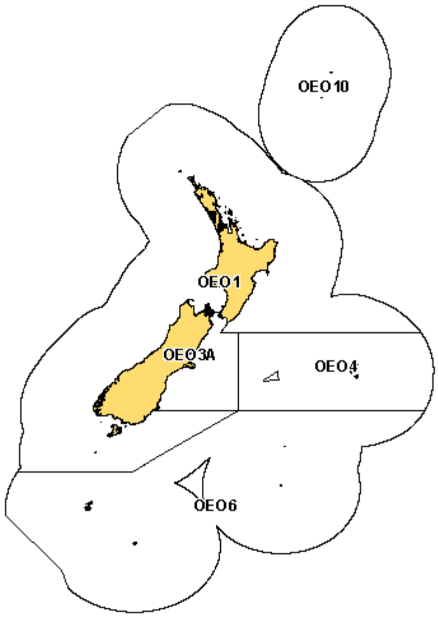
OREOS (OEO)

(*Allocyttus niger*, *Neocyttus rhomboidalis* and *Pseudocyttus maculatus*)



1. INTRODUCTION

The main black oreo and smooth oreo fisheries have been assessed separately and individual reports produced for each as follows:

1. OEO 3A black oreo and smooth oreo
2. OEO 4 black oreo and smooth oreo
3. OEO 1 and OEO 6 black oreo and smooth oreo

2. BIOLOGY

Black oreo

Occur from 600 to 1300 m depth. The geographical distribution south of about 45° S is not well known. It is a southern species and is abundant on the south Chatham Rise, along the east coast of the South Island, the north and east slope of Pukaki Rise, the Bounty Platform, the Snares slope, Puysegur Bank and the northern end of the Macquarie Ridge. They probably occur right round the slope of the Campbell Plateau.

Spawning occurs from late October to at least December and is widespread on the south Chatham Rise. Mean length at maturity for females, estimated from Chatham Rise trawl surveys (1986–87, 1990, 1991–93) using macroscopic gonad staging, is 34 cm TL.

They appear to have a pelagic juvenile phase, but little is known about this phase because only about 12 fish less than 21 cm TL have been caught. The pelagic phase may last for 4–5 years to lengths of 21–26 cm TL.

Unvalidated age estimates were obtained for Chatham Rise and Puysegur-Snares fish in 1995 and 1997 respectively using counts of the zones (assumed to be annual) observed in thin sections of otoliths. These estimates indicate that black oreo is slow growing and long lived. Maximum estimated age was 153 years (45.5 cm TL fish). Australian workers used the same methods, i.e., sections of otoliths, and reported similar results.

A von Bertalanffy growth curve was fitted to the Puysegur samples only (Table 1). Estimated age at maturity for females was 27 years.

A first estimate of natural mortality (M), 0.044 (yr^{-1}), was made in 1997 using the Puysegur growth data only. This estimate is uncertain because it appeared that the otolith samples were taken from a well fished part of the Puysegur area.

Black oreo appear to settle over a wide range of depths on the south Chatham Rise, but appear to prefer to live in the depth interval 600–800 m that is often dominated by individuals with a modal size of 28 cm TL.

Smooth oreo

Occur from 650 to about 1500 m depth. The geographical distribution south of about 45° S is not well known. It is a southern species and is abundant on the south Chatham Rise, along the east coast of the South Island, the north and east slope of Pukaki Rise, the Bounty Platform, the Snares slope, Puysegur Bank and the northern end of the Macquarie Ridge. They probably occur right round the slope of the Campbell Plateau.

Spawning occurs from late October to at least December and is widespread on the south Chatham Rise in small aggregations. Mean length at maturity for females, estimated from Chatham Rise trawl surveys (1986–87, 1990, 1991–93) using macroscopic gonad staging, is 40 cm TL.

They appear to have a pelagic juvenile phase, but little is known about this phase because only about six fish less than 16 cm TL have been caught. The pelagic phase may last for 5–6 years to lengths of 16–19 cm TL.

Unvalidated age estimates were obtained for Chatham Rise and Puysegur-Snares fish in 1995 and 1997 respectively using counts of the zones (assumed to be annual) observed in thin sections of otoliths. These estimates indicate that smooth oreo is slow growing and long lived. Maximum estimated age was 86 years (51.3 cm TL fish). Australian workers used the same methods, i.e., sections of otoliths, and reported similar results.

A von Bertalanffy growth curve was fitted to the age estimates from Chatham Rise and Puysegur-Snares fish combined and the parameters estimated for the growth curve are in Table 1. Estimated age at maturity for females was 31 years.

An estimate of natural mortality, 0.063 (yr^{-1}), was made in 1997. The estimate was from a moderately exploited population of fish from the Puysegur region. The Puysegur fishery started in 1989–90 and by August-September 1992 (when the otoliths were sampled) about 24% of the smooth oreo catch from 1989–90 to 1995–96 had been taken. Future estimates of M should, if possible, be made from an unexploited population.

There are concentrations of recently settled smooth oreo south and south west of Chatham Island, although small individuals (16–19 cm TL) occur widely over the south Chatham Rise at depths of 650–800 m.

Table 1: Biological parameters used for black oreo and smooth oreo stock assessments. –, not estimated.

Parameter	Symbol (unit)	Female	Male	Unsexed
(a) Black oreo				
Natural mortality	M (yr^{-1})	0.044	0.044	0.044
Age at recruitment	A_r (yr)	–	–	–
Age at maturity	A_m (yr)	27	–	–
von Bertalanffy parameters	L_∞ (cm, TL)	39.9	37.2	38.2
	k (yr^{-1})	0.043	0.056	0.05
	t_0 (yr)	-17.6	-16.4	-17.0
Length–weight parameters	a	0.008	0.016	0.0078
	b	3.28	3.06	3.27
Length at recruitment	(cm, TL)	–	–	–
Length at maturity	(cm, TL)	34	–	–
Recruitment variability	σ_R	0.65	0.65	0.65
Recruitment steepness		0.75	0.75	0.75
Fishing mortality	F_{max} (yr^{-1})	0.9	0.9	–
Max exploitation rate	E_{max} (yr^{-1})	–	–	0.67
(b) Smooth oreo				
Natural mortality	M (yr^{-1})	0.063	0.063	
Age at recruitment	A_r (yr)	21	21	
Age at maturity	A_m (yr)	31	–	
von Bertalanffy parameters	L_∞ (cm, TL)	50.8	43.6	
	k (yr^{-1})	0.047	0.067	
	t_0 (yr)	-2.9	-1.6	
Length–weight parameters	a	0.029	0.032	
	b	2.90	2.87	
Length at recruitment	(cm, TL)	34	–	
Length at maturity	(cm, TL)	40	–	
Recruitment variability	σ_R	0.65	0.65	
Recruitment steepness		0.75	0.75	
Fishing mortality	F_{max} (yr^{-1})	0.9	0.9	

3. STOCKS AND AREAS

Black oreo

Stock structure of Australian and New Zealand samples was examined using genetic (allozyme and mitochondrial DNA) and morphological counts (fin rays, etc.). It was concluded that the New Zealand samples constituted a stock distinct from the Australian sample based on "small but significant difference in mtDNA haplotype frequencies (with no detected allozyme differences), supported by differences in pyloric caeca and lateral line counts". The genetic methods used may not be suitable tools for stock discrimination around New Zealand.

