OREOS – OEO 1 AND OEO 6 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

4.1 Introduction

A new assessment is reported here for Southland (OEO 1/OEO 3A), while the previously reported assessments for Pukaki Rise black oreo, Pukaki smooth oreo and Bounty Plateau smooth oreo (only MPD results) are repeated.

4.2 Southland smooth oreo fishery

This assessment was updated in 2007 and applies only to the study area as defined in Figure 1 and does not include areas to the north (Waitaki) and east (Eastern canyon) of the main fishing grounds.

This fishery is mostly in OEO 1 on the east coast of the South Island but catches occur at the northern end of the fishery straddle and cross the boundary line between OEO 1 and OEO 3A at 46ºS. This is an old fishery with catch and effort data available from 1977–78. Smooth oreo catch from Southland was about 480 t (mean of 2003–04 to 2005–06). There is an industry catch limit of 400 t smooth oreo implemented after the previous (2003) assessment. There were no fishery-independent abundance estimates, so relative abundance estimates from pre- and post-GPS standardised CPUE analyses and length frequency data collected by MFish (SOP) and Orange Roughy Management Company (ORMC) observers were used.

The following assumptions were made in this analysis.

1. The CPUE analysis indexed the abundance of smooth oreo in the study area of OEO 1/3A.
2. The length frequency samples were representative of the population being fished.
3. The ranges used for the biological values covered their true values.
4. Recruitment was deterministic and followed a Beverton & Holt relationship with steepness of 0.75.
5. The population of smooth oreo in the study area was a discrete stock or production unit.
6. Catch overruns were 0% during the period of reported catch.
7. The catch histories were accurate.
8. The maximum fishing pressure (U_{MAX}) was 0.58.

An age-structured CASAL model employing Bayesian statistical techniques was developed. A two-fishery model was employed with a split into deep and shallow fisheries because of a strong relationship found between smaller fish in shallow water and large fish in deeper water. The boundary between deep and shallow was 975 m. The 2007 analysis used 5 extra years of catch and observer length frequency data compared to the 2003 assessment. The model was partitioned by the sex and maturity status of the fish and used population parameters previously estimated from fish sampled on

the Chatham Rise and Puysegur Bank fisheries. The maturity ogive used was estimated from Chatham Rise research samples.

4.2.1 Estimates of fishery parameters and abundance

Catch history

A catch history (Table 1) was derived using declared catches of OEO from OEO 1 (see Table 2 in the Fishery Summary section at the beginning of the Oreos report) and tow-by-tow records of catch from the study area (Figure 1). The tow-by-tow data were used to estimate the species ratio (SSO/BOE) and therefore the SSO taken. It was assumed that the reported landings provided the best information on total catch quantity and that the tow-by-tow data provided the best information on the species and area breakdown of catch.

Table 1: Catch history of smooth oreo from Southland. Rounded to the nearest 10 t.

Fishing year	Shallow	Deep	Fishing year	Shallow	Deep
1977–78	210	0	1992–93	410	250
1978–79	10	0	1993–94	220	150
1979–80	40	0	1994–95	80	150
1980–81	0	0	1995–96	600	500
1981–82	0	0	1996–97	440	70
1982–83	0	0	1997–98	320	230
1983–84	480	660	1998–99	480	620
1984–85	170	510	1999–00	650	480
1985–86	480	3 760	2000–01	400	610
1986–87	30	160	2001–02	580	1 470
1987–88	130	860	2002–03	130	1 320
1988–89	0	240	2003–04	330	420
1989–90	210	430	2004–05	140	290
1990–91	410	420	2005–06	120	140
1991–92	530	380			

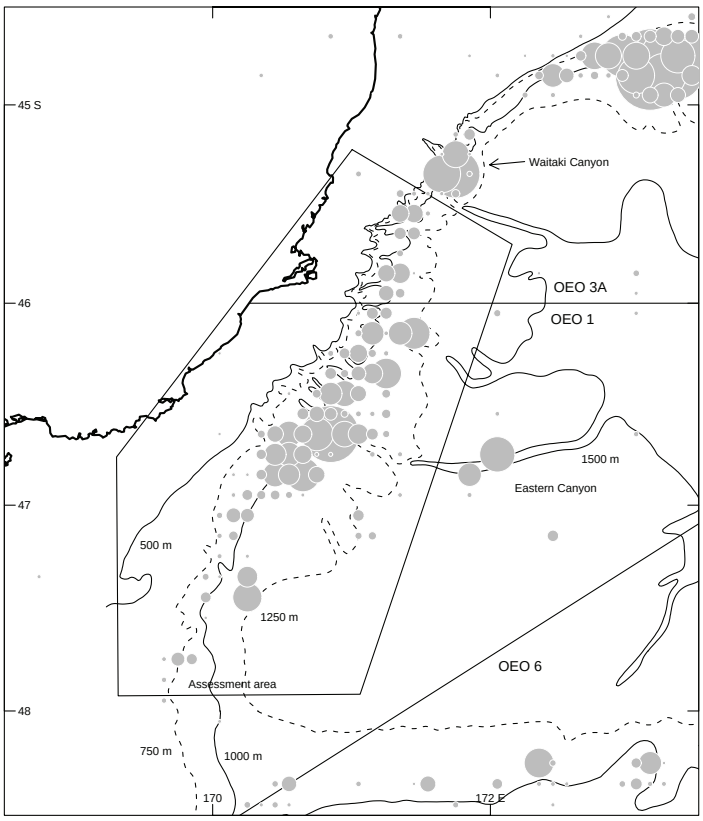


Figure 1: Smooth oreo estimated catch from all years to (and including) 2005–06. The area was divided into cells that are 0.1 degrees square and catches were summed for each cell. Circles proportional in area to the catch are plotted centred on the cells. Catches less than 10 tonnes per cell are not shown. Circles are layered so smaller circles are never hidden by larger ones. The assessment area and bottom topography are also shown.

Length data

All SOP records where smooth oreo were measured from within the assessment area are shown in Table 2: 78 samples were shallow and 51 deep. Only 13 shallow and 4 deep samples were collected before 1999–2000 (Table 2). Composite length frequency distributions were calculated for each year. Each sample was weighted by the catch weight of the tow from which the sample was taken. This was modified slightly by estimating the number of fish that would be in a unit weight of catch and multiplying by that.

Table 2: Summary of length frequency data for smooth oreo available for the study area. Year group, year applied, and the total number of length frequencies for the shallow and deep year groups.

Year group	Year applied	No. of lfs
Shallow		
a=1993–94 to 1997–98	1995–96	13
b=1999–2000	1999–00	30
c=2000–01 to 2001–02	2001–02	22
d=2002–03 to 2005–06	2004–05	13
Deep		
e=1997–98 to 2001–02	2001–02	27
f=2002–03 to 2004–05	2003–04	21

Relative abundance estimates from CPUE analyses

The standardised CPUE analyses used a two part model which separately analysed the tows which caught smooth oreo using a log-linear regression (referred to as the positive catch regression) and a binomial part which used a Generalised Linear Model with a logit link for the proportion of successful tows (referred to as the zero catch regression). The binomial part used all the tows, but considered only whether or not the species was caught and not the amount caught. The yearly indices from the two parts of the analysis (positive catch index and zero catch index) were multiplied together to give a combined index. The pre-GPS data covered the years from 1983–84 to 1987–88, was left unmodified from 2003, and was used as an index of the deep fishery as most fishing in that period was deep (Table 3). The post-GPS data covered 1992–93 to 2005–06 split into shallow and deep fisheries but the indices for the last two years (2004–05, 2005–06) were dropped because catch was constrained by the industry catch limit of 400 t for smooth oreo introduced after the 2003 assessment (Table 4).

Table 3: Smooth oreo pre-GPS combined index estimates by year, and jackknife c.v. estimates from analysis of all tows in the study area that targeted smooth oreo, black oreo, or unspecified oreo.

	Combined index	Jackknife CV (%)
1983–84	1.75	22
1984–85	1.65	29
1985–86	1.19	33
1986–87	0.48	23
1987–88	0.61	27

Table 4: Smooth oreo post-GPS combined index estimates by year, and jackknife c.v. estimates from analysis of all tows in the study area that targeted smooth oreo, black oreo, or unspecified oreo.

	Shallow		Deep	
Fishing year	Index (kg/tow)	Bootstrap c.v. (%)	Index (kg/tow)	Bootstrap c.v. (%)
1992–93	1 489	57	1 401	73
1993–94	956	47	916	53
1994–95	1 521	72	428	121
1995–96	1 173	37	1 862	84
1996–97	511	84	2 117	41
1997–98	1 477	39	502	59
1998–99	939	42	915	50
1999–00	842	44	611	48
2000–01	758	46	385	72
2001–02	573	44	658	53
2002–03	303	48	406	76
2003–04	480	57	719	218

4.2.2 Biomass estimates

Biomass estimates were made based on a Markov Chain Monte Carlo analysis which produced a total of about 1.4 million iterations was generated. The first 100 000 iterations were discarded and every 1000th point was retained, giving final converged chain of about 1300 points.

Biomass estimates for the base case are given in Table 5. These biomass estimates are uncertain because of the reliance on commercial CPUE data for abundance indices.

Table 5: Biomass estimates (t) for the base case.

