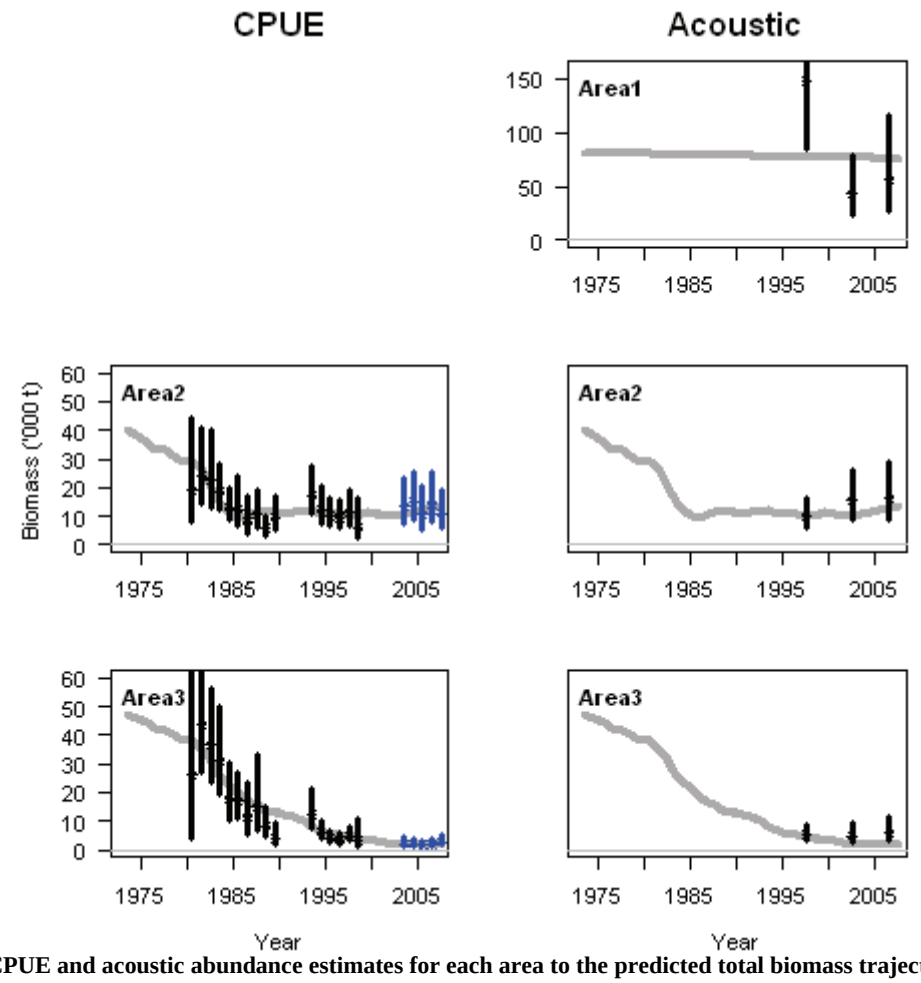
The smooth oreo stock assessment is unchanged from 2009. The black oreo stock assessment is updated with the 2008 assessment.

Stock Structure Assumptions
The two oreo stocks in FMA 3A are assessed separately but managed as a single stock. For both the black and smooth oreo stocks it is assumed there is potential mixing with stocks outside of the OEO3A area.

- **OEO3A (Black Oreos)**

Stock Status	
Year of Most Recent Assessment	2008
Assessment Runs Presented	One base case
Reference Points	Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	For the base case, B_{2007} was estimated to be about 29% B_0; the stock was estimated to be Unlikely (< 40%) to be at or above the target.
Status in relation to Limits	Overall the population was Unlikely (< 40%) to be below the Soft Limit and Unlikely (< 40%) to be below the Hard Limit.