A New Zealand pilot study examined stock relationships using samples from four management areas (OEO 1, OEO 3A, OEO 4 & OEO 6) of the New Zealand EEZ. Techniques used included genetic (nuclear and mitochondrial DNA), lateral line scale counts, settlement zone counts, parasites, otolith microchemistry, and otolith shape. Lateral line scale and pyloric caeca counts were different between samples from OEO 6 and the other three areas. The relative abundance of three parasites differed significantly between all areas. Otolith shape from OEO 3A samples was different to that from OEO 1 and OEO 4, but OEO 1, OEO 4 and OEO 6 otolith samples were not morphologically different. Genetic, otolith microchemistry, and settlement zone analyses showed no regional differences.

Smooth oreo

Stock structure of Australian and New Zealand samples was examined using genetic (allozyme and mitochondrial DNA) and morphological counts (fin rays, etc.). No differences between New Zealand and Australian samples were found using the above techniques. A broad scale stock is suggested by these results but this seems unlikely given the large distances between New Zealand and Australia. The genetic methods used may not be suitable tools for stock discrimination around New Zealand.

A New Zealand pilot study examined stock relationships using samples from four management areas (OEO 1, OEO 3A, OEO 4 & OEO 6) of the New Zealand EEZ. Techniques used included genetic (nuclear and mitochondrial DNA), lateral line scale counts, settlement zone counts, parasites, otolith microchemistry, and otolith shape. Otolith shape from OEO 1 and OEO 6 was different to that from OEO 3A and OEO 4 samples. Weak evidence from parasite data, one gene locus and otolith microchemistry suggested that northern OEO 3A samples were different from other areas. Lateral line scale and otolith settlement zone counts showed no differences between areas.

These data suggest that the stock boundaries given in previous assessment documents should be retained until more definitive evidence for stock relationships is obtained, i.e., retain the areas OEO 1, OEO 3A, OEO 4, and OEO 6 (see the figure on the first page of the Oreos assessment report above).

The three species of oreos (black oreo, smooth oreo and spiky oreo) are managed as if they were one stock. Each species could be managed separately. They have different depth and geographical distributions, different stock sizes, rates of growth, and productivity.

4. FISHERY SUMMARY

(a) Commercial fisheries

Commercial fisheries occur for black oreo (BOE) and smooth oreo (SSO). Oreos are managed as a species group, which includes spiky oreo (SOR). The Chatham Rise (OEO 3A and OEO 4) is the main fishing area, but other fisheries occur off Southland on the east coast of the South Island (OEO 1/OEO 3A), and on the Pukaki Rise, Macquarie Ridge, and Bounty Plateau (OEO 6).

Total reported landings of oreos and TACs are shown in Table 2. Total oreo catch from OEO 4 exceeded the TAC from 1991–92 to 1994–95 and was close to the TAC from 1995–96 to 2000–01 (Table 2). Catch remained high in OEO 4 while the orange roughy fishery has declined. The OEO 4 TAC was reduced from 7000 to 5460 in 2001–02 but was restored to 7000 t in 2003–04. The oreo catch from OEO 3A was less than the TAC from 1992–93 to 1995–96, substantially so in 1994–95 and 1995–96. The OEO 3A TAC was reduced from 10 106 to 6600 t in 1996–97. A voluntary agreement between the fishing industry and the Minister of Fisheries to limit catch of smooth oreo from OEO 3A to 1400 t of the total oreo TAC of 6600 t was implemented in 1998–99. Subsequently the total OEO 3A TAC was reduced to 5900 t in 1999–00, 4400 in 2000–01, 4095 in 2001–02 and 3100 t in 2002–03. Catch from the Sub-Antarctic area (OEO 6) increased substantially in 1994–95 and exceeded the TAC in 1995–96. The OEO 6 TAC was increased from 3000 to 6000 t in 1996–97. There was also a voluntary agreement not to fish for oreos in the Puysegur area which started in 1998–99. OEO 1 was fished under the adaptive management programme up to the end of 1997–98. The OEO 1 TAC reverted back to pre-adaptive management levels from 1998–99. Catches from OEO 1 declined steadily from 4852 t in 2000–01 to 735 t in 2005–06.

Reported estimated catches by species from tow by tow data recorded in catch and effort logbooks (Deepwater, TCEPR, and CELR) and the ratio of estimated to landed catch reported are given in Table 3.

Table 2: Total reported landings (t) for all oreo species combined by Fishstock from 1978–79 to 2005–06 and TACs (t) from 1982–83 to 2005–06.

Fishing	FISHSTOCK OEO 1		OEO 3A		OEO 4		OEO 6		Totals	
year	Landings	TAC	Landings	TAC	Landings	TAC	Landings	TAC	Landings	TAC
1978–79*	2808	–	1366	–	8041	–	17	–	12 231	–
1979–80*	143	–	10 958	–	680	–	18	–	11 791	–
1980–81*	467	–	14 832	–	10 269	–	283	–	25 851	–
1981–82*	21	–	12 750	–	9296	–	4380	–	26 514	–
1982–83*	162	–	8576	10 000	3927	6 750	765	–	13 680	17 000
1983–83#	39	–	4409	#	3209	#	354	–	8015	#
1983–84†	3241	–	9190	10 000	6104	6 750	3568	–	22 111	17 000
1984–85†	1480	–	8284	10 000	6390	6 750	2044	–	18 204	17 000
1985–86†	5390	–	5331	10 000	5883	6750	126	–	16 820	17 000
1986–87†	532	4000	7222	10 000	6830	6750	0	3000	15 093	24 000
1987–88†	1193	4000	9049	10 000	8674	7000	197	3000	19 159	24 000
1988–89†	432	4233	10 191	10 000	8447	7000	7	3000	19 077	24 233
1989–90†	2069	5033	9286	10 106	7348	7000	0	3000	18 703	25 139
1990–91†	4563	5033	9827	10 106	6936	7000	288	3000	21 614	25 139
1991–92†	4156	5033	10 072	10 106	7457	7000	33	3000	21 718	25 139
1992–93†	5739	6044	9290	10 106	7976	7000	815	3000	23 820	26 160
1993–94†	4910	6044	9106	10 106	8319	7000	983	3000	23 318	26 160
1994–95†	1483	6044	6600	10 106	7680	7000	2528	3000	18 291	26 160
1995–96†	4783	6044	7786	10 106	6806	7000	4435	3000	23 810	26 160
1996–97†	5181	6044	6991	6600	6962	7000	5645	6000	24 779	25 644
1997–98†	2681	6044	6336	6600	7010	7000	5222	6000	21 249	25 644
1998–99†	4102	5033	5763	6600	6931	7000	5287	6000	22 083	24 633
1999–00†	3711	5033	5859	5900	7034	7000	5914	6000	22 518	23 933
2000–01†	4852	5033	4577	4400	7358	7000	5932	6000	22 719	22 433
2001–02†	4197	5033	3923	4095	4864	5460	5737	6000	18 721	20 588
2002–03†	3034	5033	3070	3100	5402	5460	6115	6000	17 621	19 593
2003–04†	1703	5033	2856	3100	6735	7000	5811	6000	17 105	21 133
2004–05†	1025	5033	3061	3100	7390	7000	5744	6000	17 220	21 133
2005–06†	735	5033	3333	3100	6828	7000	6463	6000	17 359	21 133

Source: FSU from 1978–79 to 1987–88; QMS/MFish from 1988–89 to 2005–06. *, 1 April to 31 March. #, 1 April to 30 September. Interim TACs applied. †, 1 October to 30 September. Data prior to 1983 were adjusted up due to a conversion factor change.