		5%	median	mean	95%	c.v. (%)
Free parameters						
Virgin mature biomass (B_0)		15 600	17 400	17 900	21 700	12
Selectivity, shallow	a1	17.2	19.0	19.0	21.0	6
	sL	3.9	4.8	4.8	5.8	12
	sR	5.9	8.3	8.4	11.2	20
Selectivity, deep	a50	22.1	26.0	26.2	30.8	10
	to95	1.9	7.1	7.0	11.0	37
Derived quantities						
Current mature biomass (% initial)		19	27	28	41	25
Current selected shallow biomass (% initial)		56	65	65	73	8
Current selected deep biomass (% initial)		12	20	22	36	36

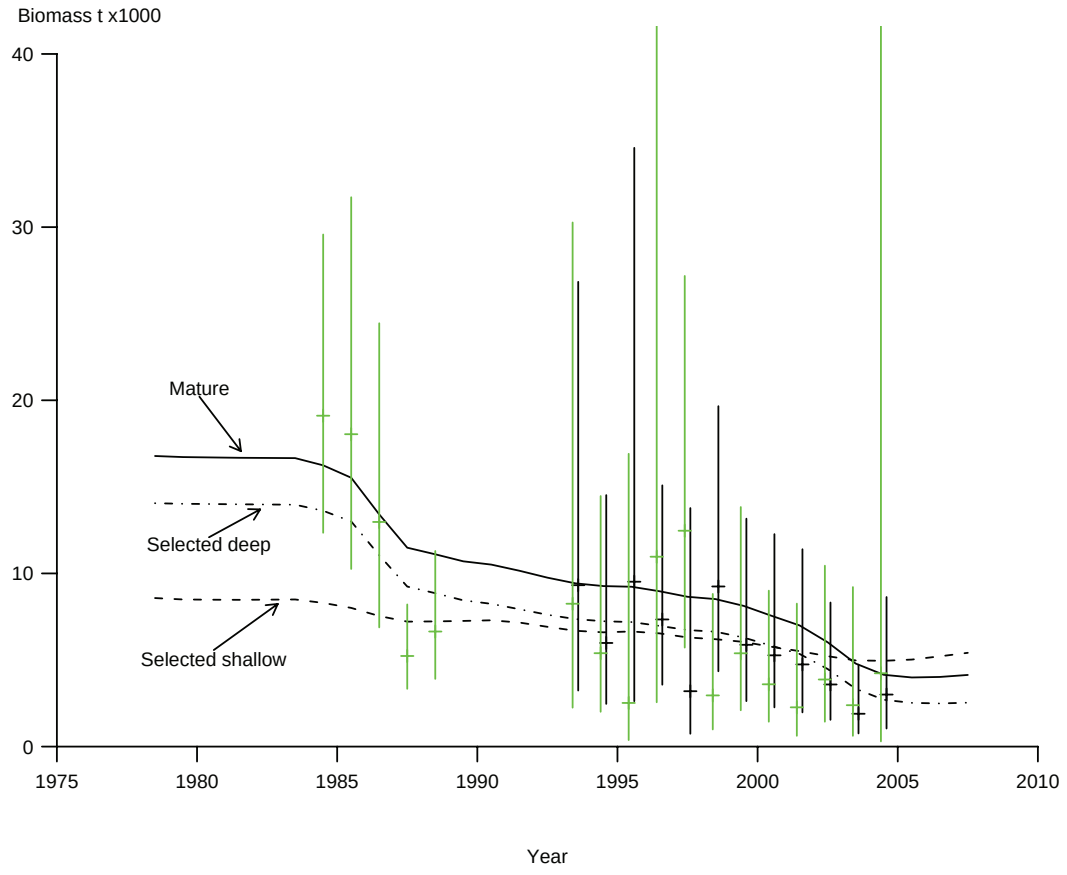


Figure 2: Predicted biomass trajectories for the 2007 base case assessment. Mature biomass and selected biomass for the shallow and deep fisheries. Also shown are the CPUE indices from the pre- and post-GPS analysis for the deep fishery (in gray) and the post-GPS analyses for the shallow fishery (in black). CPUE indices are shown with +/- 2 s.e. confidence interval indicated by the vertical lines (the post-GPS CPUE data are slightly offset to avoid over plotting). The CPUE data were scaled by catchability coefficients to match the biomass scale.

4.3 Pukaki Rise smooth oreo fishery (part of OEO 6)

This is the first assessment for this fishery (developed in 2006) and applies only to the assessment area as defined in Figure 3. This is the main smooth oreo fishery in OEO 6 with mean annual catches of about 1700 t from 1995–96 to 2004–05, taken mainly by New Zealand vessels. There was also a

small early Soviet fishery (1980–81 to 1985–86) with mean annual catches of less than 100 t. There were no fishery-independent abundance estimates, so relative abundance estimates from a post-GPS standardised CPUE analysis and length frequency data collected by MFish (SOP) and Orange Roughy Management Company (ORMC) observers were considered. Biological parameter values estimated for Chatham Rise and Puysegur Bank smooth oreo were used in the assessment because there are no research data from Pukaki Rise.

The following assumptions were made in this analysis.

1. The CPUE analysis indexed the abundance of smooth oreo in the Pukaki Rise (OEO 6) assessment area.
2. The length frequency samples were representative of the population being fished.
3. The ranges used for the biological values covered their true values.
4. Recruitment was deterministic and followed a Beverton & Holt relationship with steepness of 0.75.
5. The population of smooth oreo in the assessment area was a discrete stock or production unit.
6. Catch overruns were 0% during the period of reported catch.
7. The catch histories were accurate.
8. The maximum exploitation rate (E_{MAX}) was 0.58.
9. The prior for stock size was bounded at an upper limit of 100 000 t.

Data inputs included catch history, relative abundance estimates from a standardised CPUE analysis, and length data from SOP and ORMC observers. The observational data were incorporated into an age-based Bayesian stock assessment (CASAL) with deterministic recruitment to estimate stock size. The stock was considered to reside in a single area, with a partition by sex. Age groups were 5–70 years, with a plus group of 70+ years.

The length-weight and length-at-age population parameters are from fish sampled on the Chatham Rise and Puysegur Bank fisheries (Table 1, Biology section). Fish sampled from the Puysegur Bank fishery are used for the natural mortality estimate (Table 1). The maturity ogive is from fish sampled on the Chatham Rise, and the age at which 50% are mature is between 18 and 19 years for males and between 25 and 26 years for females.

4.3.1 Estimates of fishery parameters and abundance

Catch history

A catch history was derived using declared catches of OEO from OEO 6 (Table 2 in the "Fishery summary" section of the Oreos report above) and tow-by-tow records of catch from the assessment area (Figure 3). The tow-by-tow data were used to estimate the species ratio (SSO/BOE) and therefore the SSO taken. It was assumed that the reported landings provided the best information on total catch quantity and that the tow-by-tow data provided the best information on the species and area breakdown of catch. There may be unreported catch from before records started, although this is thought to be small. Before the 1983–84 fishing year the species catch data were combined over years to get an average figure that was then applied in each of those early years. For the years from 1983–84 onwards, each year's calculation was made independently. The catch history used in the population model is given in Table 7.

Table 7: Catch history of smooth oreo from the Pukaki Rise fishery assessment area. Catches are rounded to the nearest 10 t.

Year	Catch	Year	Catch	Year	Catch	Year	Catch
1980–81	30	1988–89	0	1996–97	1 650	2004–05	1 370
1981–82	20	1989–90	0	1997–98	1 340		
1982–83	0	1990–91	10	1998–99	1 370		
1983–84	640	1991–92	0	1999–00	2 270		
1984–85	340	1992–93	70	2000–01	2 580		
1985–86	10	1993–94	0	2001–02	2 020		
1986–87	0	1994–95	130	2002–03	1 340		
1987–88	180	1995–96	1 360	2003–04	1 660		

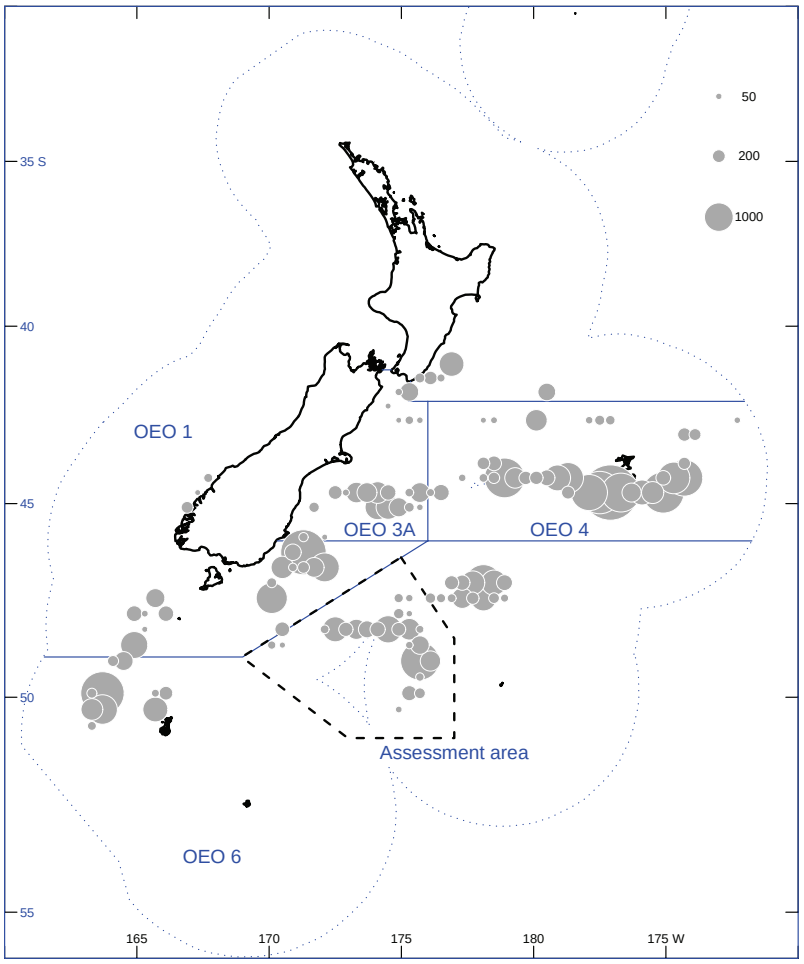


Figure 3: The Pukaki Rise fishery assessment area (polygon) abutting the north boundary of OEO 6. The circles are proportional to the mean of smooth oreo estimated catches (t) from the last 5 years (2000–01 to 2004–05) plotted by summing the catches over 0.4 x 0.4 degree grids. The dotted line is the EEZ.

Length data

Smooth oreo length frequency data collected by SOP and ORMC observers are available from the last eight years (Table 8). An in-depth analysis indicated that these data were reasonably representative of the fishery in terms of spatial, depth and temporal coverage in those years that had adequate data. The depths fished by the sampled fleet varied between years so the length data were stratified by depth resulting in shallow (less than 900 m), middle (900–990 m) and deep strata (greater than 990 m). The data from adjacent years were also grouped because some years had few samples. The resulting length frequencies are shown in Figure 4. There is a trend towards a flatter distribution over the last three grouped distributions (2000–01, 02, and 03–05).

Table 8: Summary of length frequency data for smooth oreo available for the assessment area. The table shows the number of tows sampled by year, the sample source, and the year group. –, no data.