Historical Stock Status Trajectory and Current Status



The fit of the CPUE and acoustic abundance estimates for each area to the predicted total biomass trajectories for the 2007 assessment of black oreo in OEO 3A (MPD solution, base case). The vertical lines are the 95% confidence intervals.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Biomass appeared to be stabilising in the latter years of the assessment after significant decline in the late 1980s.
Recent Trend in Fishing Mortality or Proxy	Catch has decreased with TACC since the early 1990s and remained low and relatively constant over the final 7-8 years.
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis (2008)	
Stock Projections or Prognosis	None because of uncertainties in the assessment.
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unknown Hard Limit: Unknown

Assessment Methodology	
Assessment Type	Level 1 – Quantitative stock assessment
Assessment Method	Age-structured CASAL spatial model with Bayesian estimation of posterior distributions.
Main data inputs	Updated data - Three acoustic surveys (1997, 2002, 2006), CPUE abundance - Length frequency

	- Catch history - Estimates/Assumptions of: recruitment, migration from length data, growth, *M* New information from: - Pre- and post-settlement growth - Age-dependent migration rates	
Period of Assessment	Latest assessment: 2008	Next assessment: 2012
Changes to Model Structure and Assumptions	- Process error now incorporated for CPUE estimates, acoustic length frequencies and Observer length frequencies. - Length at age CVs now estimated - Recruitment to mid-water assumed to occur at 1 year and then to Area 1 with one-way migration.	
Major Sources of Uncertainty	- Yield estimates from the early period of the fishery may be underestimated with discards of up to 270t calculated - Uncertainty in estimates of natural mortality (*M*) - Recruitment is assumed to be deterministic - Migration rates estimated from length data	

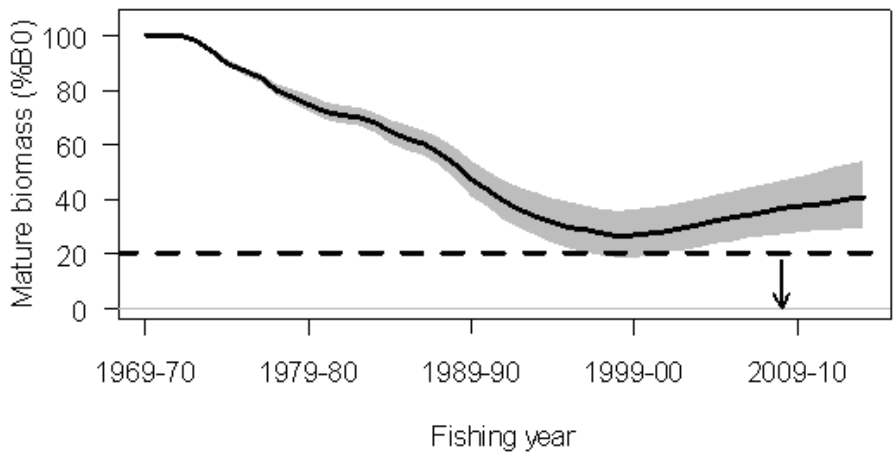
Qualifying Comments
None

Fishery Interactions
Both species of oreo are sometimes taken as bycatch in orange roughy target fisheries and in smaller numbers in hoki target fisheries. Target fisheries for oreos do exist, with main bycatch being orange roughy, rattails and deepwater sharks. Bycatch species of concern include deepwater sharks and rays, seabirds and deepwater corals.

- **OEO3A (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
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 1400t.	
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Very Unlikely (< 10%) Hard Limit: Very Unlikely (< 10%)	
Assessment Methodology		
Assessment Type	Level 1 – Quantitative stock assessment	
Assessment Method	Age-structured CASAL model with Bayesian estimation of posterior distributions.	
Main data inputs	- One acoustic absolute abundance estimate (1997) - 3 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 - 2 new standardised post-GPS CPUE series	
Period of Assessment	Latest assessment: 2009	Next assessment: Unknown
Changes to Model Structure and Assumptions	None	
Major Sources of Uncertainty	- 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
None

Fishery Interactions
Both species of oreo are sometimes taken as bycatch in orange roughy target fisheries and in smaller numbers in hoki target fisheries. Target fisheries for oreos do exist, with main bycatch being orange roughy, rattails and deepwater sharks. Bycatch species of concern include deepwater sharks and rays, seabirds and deepwater corals.

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