Table 3: Reported estimated catch (t) by species (smooth oreo (SSO), black oreo (BOE) by Fishstock from 1978–79 to 2005–06 and the ratio (percentage) of the total estimated SSO plus BOE, to the total reported landings (from Table 1). –, less than 1.

	SSO				BOE				Total	Estimated:
Year	OEO 1	OEO 3A	OEO 4	OEO 6	OEO 1	OEO 3A	OEO 4	OEO 6	estimated	landings (%)
1978–79*	0	0	0	0	9	0	0	0	9	–
1979–80*	16	5075	114	0	118	5588	566	18	11 495	98
1980–81*	1	1522	849	2	66	8758	5224	215	16 637	64
1981–82*	21	1283	3352	2	0	11 419	5641	4378	26 096	98
1982–83*	28	2138	2796	60	6	6438	1088	705	13 259	97
1983–83#	9	713	1861	0	1	3693	1340	354	7971	100
1983–84†	1246	3594	4871	1 315	1751	5524	1214	2254	21 769	99
1984–85†	828	4311	4729	472	544	3897	1651	1572	18 004	99
1985–86†	4257	3135	4921	72	1060	2184	961	54	16 644	99
1986–87†	326	3186	5670	0	163	4026	1160	0	14 531	96
1987–88†	1050	5897	7771	197	114	3140	903	0	19 072	100
1988–89†	261	5864	6427	–	86	2719	1087	0	16 444	86
1989–90†	1141	5355	5320	–	872	2344	439	–	15 471	83
1990–91†	1437	4422	5262	81	2314	4177	793	222	18 708	87
1991–92†	1008	6096	4797	2	2384	3176	1702	15	19 180	88
1992–93†	1716	3461	3814	529	3768	3957	1326	69	18 640	78
1993–94†	2000	4767	4805	808	2615	4016	1553	35	20 599	88
1994–95†	835	3589	5272	1811	385	2052	545	230	14 719	81
1995–96†	2517	3591	5236	2562	1296	3361	364	1166	20 093	84
1996–97†	2203	3063	5390	2492	2578	3549	530	1950	21 755	88
1997–98†	1510	4790	5868	2531	1027	1623	811	1982	20 142	95
1998–99†	2958	2367	5613	3462	820	3147	844	1231	20 442	93
1999–00†	2533	1733	5985	4306	970	3943	628	1043	21 142	94
2000–01†	4012	1648	5924	4183	332	3005	799	1128	21 031	93
2001–02†	2973	1769	3806	4470	697	2378	515	983	17 591	94
2002–03†	2521	1395	4105	3941	481	1636	868	1640	16 587	94
2003–04†	1046	1244	5082	3767	458	1590	973	1496	15 656	92
2004–05†	665	1447	5848	3840	234	1594	851	1580	16 059	93
2005–06†	530	1354	5145	3289	265	1770	763	2616	15 732	91

Source: FSU from 1978–79 to 1987–88 and MFish from 1988–89 to 2005–06
* 1 April to 31 March. #, 1 April to 30 September. †, 1 October to 30 September.

Descriptive analyses of the main New Zealand oreo fisheries were updated with data from 2005–06 in 2007. The standardised CPUE analysis of black oreo in OEO 3A was updated in 2003. A new smooth oreo OEO 3A standardised CPUE analysis was developed in 2004. Standardised analyses of OEO 4 black oreo were carried out for the 2000 stock assessment and were updated in 2001. Standardised analyses of OEO 4 smooth oreo were updated in 2007. Standardised analyses of the main fisheries in OEO 1 and OEO 6 were developed in 2001. A new standardised CPUE analysis of Pukaki Rise smooth oreo was developed in 2006.

(b) Recreational fisheries

There are no known recreational fisheries for black oreo and smooth oreo.

(c) Maori customary fisheries

There is no known Maori customary fishing for black oreo and smooth oreo.

(d) Illegal catch

Estimates of illegal catch are not available.

(e) Other sources of mortality

Dumping of unwanted or small fish and accidental loss of fish (lost codends, ripped codends, etc.) were features of oreo fisheries in the early years. These sources of mortality were probably substantial in those early years but are now thought to be relatively small. No estimate of mortality from these sources has been made because of lack of hard data and because they now appear to be small. Estimates of discards of oreos were made for 1994–95 and 1995–96 from MFish observer data. This involved calculating the ratio of discarded oreo catch to retained oreo catch and then multiplying the annual total oreo catch from the New Zealand EEZ by this ratio. Estimates were 207 and 270 t for 1994–95 and 1995–96 respectively.

5. FOR FURTHER INFORMATION

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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

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.

Black oreo

The assessment was unchanged from 2004. That assessment used an acoustic absolute abundance estimate (and associated length and biological data) made from a survey carried out in 2002. The assessment used the NIWA CASAL software and Bayesian statistical techniques in line with the 2003 assessment of OEO 4 smooth oreo and replaced the 2002 NIWA assessment.

The 2002 assessment for black oreo in OEO 3A (termed the spatial analysis) used an age-structured population model. Three areas within the study area were modelled, corresponding to an increasing mean length of the catch as seen in the observer length frequency data. Area 1 contained small fish and flat ground while area 3 contained the largest fish and many features where short tows have historically taken place. One-way migration was allowed in the model and area specific selectivity curves were estimated using length frequencies derived from observed tows in the commercial fishery.
The 2004 assessment retained the three areas (revised) and one-way migrations and used updated and new data gathered since 2001.

Smooth oreo

An assessment of smooth oreo in OEO 3A was completed in 2005 and replaced the 1999 assessment. 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 relative abundance indices from a new standardised catch per unit effort analysis.

4.2 Black oreo

NIWA CASAL spatial model

An age structured, CASAL model employing Bayesian statistical techniques was developed, to jointly analyse the population dynamics within three areas of the black oreo stock in OEO 3A. A list of the data inputs and main changes between the base case for the assessment model and the previous (2002) spatial model is in Table 1.

Table 1: CASAL model data inputs and method changes compared to the previous (2002) spatial model.