	Year group	Number of tows sampled		
Year		ORMC	SOP	All
1997–98	98–99	–	15	15
1998–99	98–99	64	9	73
1999–00	00–01	5	36	41
2000–01	00–01	37	17	54
2001–02	2	42	22	64
2002–03	03–05	4	12	16
2003–04	03–05	–	19	19
2004–05	03–05	–	19	19
Totals		152	149	301

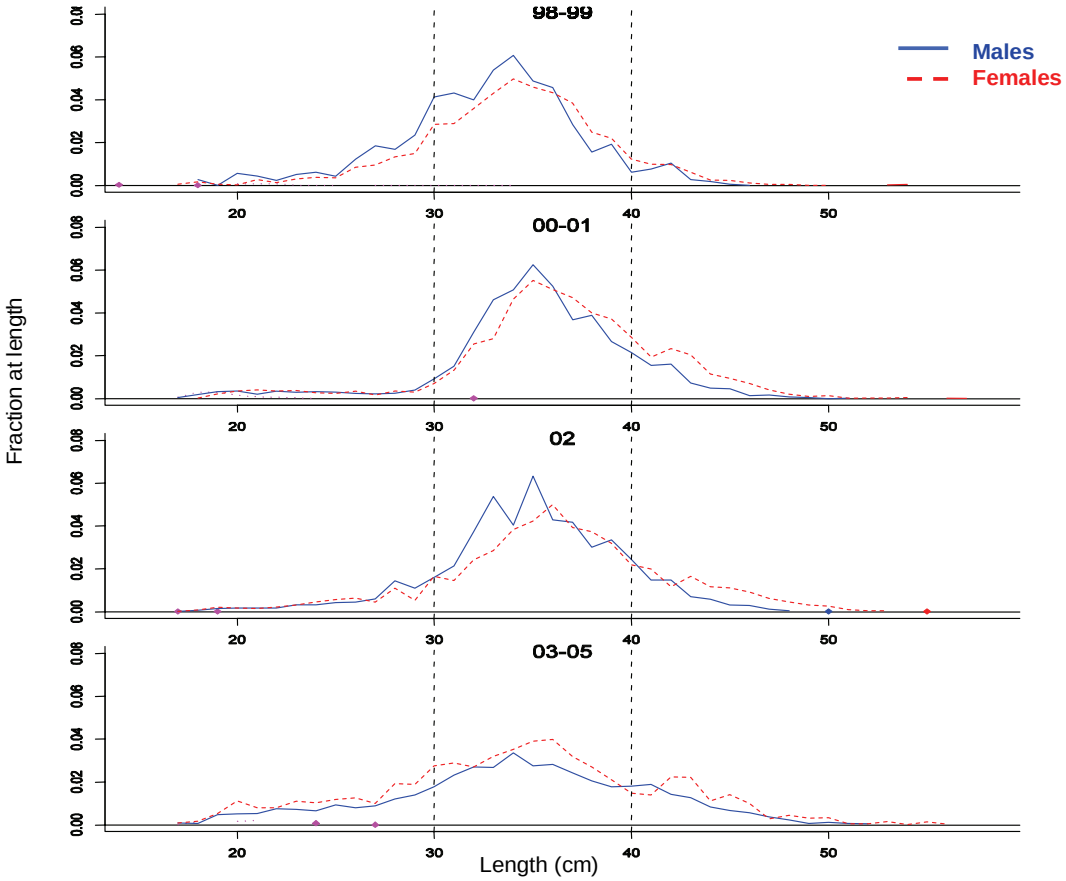


Figure 4: Length frequencies for Pukaki Rise smooth oreo, stratified by depth (see text), and grouped by years.

Relative abundance estimates from CPUE analyses

There was a small early Soviet fishery (1980–81 to 1985–86) with too few data for a standardised CPUE analysis. The New Zealand vessel fishery (1995–96 to 2004–05) was used to analyse standardised CPUE.

This new standardised CPUE analysis of Pukaki Rise smooth oreo used regression based methods similar to those in previous oreo CPUE analyses but because the fraction of zero tows were low (Table 9) only a positive catch model was used. The annual CVs for the index were estimated using bootstrap methods. The data used are summarised in Table 9.

Table 9: Summary of data used as input to the standardised CPUE analysis for New Zealand vessels.

Year	No. of tows	No. of vessels	Estimated catch (t)	Mean t/tow	Zero catch tows (%)
1995–96	278	9	1 170	4.2	1
1996–97	402	10	1 490	3.7	1
1997–98	356	10	1 190	3.4	5
1998–99	377	12	1 230	3.3	7
1999–00	591	9	2 070	3.5	7
2000–01	651	9	2 310	3.5	8
2001–02	415	7	1 920	4.6	1
2002–03	533	9	1 240	2.3	5
2003–04	585	9	1 520	2.6	2
2004–05	712	12	1 300	1.8	5

The regression model chosen as the final run included vessel, time of year (day), depth, and axis-position (point on a line drawn through the fishery that follows the 1000 m contour around the Pukaki Rise), and excluded data from vessels that fished for less than three years. Target species was chosen as a predictor variable in initial runs but was excluded in the final run because it is believed that it is not accurately reported. The final run index declines (Table 10).

Table 10: Final run CPUE index estimates by year, and bootstrap CV estimates from analysis of all tows in the assessment area that caught smooth oreo.

Year	Standardised CPUE index	
	kg/tow	CV
1995–96	3 339	0.316
1996–97	2 266	0.417
1997–98	1 421	0.421
1998–99	1 143	0.243
1999–00	969	0.272
2000–01	1 260	0.319
2001–02	1 247	0.27
2002–03	804	0.451
2003–04	735	0.829
2004–05	243	0.768

4.3.2 Biomass estimates

In all model runs the length-frequency data were poorly fitted, even if selectivity was allowed to vary with depth. This may be due to the use of growth parameters that were derived from another area or to other modelling problems, and is an issue that should be further investigated in the future. In the meantime, the length frequency data were omitted from the stock assessment and the model was fitted to the CPUE data alone. The age at 50% selectivity (a_{50}) was assumed to be knife-edged at 19 yr, corresponding to a fish size of approximately 33 cm. For this model, the MPD estimate of virgin mature biomass (B_0) was 17 400 t, and the current mature biomass was 22% B_0 (Figure 5).

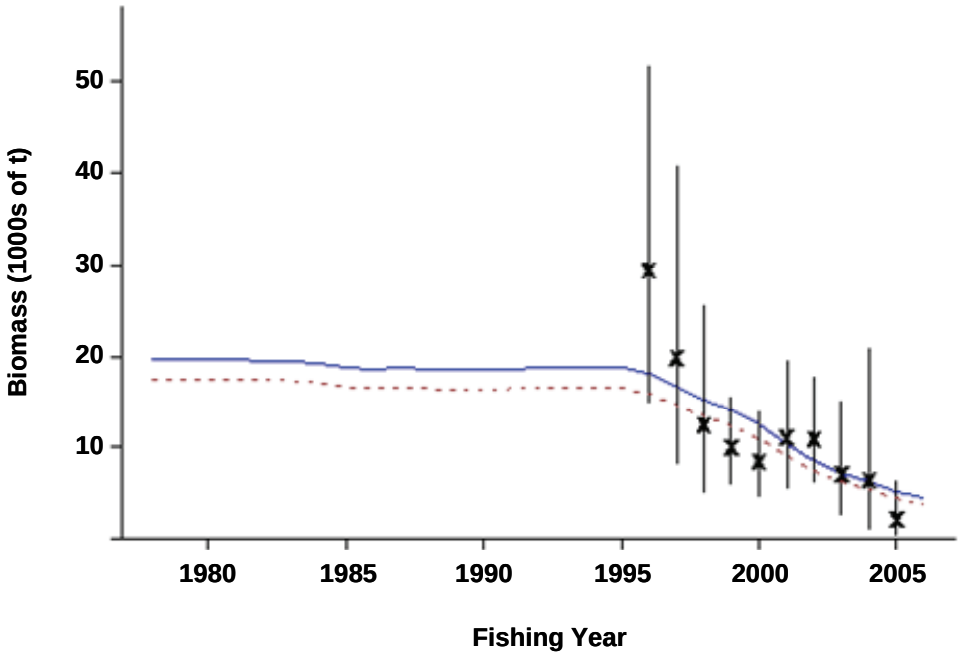


Figure 5: Model run based on CPUE data only, with a_{50} set at 19 yr. The crosses show the CPUE data (vertical lines are the 95% confidence intervals for the indices) and their fits to the vulnerable biomass trajectory (solid line). The dashed line shows the mature biomass trajectory. Fits and trajectories are from MPD estimates.

MCMC runs resulted in extremely skewed distributions of B_0 and $B_{CURRENT}$ with right hand tails extending to very high biomass levels. Based on comparisons with other smooth oreo stocks (e.g., OEO 4), and the observation that the standardised CPUE has declined rapidly even though catches have been relatively small, a modified prior which truncated B_0 at an upper limit of 100 000 t was adopted. This gave a median estimate of B_0 of 24 000 t (90% confidence intervals 16 000 - 78 000 t) and a median estimate of $B_{CURRENT}$ of 9800 t (2400 - 64 000 t). Because of the wide confidence intervals, the current status (%B_0) is highly uncertain with a median of 42% but 90% confidence intervals of 15 - 82% (Table 11 and Figure 6).

Table 11: Mid-year mature biomass estimate (median, with 90% confidence intervals in parentheses) for the model run with only CPUE data. $B_{CURRENT}$ is the mid-year mature biomass in 2006.

Run	B_0(t)	$B_{CURRENT}$(t)	$B_{CURRENT}$(% B_0)
Only CPUE	24 000 (16 000-78 000)	9 800 (2 400-64 000)	42 (15-82)

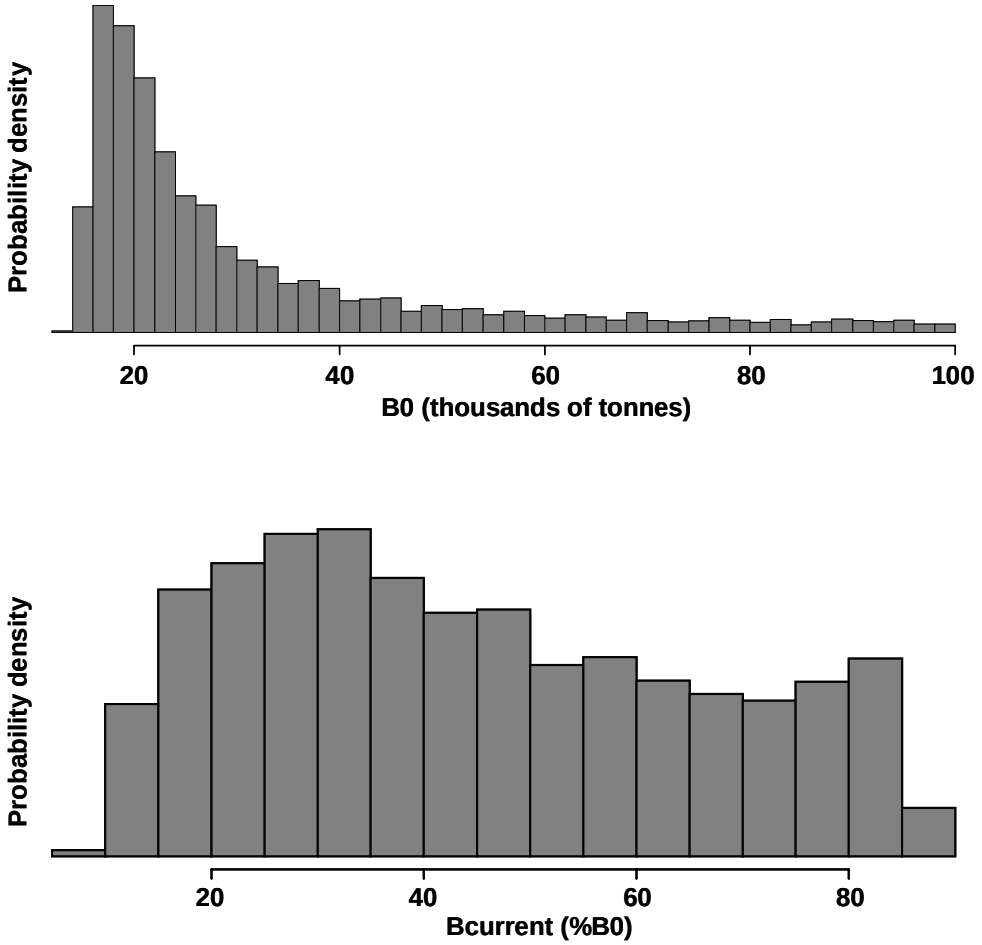


Figure 6: Posterior densities for mature biomass estimates (virgin biomass, and current biomass as a percentage of virgin biomass).

4.3.3 Yield estimates

Estimates of the Maximum Average Yield (MAY) were based on calculations performed for the Southland smooth oreo stock, which has similar life history characteristics (e.g., assumed natural mortality and steepness, and length-age and weight-age relationships) (Coburn *et al*. 2003). For Southland, the MAY was estimated to be 2.3% of the median mature virgin biomass. Applying this value to the estimates of B_0 in Table 11 gives a median estimate of MAY for Pukaki smooth oreo of 550 t, with 90% confidence intervals 370-1800 t.

4.3.4 Projections

No projections were made because of the uncertainty in this assessment.

4,4 Bounty Plateau smooth oreo fishery (part of OEO 6)

The first assessment for this fishery was developed in 2008 and applies only to the study area as defined in Figure 7. There were no fishery-independent abundance estimates, so relative abundance estimates from a post-GPS standardised CPUE analysis and length frequency data collected by MFish (SOP) and Orange Roughy Management Company (ORMC) observers were considered. Biological parameter values estimated for Chatham Rise and Puysegur Bank smooth oreo were used in the assessment because there are no research data from Bounty Plateau.

The following assumptions were made in this analysis.

1. The CPUE analysis indexed the abundance of smooth oreo in the Bounty Plateau (OEO 6) assessment area.
2. The length frequency samples were representative of the population being fished.
3. The biological parameters values used (from other assessment areas) are close to the true values.
4. Recruitment was deterministic and followed a Beverton & Holt relationship with steepness of 0.75.
5. The population of smooth oreo in the assessment area was a discrete stock or production unit.
6. Catch overruns were 0% during the period of reported catch.
7. The catch histories were accurate.
8. The maximum exploitation rate (E_{MAX}) was 0.58.

Data inputs included catch history, relative abundance estimates from a standardised CPUE analysis, and length data from SOP and ORMC observers. The observational data were incorporated into an age-based Bayesian stock assessment (CASAL) with deterministic recruitment to estimate stock size. The stock was considered to reside in a single area, with a partition by sex. Age groups were 1–70 years, with a plus group of 70+ years.

The length-weight and length-at-age population parameters are from fish sampled on the Chatham Rise and Puysegur Bank fisheries (Table 1, Biology section). The natural mortality estimate is based on fish sampled from the Puysegur Bank fishery. The maturity ogive is from fish sampled on the Chatham Rise, and the age at which 50% are mature is between 18 and 19 years for males and between 25 and 26 years for females.

4.4.1 Estimates of fishery parameters and abundance

Catch history

A catch history was derived using declared catches of oreos from OEO 6 (Table 2 in the "Fishery summary" section of the Oreos report above) and tow-by-tow records of catch from the assessment area (Figure 7). The tow-by-tow data were used to estimate the species ratio (SSO/BOE) and therefore the SSO taken. The catch history used in the population model is given in Table 12.

Table 12: Catch history (t) of smooth oreo from the Bounty Plateau fishery assessment area. Catches are rounded to the nearest 10 t.

Year	Catch	Year	Catch
1983–84	620	1996–97	610
1984–85	0	1997–98	650
1985–86	0	1998–99	1 200
1986–87	0	1999–00	870
1987–88	10	2000–01	550
1988–89	0	2001–02	980
1989–90	0	2002–03	1 530
1990–91	20	2003–04	1 420
1991–92	0	2004–05	2 190
1992–93	110	2005–06	1 790
1993–94	490	2006–07	670
1994–95	1 450	2007–08	670
1995–96	900		

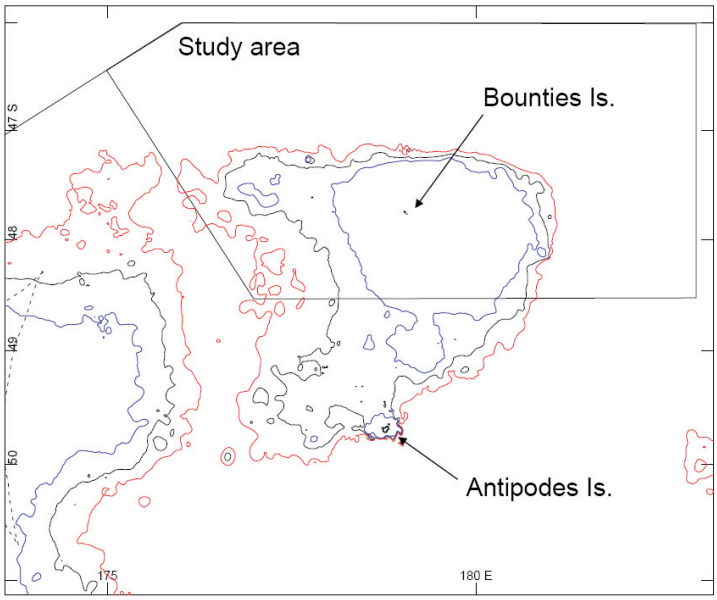


Figure 7: The Bounty Plateau fishery assessment study area.

Length data

Smooth oreo length frequency data collected by SOP and ORMC observers are available from the last twenty eight years. An in-depth analysis indicated that these data were reasonably representative of the fishery in terms of spatial, depth and temporal coverage in those years that had adequate data. Length frequencies were based on tows from the core area (a subset of the study area where about 80% of the catch is take). The data from adjacent years were grouped because some years had few samples (Table 13). The resulting length frequencies are shown in Figure 8. In the final model runs the 1994–95 year of the length frequency series was omitted as it contained very few samples.

Table 13: Core length analysis Year group, year applied and the number of length frequencies. Smooth oreo sample catch weight, fishery catch and sample catch as percentage of the fishery.

Year group	Year applied	No. of lfs	Catch sampled (t)	Fishery catch (t)	% fishery sampled
1991–92 to 1995–96	1994-95	7	88	1505	6
1998–99 to 1999–2000	1998-99	30	246	1121	22
2000–2001 to 2002–03	2001-02	25	398	2261	18
2003–04 to 2004–05	2004-05	29	261	2280	11
2005–06	2005-06	32	379	1121	34
2006–07 to 2007–08	2006-07	17	168	494	34

Relative abundance estimates from CPUE analyses

The small early Soviet fishery had too few data for a standardised CPUE analysis. The standardised CPUE analysis was from the the New Zealand vessel fishery and only included those vessels that had fished at least three years. Just a single vessel puts in significant continuous effort from 1995–2007, with the rest of the vessels effort confined to mainly either 1995–2000 (early) or 2001–2007 (late). Because of this, in addition to the single standardised CPUE covering the entire time period, two separate standardised CPUE indices were calculated covering the early and late periods.The final indices are shown in Tables 14 and 15.