Input	Description of changes and new estimates made
Recruitment	Assumed recruitment to mid-water at age one year and then into area 1 with one-way migration.
Migration	Age-dependent rates.
Fishing selectivities	None.
Growth	New growth, pre- and post-settlement. 1–70 years. Length-at-age CVs estimated.
CPUE abundance	Updated with 2000–01 and 2001–02. New standard errors. 20% process error assumed.
Acoustic abundance	Revised 1997 (target strength) plus 2002 surveys.
Acoustic length frequency	1997 plus 2002 survey data. Lognormal error structure. Process error estimated.
Observer length frequency	Updated with 2001–02 and 2002–03. Lognormal error structure, grouped over years. Process error estimated.
Catch history	Updated with 2000–01 and 2001–02.

It assumed Baranov fishing mortality, but had a maximum exploitation rate (0.80) instead of a maximum instantaneous fishing mortality. Natural mortality was partitioned into recruits and mature mortalities to determine differences that may occur when assuming a higher juvenile mortality. A maturation curve was estimated outside the model by fitting a loess curve through 7 points spread between the ages 18 and 48 years. Deterministic recruitment was assumed although recruitment deviates were estimated in one case. The latter suggested a very high level of recruitment in 1973 followed by very low levels until the late 1990s. This was driven by better fits to the acoustic length frequency data in area 1 and observer length frequency data in area 2. Fish recruit to the population at age one year.

The model estimated initial recruitment (mid-water only), the CV 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 new stock assessment included: new absolute abundance estimates and length data from the 2002 acoustic survey and revised estimates from the 1997 acoustic survey; revised and updated catch history, revised and updated relative abundance estimates from pre-GPS and post-GPS standardised CPUE analyses, revised observer length frequencies, revised growth parameter estimates, and age dependent migration (base case). 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, and 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 CV (estimated as 0.077 from the age-length data) 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 sensitivity of the model to the effects of estimating mature fish natural mortality (M), immature fish M, catchability in Area 1, and recruitment were investigated. Additional runs excluded pre-GPS or post-GPS standardised CPUE and included research trawl survey length frequency data for area 1.

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).

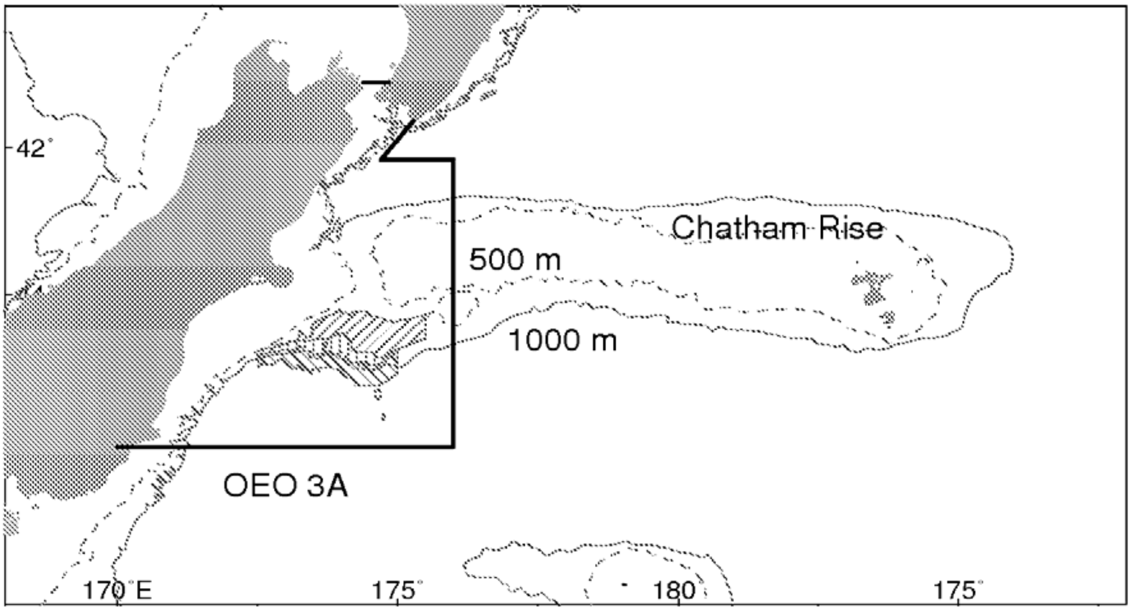

Figure 1: The three spatial areas used in the CASAL model and 2002 acoustic abundance survey. Area one at the top with right sloping shading; area two in the middle with vertical shading; area three at the bottom with left sloping shading. The thick dark line enclosed management area OEO 3A.

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. Thus, 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.

(a) 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 2.

Table 2: 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	†3440	110	2010	1320	1987–88	3140	40	1940	1160
1973–74	†3800	130	2220	1460	1988–89	3230	170	2490	570
1974–75	†5100	170	2970	1 960	1989–90	2830	620	1050	1160
1975–76	†1260	40	730	480	1990–91	4770	890	2310	1580
1976–77	†3880	130	2260	1490	1991–92	3450	300	1290	1870
1977–78	†5750	190	3350	2210	1992–93	4960	230	2810	1920
1978–79	720	20	420	270	1993–94	4160	340	2510	1320
1979–80	5740	430	2670	2650	1994–95	2400	120	1560	720
1980–81	12 640	80	8260	4300	1995–96	3760	200	2530	1030
1981–82	11 460	100	6400	4960	1996–97	3750	450	2190	1110
1982–83	8290	510	4940	2840	1997–98	1600	170	590	840
1983–84	7410	300	4200	2910	1998–99	3290	160	2450	680
1984–85	3930	150	1510	2270	1999–00	4070	160	2780	1120
1985–86	2190	10	920	1260	2000–01	2960	100	2010	850
1986–87	4030	30	1970	2020	2001–02	2250	60	1530	660

† 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 1995–96, was not included, (Table 3). 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 revised 1997, and the new 2002 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 4.

Table 3: 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	–	

Table 4: Length frequency proportions at length for the model area for the revised 1997 and 2002 acoustic surveys.

			1997			2002
Length (cm)	Area 1	Area 2	Area 3	Area 1	Area 2	Area 3
1–25	0.015	0.013	0.009	0.022	0.016	0.008
26	0.035	0.027	0.019	0.039	0.030	0.013
27	0.113	0.061	0.029	0.051	0.038	0.018
28	0.165	0.090	0.038	0.085	0.062	0.029
29	0.153	0.104	0.064	0.117	0.091	0.044
30	0.143	0.105	0.065	0.139	0.119	0.060
31	0.131	0.119	0.089	0.123	0.122	0.086
32	0.102	0.121	0.105	0.137	0.133	0.127
33	0.046	0.094	0.098	0.112	0.123	0.141
34	0.041	0.086	0.097	0.065	0.084	0.138
35	0.029	0.058	0.083	0.054	0.064	0.100
36	0.015	0.043	0.091	0.021	0.052	0.104
37	0.006	0.037	0.080	0.015	0.025	0.049
38–50	0.006	0.042	0.131	0.020	0.041	0.083

Absolute abundance estimates from the 1997 and 2002 acoustic surveys

Absolute estimates of abundance for black oreo are available from two acoustic surveys of oreos carried out from 10 November to 19 December 1997 (TAN9713) (Doonan et al., 1998, 1999b) and 25 September to 7 October 2002 (TAN0213). 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 1997 estimate used in the previous assessment was updated using revised estimates of target strength for smooth oreo, black oreo and some other species. The 2002 survey was limited to flat ground with 77 acoustic transect and 21 mark identification trawls completed. The estimated total abundance (immature plus mature) for each area is shown in Table 5.