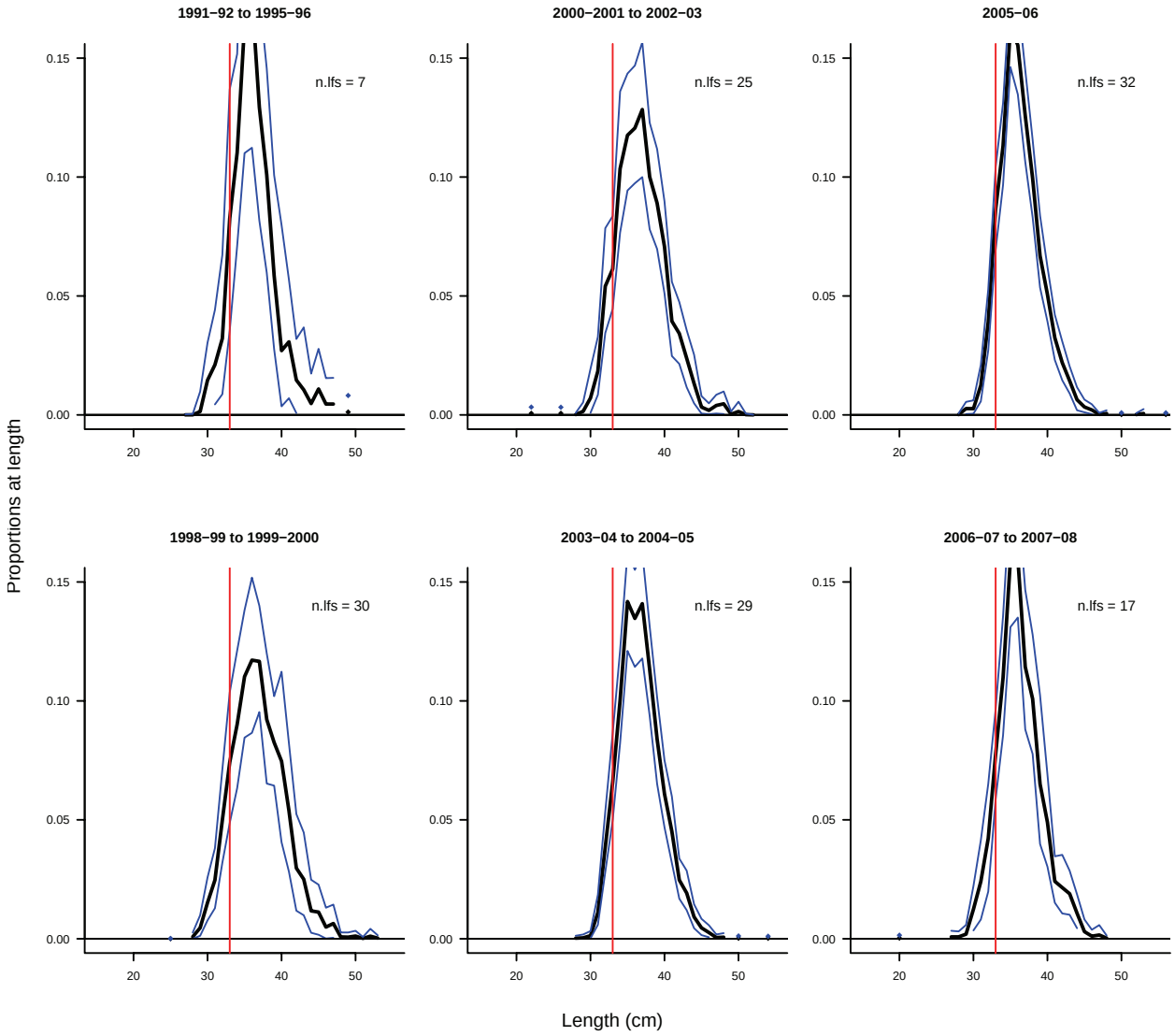


Figure 8: Length frequency distribution plots for core data only (thick lines) with 95% confidence interval (thin lines)

Table 14: Early and late period CPUE combined index estimates by year, and bootstrap c.v. estimates.

	Kg/tow	C.v	Late period	Kg/tow	C.v
1995–96	3551	0.423	2000–01	850	0.487
1996–97	3322	0.496	2001–02	2976	0.274
1997–98	2306	0.980	2002–03	1489	0.243
1998–99	781	0.391	2003–04	1727	0.260
1999–2000	1536	0.306	2004–05	1604	0.227
			2005–06	1386	0.310
			2006–07	966	0.232

Table 15: Single period CPUE combined index estimates by year, and bootstrap c.v. estimates.

	Kg/tow	C.v
1995–96	7472	0.286
1996–97	4453	0.735
1997–98	3366	1.264
1998–99	1444	0.406
1999–2000	2835	0.286
2000–01	2817	0.436
2001–02	632	0.680
2002–03	1973	0.663
2003–04	1296	0.615
2004–05	1284	0.445
2005–06	1289	0.563
2006–07	1056	1.200

4.4.2 Biomass estimates

In all preliminary model runs the length-frequency data series were not well fitted to, and gave a strong but contrasting biomass signal relative to the CPUE indices. Therefore, for final model runs, the length frequency data was down-weighted by using just the 1999 length frequency.

The basecase model used early and late period CPUE indices, and the 1999 length frequency data, and current mature biomass was estimated to be 33% of a virgin biomass of 17 400 t (Figure 9).

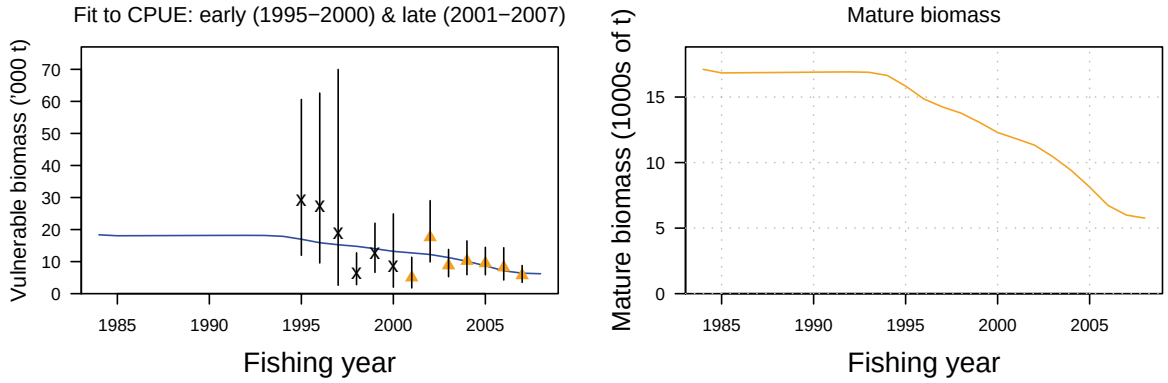


Figure 9: Model run showing the MPD fit to the CPUE data (vertical lines are the 95% confidence intervals for the indices) and the trajectory of mature biomass.

Two sensitivity model runs were carried out with the 1999 length frequency data dropped from the model, but retaining the fishery selectivity estimated using the length data. The first used the early and late period CPUE indices and current biomass was estimated to be 39% of a virgin biomass of 19 300 t. In the second, the single CPUE series covering the same period was used and current biomass was estimated to be 17% of a virgin biomass of 13 900 t. No MCMC runs were carried out with the basecase model as the sensitivity run showed that the assessment was quite different if the CPUE analysis was not split into two series.

Biomass estimates are uncertain because of the reliance on commercial CPUE data, the use of biological parameter estimates from other oreo stocks, and because of contrasting biomass signals from using either a single or split CPUE indices.

4.4.3 Projections

No projections were made because of the uncertainty in the assessment.

4.5 Pukaki Rise black oreo stock (part of OEO 6)

This 2009 assessment was the first for this stock applying to the area defined in Figure 10. In 2009, this was the largest black oreo fishery in the New Zealand EEZ with mean (1994–95 to 2007–08) annual catches of 1800 t, but with over 3000 t taken in the previous two years, mainly by New Zealand vessels. There was an early Soviet fishery (1980–81 to 1984–85) with mean annual catches of about 1700 t. Fishery-independent abundance estimates were not available, so a series of relative abundance indices, based on an analysis of post-GPS standardised CPUE, have been developed. Length frequency data collected by MFish (SOP) and Orange Roughy Management Company (ORMC) observers were included in the model. The assessment used biological parameter values estimated for Chatham Rise and Puysegur Bank black oreo because no biological data from Pukaki Rise are available.

The following assumptions were made in this assessment.

1. The CPUE is an index of abundance of black oreo in the Pukaki Rise (OEO 6) assessment area.
2. The length frequency samples were representative of the population being fished.
3. The ranges used for the biological values covered their true values.
4. Recruitment was deterministic and followed a Beverton & Holt relationship with steepness of 0.75.

5. The population of black oreo in the assessment area was a discrete stock or production unit.
6. The catch histories were accurate with no assumed overruns.
7. The maximum exploitation rate (E_{MAX}) was 0.80.
8. The prior for stock size was bounded at an upper limit of 150 000 t.

Data inputs included catch history, relative abundance estimates from a standardised CPUE analysis, and length data from SOP and ORMC observers. The observational data were incorporated into an age-based Bayesian stock assessment (CASAL) with deterministic recruitment to estimate stock size. Life history parameters are from Table 1 of the Biology section at the beginning of the Oreo report.

4.5.1 Estimates of fishery parameters and abundance

Catch history

A catch history for black oreo was derived (Table 16) using declared catches of OEO from OEO 6 (Table 2 in the "Fishery summary" section of the Oreos report above) and tow-by-tow records of catch from the assessment area (Figure 10). The catch history used in the population model is given in Table 16.

Table 16: Catch history (t) of black oreo from the Pukaki Rise fishery assessment area.

Year	Catch	Year	Catch	Year	Catch
1978–79	17	1988–89	0	1998–99	1 181
1979–80	5	1989–90	0	1999–00	1 061
1980–81	283	1990–91	15	2000–01	1 158
1981–82	4 180	1991–92	27	2001–02	988
1982–83	1 084	1992–93	27	2002–03	1 701
1983–84	1 150	1993–94	10	2003–04	1 530
1984–85	1 704	1994–95	242	2004–05	1 588
1985–86	46	1995–96	1 352	2005–06	2 811
1986–87	0	1996–97	2 413	2006–07	3 434
1987–88	0	1997–98	2 244	2007–08	3 346

Length data

Black oreo length frequency data collected by SOP and ORMC observers are available from the last twelve years (Table 17). An analysis indicated that there was a trend in fish size across years (with smaller mean lengths in more recent years) and with depth (deeper fish being larger). The length data were considered reasonably representative of the fishery in terms of spatial, depth and temporal coverage for those years that had adequate data. The length data were stratified into two depth bins: shallow (less than 900 m), and deep strata (greater than 900 m). Length data from adjacent years were grouped because of the low number of samples in some years (Figure 11). There is no trend in mean length over the first six year-groups, but fish sizes appear to be generally smaller in the later year-groups with the mode of the distributions shifting to the left in the plots for 2005–6, 2006–7, and 2007–8

Table 17: Summary of length frequency data for black oreo available from the assessment area. The table shows the number of tows sampled by year, the sample source, and the year group.