Table 5: Total (immature plus mature) black oreo abundance estimates (t) for the 1997 (revised from the values used in the 2002 assessment) and 2002 acoustic surveys for the three model areas in OEO 3A.

Abundance (CV %)	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)

Relative abundance estimates from standardised CPUE analysis

Standardised CPUE indices were obtained for each area. Because of the apparent changes in fishing practise attributable to the introduction of GPS, the data were split into pre- and post-GPS series. The catch and effort data were restricted to all tows that targeted or caught black oreo in OEO 3A up to and including the 2001–02 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 was also modified from the previous (2002) analysis to provide 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 analysis of area 1 had data from 1979–80, 1989–90, 1990–91 and 1995–96 to 1999–00 but the data from years prior to 1995–96 were poorly linked by common vessels fishing in both periods, so a CPUE index was only provided from 1995–96 onwards (Table 6). For Areas 2 and 3 the pre-GPS combined indices (log-linear and binomial) and the post-GPS log-linear model indices for each area using the modified model with year-area interaction are in Table 6.

Table 6: Summary of the OEO 3A black oreo pre-GPS and post-GPS time series of standardised catch per unit effort indices and jack-knife CV estimates (%). –, no estimate.

Fishing	**Pre-GPS**			**Post-GPS**		
year	**Area 1**	**Area 2**	**Area 3**	**Area 1**	**Area 2**	**Area 3**
1979–80	–	1.45 (39)	1.50 (125)	–	–	–
1980–81	–	1.84 (17)	2.52 (15)	–	–	–
1981–82	–	1.72 (22	2.13 (9)	–	–	–
1982–83	–	1.41 (8)	1.79 (14)	–	–	–
1983–84	–	0.98 (8)	1.02 (19)	–	–	–
1984–85	–	0.94 (27)	0.97 (12)	–	–	–
1985–86	–	0.63 (31)	0.68 (33)	–	–	–
1986–87	–	0.82 (22)	0.87 (36)	–	–	–
1987–88	–	0.47 (20)	0.48 (23)	–	–	–
1988–89	–	0.70 (21)	0.24 (44)	–	–	–
1989–90	–	–	–	–	–	–
1990–91	–	–	–	–	–	–
1991–92	–	–	–	–	–	–
1992–93	–	–	–	–	1.45 (28)	1.50 (42)
1993–94	–	–	–	–	1.84 (39)	2.52 (24)
1994–95	–	–	–	–	1.72 (12)	2.13 (22)
1995–96	–	–	–	0.95 (54)	1.41 (19)	1.79 (53)
1996–97	–	–	–	1.23 (32)	0.98 (16)	1.02 (21)
1997–98	–	–	–	0.93 (32)	0.94 (36)	0.97 (21)
1998–99	–	–	–	0.95 (38)	0.63 (46)	0.68 (29)
1999–00	–	–	–	1.19 (32)	0.82 (52)	0.87 (17)
2000–01	–	–	–	1.11 (41)	0.47 (82)	0.48 (62)
2001–02	–	–	–	0.73 (113)	0.70 (27)	0.24 (8)

(b) Biomass estimates

A MCMC chain of 8000 was used which was derived from systematically sub-sampling every 1000th point after a burn-in of 860 iterations. The chain converged, but only after two parameters were set to their MPD values (i.e., age at 50% selection for the mid-water to area 1 migration, and ages for 50 to 95% selection in the area 1 to area 2 migration). 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 7. The vulnerable biomass estimates are the same as the total biomass estimates in areas 2 plus 3.

Table 7: 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_{2003}	B_{2003}/B_0	B_0	B_{2003}	B_{2003}/B_0	B_0	B_{2003}	B_{2003}/B_0	B_0	B_{2003}	B_{2003}/B_0
Mature	71 600	68 400	96	40 500	11 600	29	47 700	3 100	7	159 800	83 200	52
Vulnerable	–	–	–	–	–	–	–	–	–	89 800	15 800	18
Total	92 100	88 200	96	42 000	12 600	30	47 800	3 200	7	181800	104 000	57

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 year of the CPUE indices in areas 2 and 3, or to the acoustic estimates in area 1.

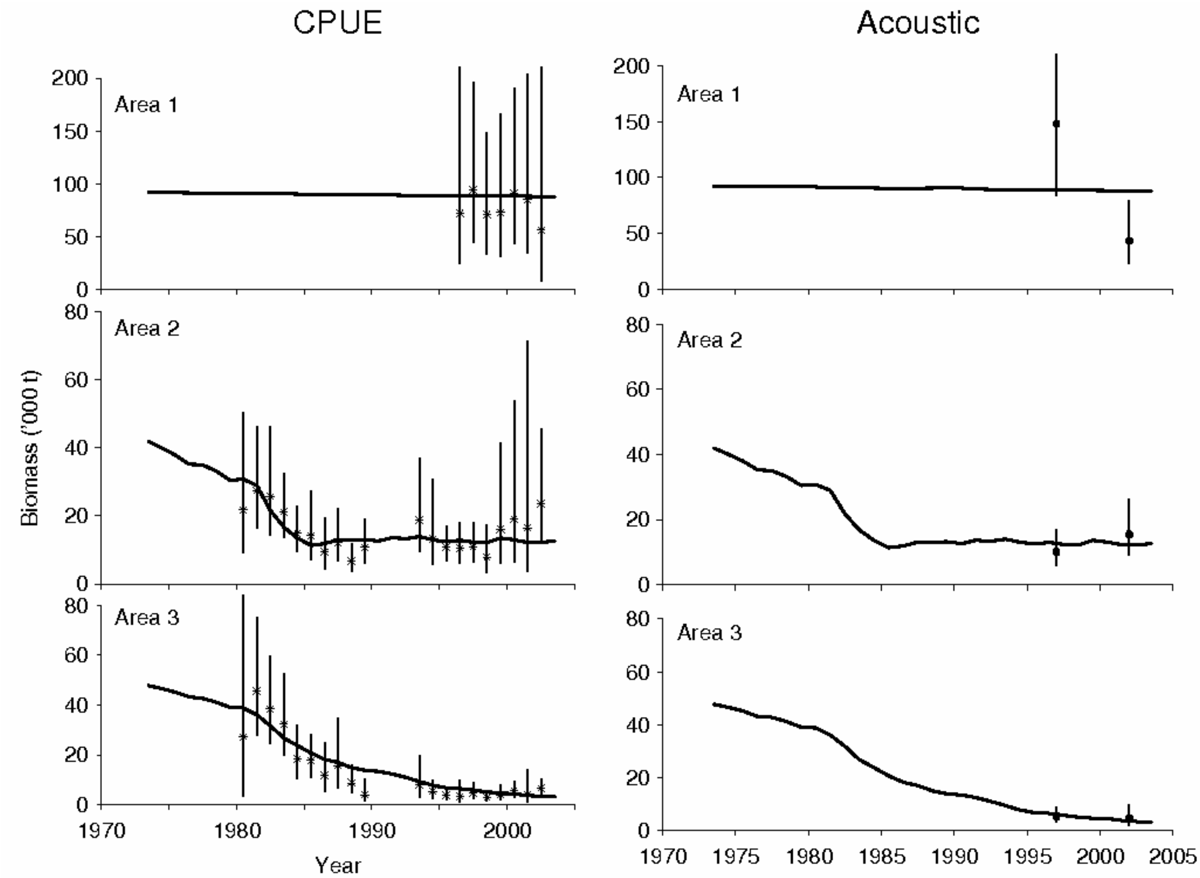

Figure 2: The fit of the abundance observations (CPUE and the absolute acoustic estimates) for each area to the predicted total biomass trajectories for the 2004 assessment of black oreo in OEO 3A (MPD solution, base case). The vertical lines are the 95% confidence intervals. The CPUE series were adjusted by their estimated catchability so that they are in absolute biomass units.

Biomass estimates from all the sensitivity runs were not substantially different from the base case, Table 8.

Table 8: Estimated mature $B_{2002–03}/B_0$ (%) for the MPD sensitivity runs. Runs were ranked (small values at the top) by summing the absolute percentage differences for each area for each run compared to the base case.

	Area 1	Area 2	Area 3
Base case	96	29	7
Estimate juvenile natural mortality	95	29	7
Treat area 1 acoustic absolute estimates as relative	96	28	7
Exclude post-GPS CPUE series	96	28	7
Migration rates: not age dependence	96	30	9
Exclude pre-GPS CPUE series	95	32	7
Add in trawl survey length frequencies (area 1)	95	28	4
Age and density dependent migration	95	20	7
Estimate mature fish M	97	37	6
Estimate recruitment deviates with 6 degrees of freedom	132	41	7
Estimate recruitment deviates	131	42	6

Comparison of the CASAL spatial model with previous stock assessments

The 1999 assessment used a single area, but both the SeaFIC and NIWA models were unable to explain some of the data (Table 9) and also produced conflicting assessment results. When stock assessment models cannot satisfactorily predict what appear to be valid observations for fish populations, it may be that the model is mis-specified, the observations are incorrect, or both. In response to these problems, a spatial model based on splitting the population into three areas was produced in 2002. This solved most of the problems with the 1999 assessment (Table 9) and was accepted. The 2004 model built on the 2002 model and solved more of the problems (Table 9) as well as using methods employed by NIWA for other recent oreo assessments, e.g., 2003 OEO 4 smooth oreo.

Table 9: The main problems with OEO 3A black oreo stock assessment models (1999, 2002, 2004). Yes –explained the data to an acceptable level. No - unable to explain the data to an acceptable level. NA, not applicable or not used.

Observation	1999 NIWA	1999 SeaFIC	2002	2004
Whole area				
Soviet CPUE declined steeper than the predicted biomass trajectory	No	NA	Yes	Yes
Annual length frequency switched from large to small fish and vice versa	No	No	Yes	Yes
Large acoustic abundance of small fish in area 1	No	No	Yes†	Yes
Spatial areas (1–3)				
Area 1 acoustic and observer length frequencies	NA	NA	No	Yes
Area 2 observer length frequencies	NA	NA	No	Yes
Area 3 observer length frequencies	NA	NA	No	Yes

† only when juvenile natural morality was estimated

The 2004 model produced more optimistic biomass estimates compared to the 2002 analysis. The more optimistic estimates appear to be due, in part, to density dependent migration being selected in the 2002 model.

(c) Projections

Forward projections over the next five years were performed to determine the probability that the projected biomass would exceed the current biomass, the probability that the projected biomass would exceed 20%B_0, and the probability that the projected biomass would exceed B_{MSY} (which was interpreted as being 27%B_0). A catch split of 5%, 68%, and 27% was used for areas 1–3 respectively and recruitment variability (lognormal with $\sigma_r = 0.67$) and parameter variability were introduced. The probabilities for the base case projected under different catch levels are presented in Table 10.

Table 10: Probability that biomass in 5 years ($B_{2007–08}$) is greater than the reference biomass (20% and 27%B_0) and the median biomass in 5 years as a %B_0 ($Bmed_{2007–08}$) under different constant catch scenarios. The 2002–03 catch limit for black oreo in OEO 3A was 1855 t.

Annual catch (t)	P($B_{2007–2008}$>20%Bo)	P($B_{2007–2008}$>27%Bo)	$Bmed_{2007–08}$
(a) Mature biomass Areas 1–3			
1000	1.0	1.0	56
1500	1.0	1.0	55
1855	1.0	1.0	54
2000	1.0	1.0	54
2500	1.0	1.0	52
3000	1.0	1.0	51
(b) Vulnerable biomass (areas 2 & 3)			
1000	1.0	0.06	24
1500	0.88	0.01	22
1855	0.65	0	21
2000	0.51	0	20
2500	0.15	0	18
3000	0.03	0	16

(d) 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

2005 assessment

The stock assessment analyses were conducted using the CASAL age-structured population model employing Bayesian statistical techniques. Changes compared to previous assessments included new pre- and post-GPS standardised CPUE analyses and the inclusion of observer and acoustic survey length data in the population model. 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.

(a) 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	†3440	1980–81	2196	1988–89	6963	1996–97	3239
1973–74	†3800	1981–82	1288	1989–90	6459	1997–98	4733
1974–75	†5100	1982–83	2495	1990–91	5054	1998–99	2474
1975–76	†1260	1983–84	3979	1991–92	6622	1999–00	1789
1976–77	†3880	1984–85	4351	1992–93	4334	2000–01	1621
1977–78	†5750	1985–86	3142	1993–94	4942	2001–02	1673
1978–79	650	1986–87	3190	1994–95	4199	2002–03	1412
1979–80	5215	1987–88	5905	1995–96	4022	2003–04	‡1410

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

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 3). Only samples where the catch weight was available and where a valid depth was 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 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	1300	2	Applied
1988–89	15	1540	2	–
1989–90	0	0	–	–
1990–91	28	3029	3	Applied
1991–92	9	919	3	–
1992–93	0	0	–	–
1993–94	24	1454	4	Applied
1994–95	8	778	4	–
1995–96	2	207	4	–
1996–97	3	365	5	–
1997–98	13	1720	5	–
1998–99	5	770	5	–
1999–00	82	7700	5	Applied
2000–01	97	9450	6	Applied
2001–02	22	3068	7	–
2002–03	25	1667	7	Applied

Length frequency data from the 1997 acoustic survey

Length data collected during the 1997 survey were used to generate a population length frequency by sex. A length frequency was generated from the trawls in each mark-type and also for the seamounts. These frequencies were combined using the fraction of smooth oreo abundance in each mark-type. The overall frequency was normalised over both male and female frequencies so that the sum of the frequencies over both sexes was 100%. The CV for each length class was given by the regression, log(CV) = 0.86 + 8.75/log(proportion). This regression was estimated from the CVs obtained by bootstrapping the data and provides a smoothed estimate of the CVs. The estimated length frequency is in Figure 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 previous OEO 3A smooth oreo assessment were revised using new target strength estimates for smooth oreo, black oreo and a number of bycatch species. The new estimate was 25 200 t with a CV of 23% (previously 35 100 t with CV of 27%). There is uncertainty in the estimates of biomass because the acoustic estimate includes smooth oreo in layers that are a mixture of species for which the acoustic method has potential bias problems.