		Number of tows sampled		
Year	Year group	SOP	ORMC	All
1996–97	97–98	7	0	7
1997–98	97–98	25	0	25
1998–99	99–00	7	44	51
1999–00	99–00	6	0	6
2000–01	01–02	8	18	26
2001–02	01–02	2	8	10
2002–03	03–05	7	2	9
2003–04	03–05	18	0	18
2004–05	03–05	21	0	21
2005–06	06	21	42	63
2006–07	07	154	11	165
2007–08	08	31	9	40
Total		307	134	441

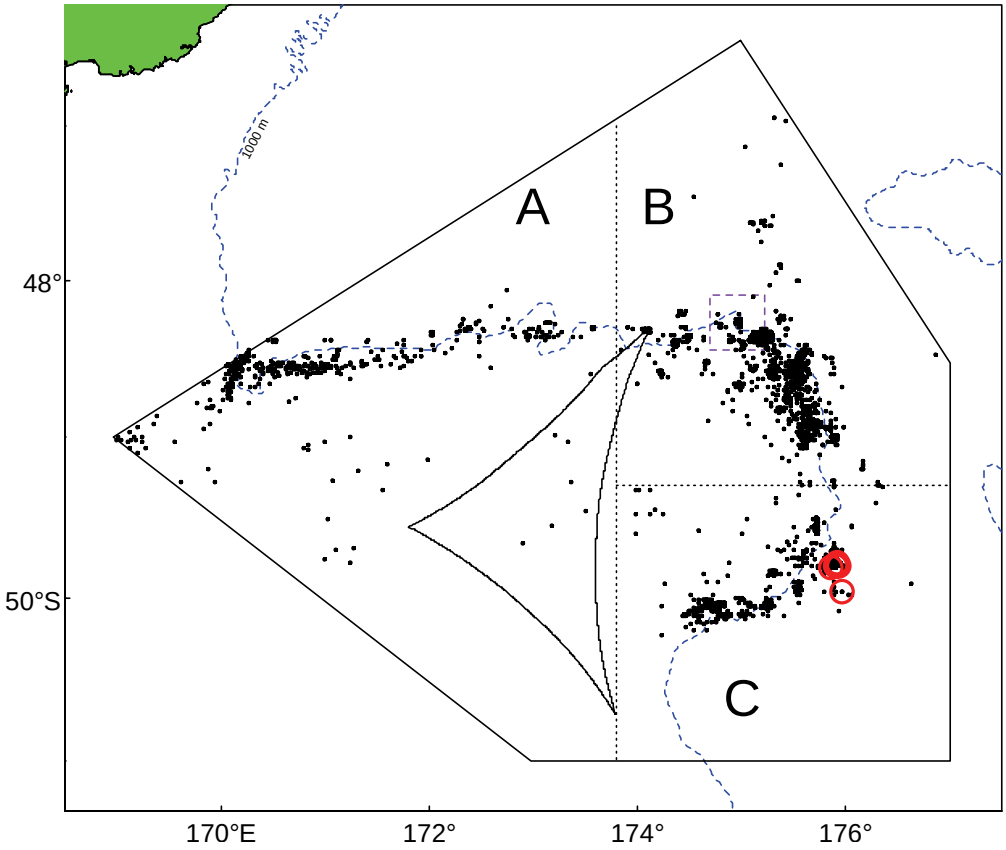


Figure 10: The Pukaki Rise fishery black oreo assessment area (polygon) abutting the boundary of OEO 6/OEO 1 in the north-west. The dots show tows positions where black oreo catch was reported from 1980–81 to 2007–08. A, B, and C are the three areas defined in the standardised CPUE analysis.

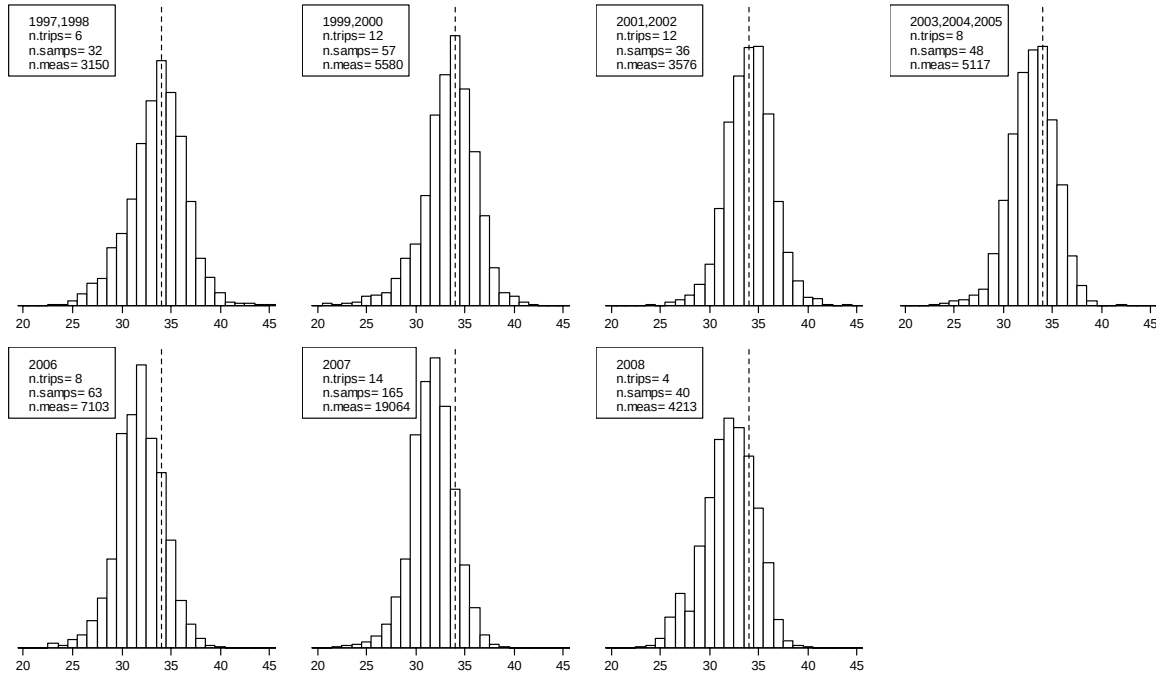


Figure 11: Observer length frequencies for Pukaki Rise black oreo, stratified by depth (see text), and grouped by years (in the legends 1997=1996–97 etc.). The vertical dashed lines indicate the approximate overall mean length as an aid to comparing the distributions.

Relative abundance estimates from CPUE analyses

The fishery taking Pukaki Rise black oreo divides into two distinct periods: a pre-GPS period 1980–81 to 1984–85 when much of the catch was taken by Soviet and Korean vessels, and a post-GPS

period, 1995–96 to 2007–08 when most of the catch was taken by New Zealand vessels. The intervening period was characterised by low catches and the introduction of GPS technology in the fleet. Standardisation of CPUE for the pre-GPS period was attempted but rejected due to poor linkage of vessels across years and the shifting of fishing effort between areas.

The standardised CPUE analysis of Pukaki Rise black oreo was therefore based on the post-GPS period and used regression based methods similar to those in previous oreo CPUE analyses but, because the fraction of zero tows was low, only a positive catch model was used. The annual c.v.s for the index series used in the assessment model were derived from the regression model standard errors. The analysis was restricted to data from vessels fishing in the eastern areas (B and C in Figure 10) with a minimum of 20 successful tows for black oreo in at least three years . Tows orginating from a set of ten features identified (by the catch history) as mainly orange roughy or smooth oreo features and which targeted these two species were not used. The selected explanatory variables in this model were depth, tow duration, and area, and the resultant indices showed a decline over the period. The number of tows and CPUE indices are summarised in Table 18.

Table 18: Summary of data used as input to the standardised core target CPUE analysis, CPUE index values and c.v.s by year as used in the assessment model.

Year	No. of tows	CPUE index	c.v.	Year	No. of tows	CPUE index	c.v.
1995–96	63	1.91	0.11	2002–03	303	1.13	0.14
1996–97	55	1.50	0.15	2003–04	324	1.17	0.13
1997–98	187	1.58	0.11	2004–05	294	0.89	0.17
1998–99	221	1.35	0.12	2005–06	465	1.05	0.14
1999–00	242	0.94	0.17	2006–07	618	0.90	0.15
2000–01	189	1.21	0.14	2007–08	747	0.78	0.18
2001–02	167	1.17	0.15				

4.5.2 Biomass estimates

The base case (NoLF) employed a two-step approach, estimating the fishery selectivities from the observer length data during the first phase followed by a second estimation phase where the selectivities were fixed at the MPD values from the first phase and estimating the biomass-related parameters solely on the basis of the CPUE relative biomass indices. The WG chose a basecase with M fixed at its best estimate (0.044). Other cases investigated the sensitivity of the model to alternative fixed values for M, representing the range of plausible values for this parameter (0.029 and 0.066) and the influence of the length frequency data (M fixed at 0.044). The three NoLF MCMC runs used a prior on B_0 which limited this parameter to a maximum of 150 000 t, based on estimates of B_0 from other oreo fisheries. In the basecase, the current status ($\%B_0$) is highly uncertain with a median of 44% and 95% confidence intervals of 19–80% (Table 19, Figure 12).

Table 19: Mid-year mature biomass estimates (medians) and 95% confidence intervals for the basecase model run. $B_{CURRENT}$ is the mid-year mature biomass in 2009, V=vulnerable biomass.

	NoLF, M=0.044		
Biomass estimates	Median	5% CI	95% CI
B_0	40 900	26 900	116 000
$B_{CURRENT}$	18 000	5 060	92 400
$B_{CURRENT}$ ($\%B_0$)	44	19	80
V_0	39 700	26 200	113 000
$V_{CURRENT}$	18 600	6 110	90 600
$V_{CURRENT}$ ($\%V_0$)	47	23	81

4.5.3 Yield estimates

No yield estimates were made.

4.5.4 Projections

Projections were made using the basecase model, assuming deterministic recruitment and the current catch (3346 t) for the next five years (Figure 12). The estimated probability of the biomass being less than 20% B_0 went from 0.06 in 2008–09 to 0.47 in 2013–14.