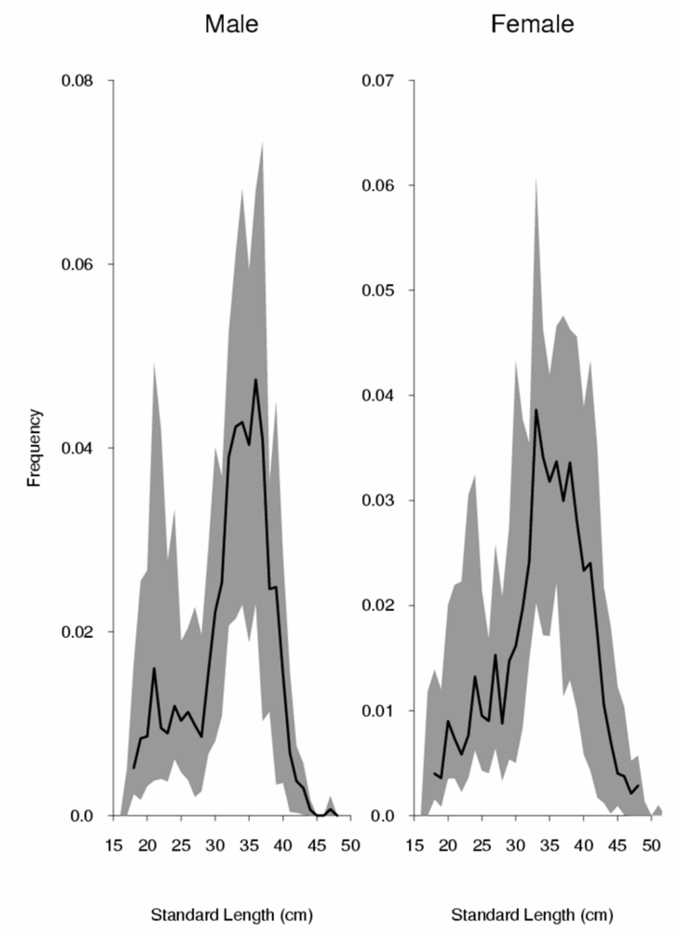

Figure 3: Population length frequency derived from the 1997 acoustic survey data. The bold line is the estimated value and the shaded area is the spread from 300 bootstraps.

Relative abundance estimates from standardised CPUE analysis

The CPUE study area is shown in Figure 4. Two analyses were carried out; a pre-GPS analysis that included data from 1980–81 to 1988–89 and a post-GPS analysis that included data from 1992–93 to2002–03. The pre-GPS indices trend down, are fairly linear, and decline to approximately a third of the initial level over the eight-year period. The post-GPS indices trend downward from the start of the series to 2000–01 declining to approximately a third of the initial level over these eight years. Since 2000–01 the trend is upward to nearly match the initial year in 2002–03. The base case stock assessment analysis used the indices from both the pre- and post-GPS series (Table 13).

Table 13: CPUE indices by year and jackknife CV estimates from the pre-GPS and the post-GPS analyses.

	Pre-GPS			Post-GPS	
	CPUE	**Jackknife CV %**		**CPUE**	**Jackknife CV %**
1980–81	1.00	27	1992–93	1.00	35
1981–82	0.82	26	1993–94	0.93	47
1982–83	0.72	62	1994–95	0.76	81
1983–84	0.59	61	1995–96	0.55	53
1984–85	0.72	22	1996–97	0.61	67
1985–86	0.61	19	1997–98	0.69	25
1986–87	0.46	16	1998–99	0.53	18
1987–88	0.42	16	1999–00	0.46	42
1988–89	0.26	28	2000–01	0.36	16
			2001–02	0.52	18
			2002–03	0.81	33

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.

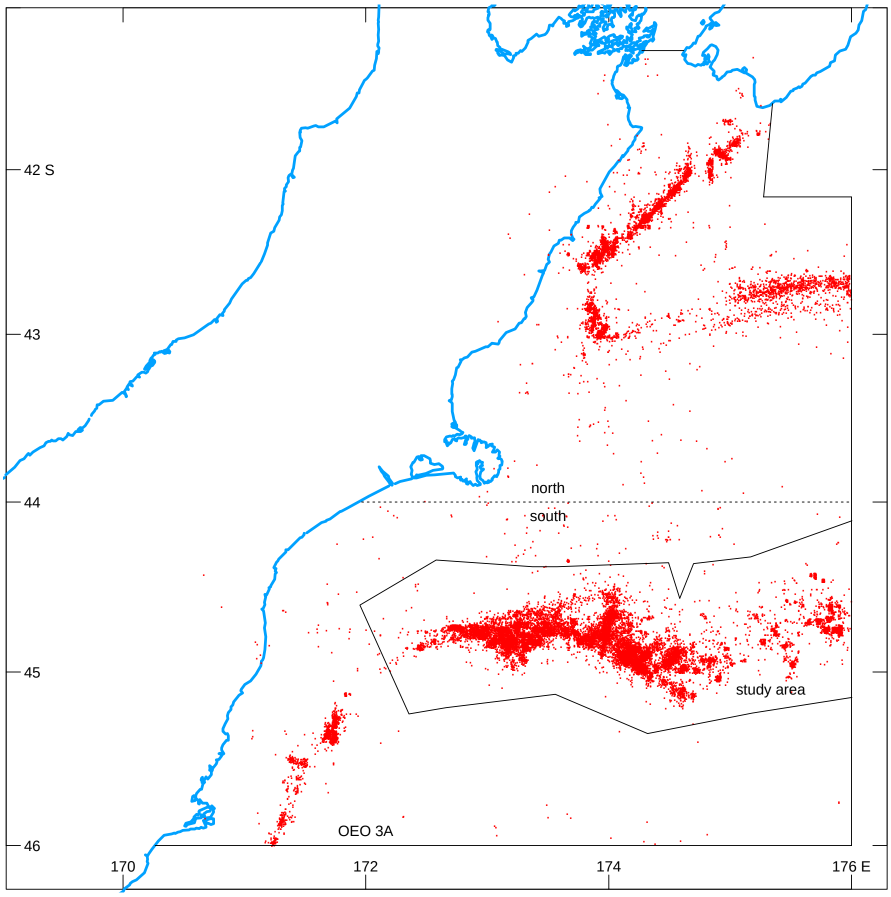

Figure 4: Locations of all tows in OEO 3A with a reported catch of smooth oreo from 1979–80 to 2002–03 (dots). The study area is shown along with the line chosen to split north from south Chatham rise catches.

(b) Biomass estimates

The Markov Chain Monte Carlo analysis for the base case produced a total chain length of 38 million. The first 5 million points were discarded (burn-in) and then every 10 000th point was retained. Convergence diagnostics were run on the resulting sample of 3300 points. Autocorrelations, and single chain convergence tests were applied to the chain to test for non-convergence. The tests showed that the MCMC runs converged.