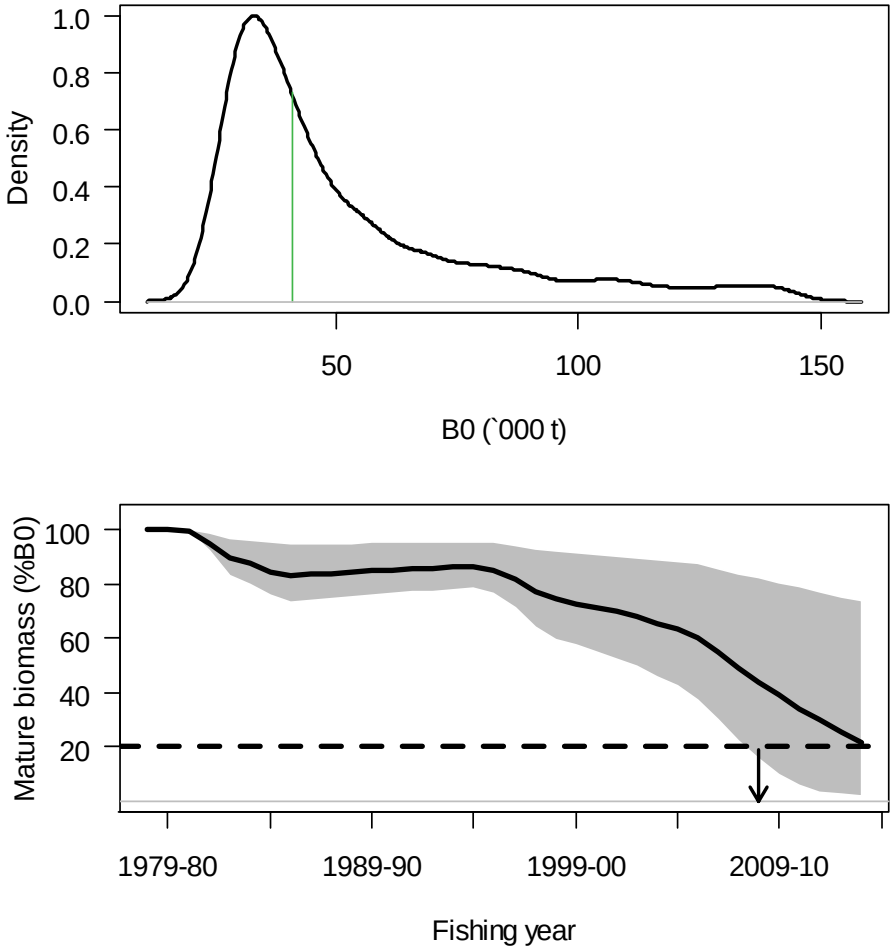


Figure 12: Biomass estimates (B_0) and fishery projections of mature biomass (as %B_0) for the next five fishing years (to 2013–14) for the basecase,. A prior on B_0 limited it to a maximum of 150 000 t. Catch levels were assumed constant at the current level (3346 t).

4.6 Other oreo fisheries in OEO 1 and OEO 6

4.6.1 Estimates of fishery parameters and abundance

Relative abundance estimates from trawl surveys

Two comparable trawl surveys were carried out in the Puysegur area of OEO 1 (TAN9208 and TAN9409). The 1994 oreo abundance estimates are markedly lower than the 1992 values (Table 20).

Table 20: OEO 1. Research survey abundance estimates (t) for oreos from the Puysegur and Snares areas. N is the number of stations. Estimates for smooth oreo were made based on a recruited length of 34 cm TL. Estimates for black oreo were made using knife-edge recruitment set at 27 cm TL.

Smooth oreo					
Puysegur area (strata 0110–0502)					
	Mean biomass	Lower bound	Upper bound	CV (%)	N
1992	1 397	736	2 058	23	82
1994	529	86	972	41	87
Snares area (strata 0801–0802)					
	Mean biomass	Lower bound	Upper bound	CV (%)	N
1992	2 433	0	5 316	59	8
1994	118	0	246	54	7
Black oreo					
Puysegur area (strata 0110–0502)					
	Mean biomass	Lower bound	Upper bound	CV (%)	N
1992	2 009	915	3 103	27	82
1994	618	0	1 247	50	87
Snares area (strata 0801–0802)					
	Mean biomass	Lower bound	Upper bound	CV (%)	N
1992	3 983	0	8 211	53	8
1994	1 564	0	3 566	64	7

4.6.2 Biomass estimates
Estimates of virgin and current biomass are not yet available.

4.6.3 Estimation of Maximum Constant Yield (MCY)
MCY cannot be estimated because of the lack of current biomass estimates for the other stocks.

4.6.4 Estimation of Current Annual Yield (CAY)
CAY cannot be estimated because of the lack of current biomass estimates for the other stocks.

4.6.5 Other factors
Recent catch data from this fishery may be of poor quality because of area misreporting.

5. STATUS OF THE STOCKS

New assessment results are reported here for the 2007 Southland assessment.

Stock Structure Assumptions
Oreos in the OEO1+6 FMAs are managed as a single stock but assessed as 4 separate stocks, separated by species and geography.

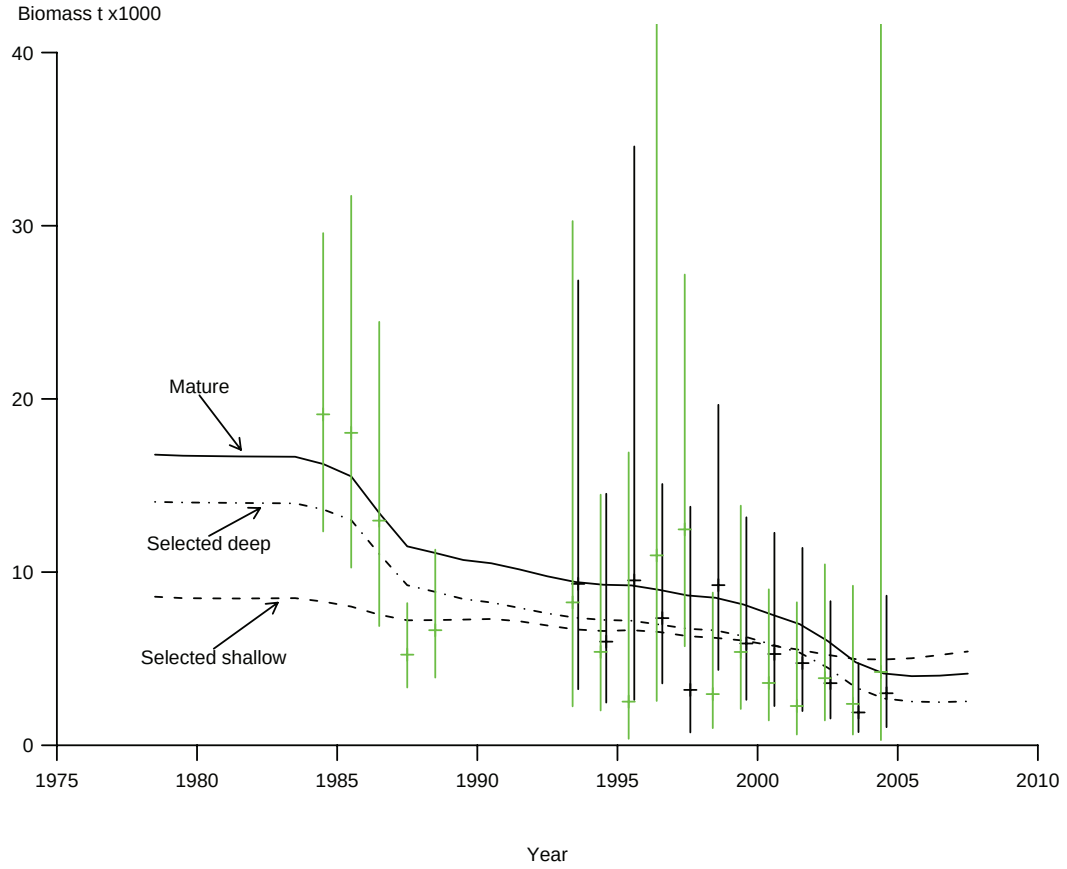
The Southland smooth oreo stock is based along the east coast of the south island in OEO1 but extends slightly into OEO3. It does not include the Waitaki and Eastern canyon areas but is likely to have some level of mixing with other smooth oreo fishstocks. The Pukaki Rise smooth oreo stock comprises the major part of OEO6 stocks and is centered on its namesake. Some mixing with other smooth oreo fishstocks is thought to occur. The Bounty Plateau smooth oreo stock is located across the Bounty Plateau and the Bounty Islands. Some mixing is thought to occur with other smooth oreo fishstocks.

The Pukaki Rise black oreo stock is the main black oreo fishstock in OEO6 and the largest black oreo fishstock in the New Zealand EEZ. It extends the entire length of the Rise towards OEO1. It is assessed separately to other fishstocks but managed as a part of OEO6. Black oreos on the Pukaki Rise are thought to be non-mixing with other black oreo fishstocks.

- **OEO1+3A Southland (Smooth Oreos)**

Stock Status	
Year of Most Recent Assessment	2007
Assessment Runs Presented	One base case only
Reference Points	Target(s): 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	B_{2007} was estimated at 27% B_0, Unlikely (< 40%) to be at or above the target.
Status in relation to Limits	B_{2007} was estimated to be 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



Predicted biomass trajectories for the 2007 base case assessment. Mature biomass and selected biomass for the shallow and deep fisheries. Also shown are the CPUE indices from the pre- and post-GPS analysis for the deep fishery (in gray) and the post-GPS analyses for the shallow fishery (in black). CPUE indices are shown with +/- 2 s.e. confidence interval indicated by the vertical lines (the post-GPS CPUE data are slightly offset to avoid over plotting). The CPUE data were scaled by catchability coefficients to match the biomass scale.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Biomass has been declining at a steady rate since the late 1980s.
Recent Trend in Fishing Mortality or Proxy	Unknown
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis	
Stock Projections or Prognosis	None because of assessment uncertainty.
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unknown Hard Limit: Unknown

Assessment Methodology	
Assessment Type	Type 1 – Quantitative stock assessment
Assessment Method	Age-structured CASAL model with Bayesian estimation of posterior distributions.
Main data inputs	- Length-frequency data collected by SOP and ORMC observers - A second, earlier fishery based on Soviet vessels was included in the assessment using historical catch data. - Standardised CPUE indices were derived from the historical and modern datasets.

Period of Assessment	Latest assessment: 2007	Next assessment: 2012
Changes to Model Structure and Assumptions	None	
Major Sources of Uncertainty	- Scarcity of observer length frequency data - Poor quality area catch data due to significant misreporting - Lack of fishery-independent abundance estimates creates reliance on commercial CPUE data.	

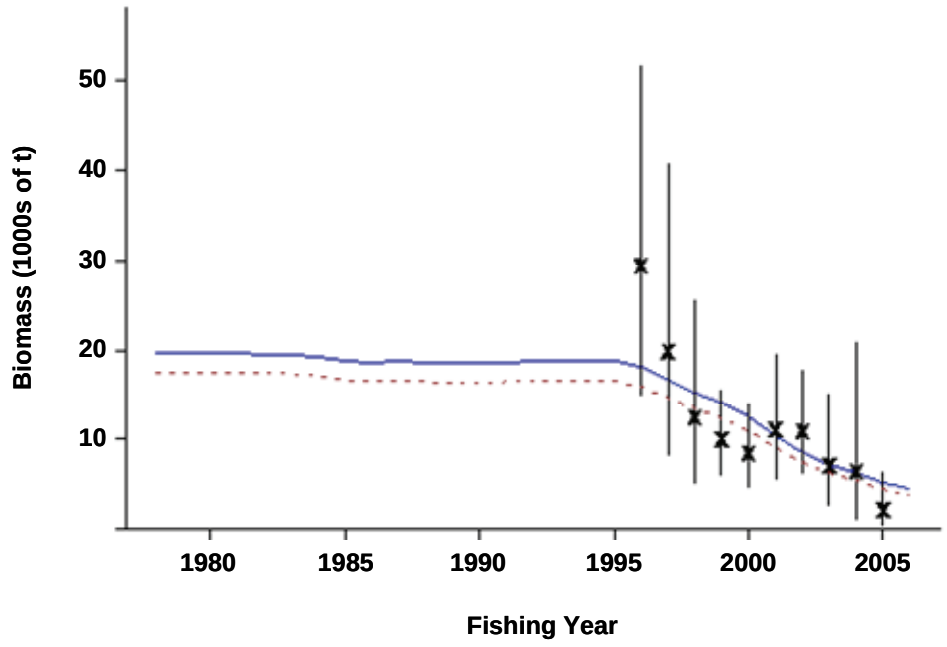
Qualifying Comments
None

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.

- **OEO6 Pukaki Rise (Smooth Oreos)**

Stock Status	
Year of Most Recent Assessment	2006
Assessment Runs Presented	A base case with 4 sensitivities.
Reference Points	Target(s): 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	For the base case, B_{2006} was estimated at 42% B_0. B_{2006} is About As Likely As Not (40-60%) to be at or above the target.
Status in relation to Limits	B_{2006} 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



Model run based on CPUE data only, with a_{50} set at 19 yr. The crosses show the CPUE data (vertical lines are the 95% confidence intervals for the indices) and their fits to the vulnerable biomass trajectory (solid line). The dashed line shows the mature biomass trajectory. Fits and trajectories are from MPD estimates.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Biomass is estimated to have been declining since 1996
Recent Trend in Fishing Mortality or Proxy	Unknown
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis	
Stock Projections or Prognosis	No projections were made due to the uncertainties in the assessment.
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unknown Hard Limit: Unknown

Assessment Methodology		
Assessment Type	Type 1 – Quantitative stock assessment	
Assessment Method	Age-structured CASAL model with Bayesian estimation of posterior distributions.	
Main data inputs	- Catch history - Standardised CPUE abundance estimates - Length data (SOP, ORMC observers)	
Period of Assessment	Latest assessment: 2006	Next assessment: Unknown
Changes to Model Structure and Assumptions	None	
Major Sources of Uncertainty	- Lack of fishery-independent biomass estimates creates reliance on commercial CPUE data - Lack of biological parameters specific to Smooth Oreo in the target area – data from Chatham Rise/ Puysegur Bank had to be substituted instead.	

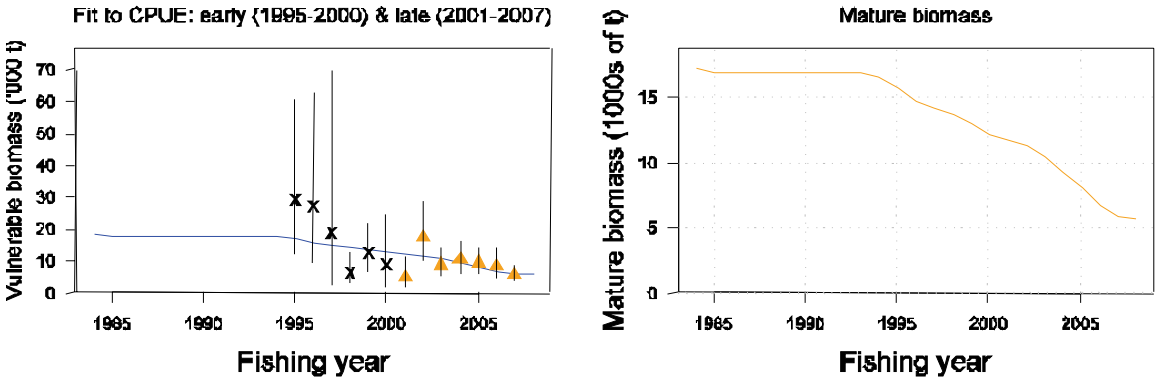
Qualifying Comments
None

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.

- **OEO6 Bounty Plateau (Smooth Oreos)**

Stock Status	
Year of Most Recent Assessment	2008
Assessment Runs Presented	A base case with 2 sensitivity runs
Reference Points	Target(s): 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Targe	B_{2008} was estimated at 33% B_0; Unlikely (< 40%) to be at or above the target.
Status in relation to Limits	B_{2008} 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



Model run showing the MPD fit to the CPUE data (vertical lines are the 95% confidence intervals for the indices) and the trajectory of mature biomass.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Biomass is estimated to have been decreasing rapidly since 1995.
Recent Trend in Fishing Mortality or Proxy	Unknown
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	-

Projections and Prognosis	
Stock Projections or Prognosis	No projections were made because of the uncertainty of the assessment.
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unknown Hard Limit: Unknown

Assessment Methodology		
Assessment Type	Type 1 – Quantitative stock assessment	
Assessment Method	Age-structured CASAL model with Bayesian estimation of posterior distributions.	
Main data inputs	- Catch history - Abundance estimates derived from a standardised CPUE - Length data from SOP and ORMC observers	
Period of Assessment	Latest assessment: 2008	Next assessment: Unknown
Changes to Model Structure and Assumptions	None	
Major Sources of Uncertainty	- Reliance on commercial CPUE data - To estimate biological parameters, data was used from different stocks (Puysegur Bank + Chatham Rise) to the target stock - Using a single CPUE index vs. split indices give contrasting biomass signals.	

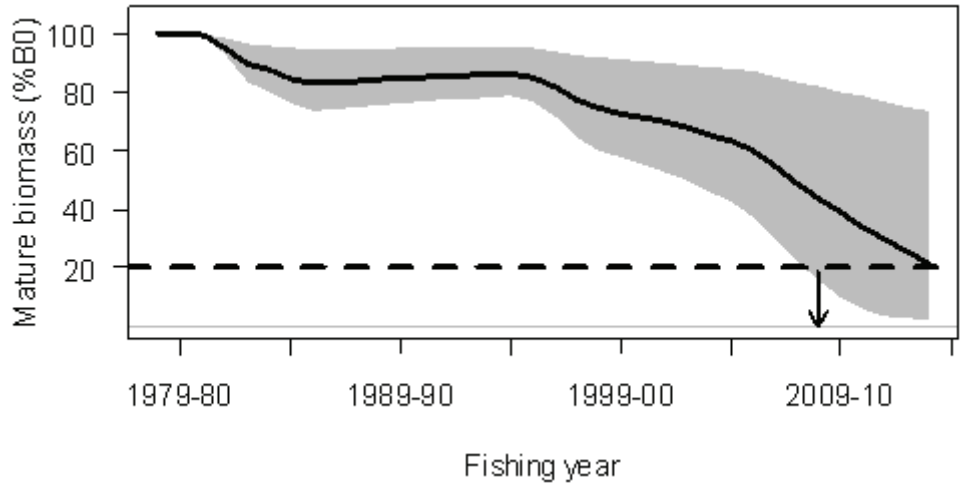
Qualifying Comments
None

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.

- **OEO6 Pukaki Rise (Black Oreos)**

Stock Status	
Year of Most Recent Assessment	2009
Assessment Runs Presented	A base case and 3 sensitivity runs
Reference Points	Target: 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	B_{2009} was estimated at 44% B_0. B_{2009} is About As Likely As Not (40-60%) to be at or above the target.
Status in relation to Limits	B_{2009} was estimated to be 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



Black Oreo Pukaki Rise Stock - Mature biomass trajectories as a percentage of virgin biomass from the analysis of the "NoLF" case with M = 0.044 (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 estimated to have been decreasing since the 1980s with a major decline starting about 1995.
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	Biomass is likely to decline in the next 5 years if catches are maintained at the 2007-08 level (3346 t). Estimated probability of the biomass being less than 20% B_0 went from 0.06 in 2008–09 to 0.47 in 2013–14.
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: About As Likely As Not (40-60%) Hard Limit: Unknown

Assessment Methodology	
Assessment Type	Type 1 – Quantitative stock assessment
Assessment Method	Age-structured CASAL model

Main data inputs	- Catch history data - Abundance estimates derived from a standardised CPUE - Length data from SOP and ORMC observers	
Period of Assessment	Latest assessment: 2009	Next assessment: Unknown
Changes to Model Structure and Assumptions	None	
Major Sources of Uncertainty	- Lack of fisheries-independent data causes reliance on commercial CPUE data. - Lack of biological parameter estimates specific to Black Oreo in this assessment area.	

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.

6. FOR FURTHER INFORMATION

Coburn RP., Doonan IJ., McMillan PJ. 2002. CPUE analyses for the Southland black oreo and smooth oreo fisheries, 1977–78 to 1999–2000. New Zealand Fisheries Assessment Report 2002/3. 28 p.

Coburn, RP; Doonan, I.J.; McMillan, P.J. 2002. CPUE analyses for the major black oreo and smooth oreo fisheries in OEO 6, 1980–81 to 1999–2000. New Zealand Fisheries Assessment Report 2002/6. 29p.

Coburn RP., Doonan IJ., McMillan PJ. 2003. Stock assessment of smooth oreo in the Southland fishery (OEO 1 and 3A) for 2003. New Zealand Fisheries Assessment Report 2003/62. 32p.

Coburn, RP., Doonan, IJ., McMillan, PJ. 2008. A stock assessment of smooth oreo in Southland (part of OEO 1 & OEO 3A). New Zealand Fisheries Assessment Report 2008/37. 43 p.

Coburn RP., McMillan PJ., Gilbert DJ. 2007. Inputs for a stock assessment of smooth oreo, Pukaki Rise (part of OEO 6). New Zealand Fisheries Assessment Report 2007/23. 32p

McKenzie A. 2007. Stock assessment for east Pukaki Rise smooth oreo (part of OEO 6). New Zealand Fisheries Assessment Report 2007/34. 27p.

McMillan PJ., Coburn RP., Hart AC., Doonan IJ. 2002. Descriptions of black oreo and smooth oreo fisheries in OEO 1, OEO 3A, OEO 4, and OEO 6 from 1977–78 to the 2000–01 fishing year. New Zealand Fisheries Assessment Report. 2002/40.