The fit of the base case biomass trajectory (MPD solution) to the abundance estimates is satisfactory (Figure 5).

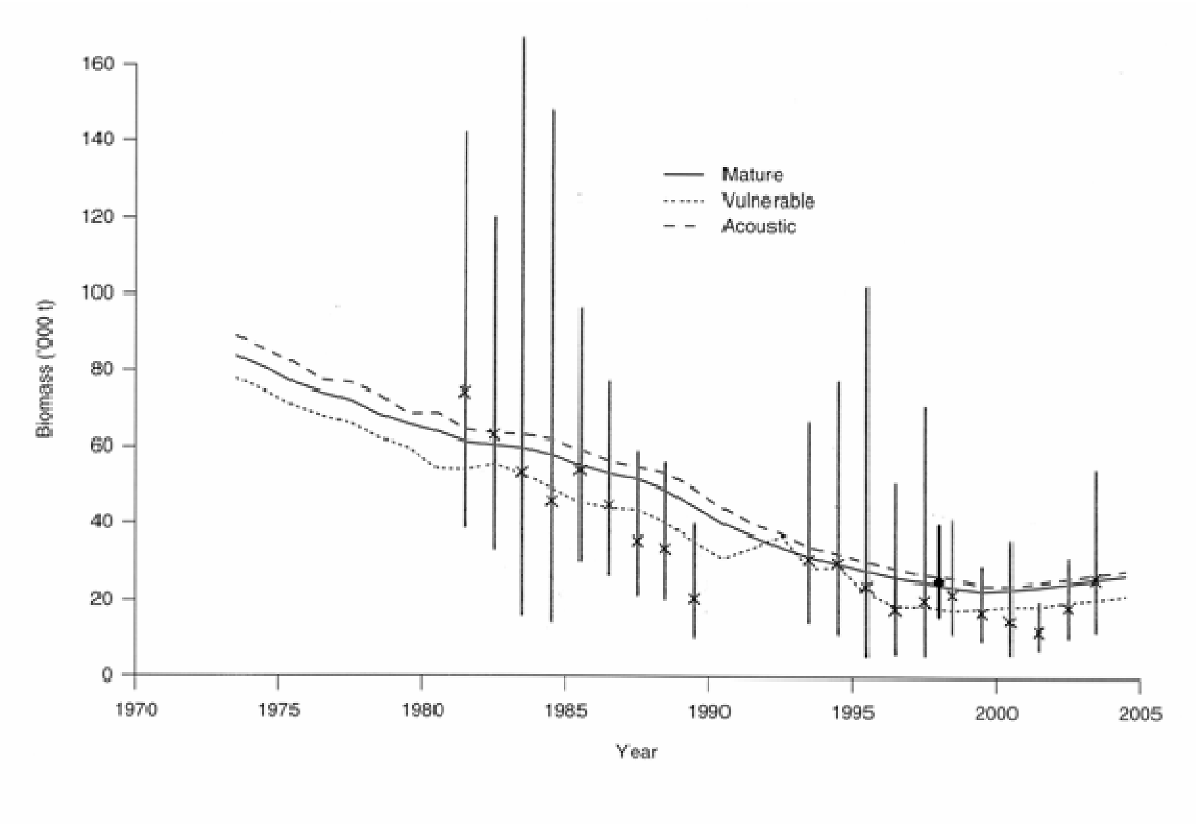

Figure 5: Smooth oreo 3A: fit of the abundance observations, CPUE (Xs), and the absolute acoustic estimate (◆), to the predicted total biomass trajectories (MPD base case). The vertical lines are the 95% confidence intervals. The CPUE series were adjusted by their estimated catchability so that they are in absolute biomass units.

A random sample of 1000 points from the MCMC was used to derive estimates of biomass (Table 14). Total mature biomass for 2003–04 was estimated to be 29% of the initial biomass (B_0), which is greater than B_{MAY} (25%B_0). Several sensitivities were conducted for MPD runs only. Except for two cases all gave estimates of current biomass between 27% and 36% of virgin biomass. When CPUE data only was included biomass was much lower (12% B_0); when acoustic data only was included current stock status was higher (47%B_0).

Table 14: Base case biomass and yield estimates.

Mature biomass estimates (t)		
Smooth oreo 3A	**Median**	**90% C.I.**
Virgin biomass	81 000	77 000–86 000
2003–04 mid-year	24 000	19 000–29 000
2003–04 mid-year/B_0 (%)	29	25–33
	Mean	
B_{MAY}	20 400‡	
B_{MAY} /B_0(%)	25‡	
‡ mid-year mature biomass.		

(c) Projections

Forward projections over the next five years were performed to determine the probability that the projected biomass would exceed 20%B_0, and the probability that the projected biomass would exceed B_{MAY} (25% B_0). Recruitment variability (lognormal with σ_r = 0.67) and parameter variability were considered (1000 random draws from the posterior distribution). The probabilities for the base case projected under different catch levels are presented in Table 15.

Table 15: Probability that the mature biomass in 5 years ($B_{2008–09}$) is greater than the reference biomass (20% and 25%B_0) and the median biomass in 5 years as a %B_0 ($Bmed_{2008–09}$) under different constant catch scenarios. The 2003–04 catch limit for smooth oreo in OEO 3A was 1400 t.

Annual catch (t)	$P(B_{2008–2009}>20\%B_0)$	$P(B_{2008–2009}>25\%B_0)$	$Bmed_{2008–09}$ (%)
1000	1	1	36
1400	1	1	35
2000	1	1	32
2500	1	0.98	30
3000	1	0.87	28
4000	0.93	0.32	24

(d) 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 that might be caused by the application of a single TACC to separate species in OEO 3A.

Model biomass estimates are uncertain because of a range of factors, including sensitivity to the target strength of black oreo and uncertainty in the estimates of M. However, the Plenary considered that for smooth oreo the model underestimates uncertainty. The lack of uncertainty results from model assumptions that recruitment is deterministic, and that the acoustic index can be considered as an absolute estimate of abundance. In addition, the Plenary 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. The sex ratio information will be investigated more fully inter-sessionally.

5. STATUS OF THE STOCKS

Black oreo, OEO 3A

Current and virgin biomass for black oreo in OEO 3A were estimated using a CASAL spatial stock assessment, which estimated higher levels of stock status than the 2002 assessment for the same Fishstock. Total mature biomass for 2002–03 was estimated to be 52% of the initial biomass (B_0), which is greater than B_{MSY} (27%B_0). However, the size of the current biomass relative to B_0 is not equal across the three sub-areas, with Areas 2 and 3 being 29% and 7% of their respective mature equilibrium virgin biomass levels while Area 1 is estimated to be at 96%. There is uncertainty in the estimates of biomass in Area 1 because the acoustic estimate is based on black oreo in layers that are a mixture of species for which the acoustic method has potential bias problems.

Five year projections to estimate future mature and vulnerable biomass were carried out at different constant annual catches assuming the current catch split between areas. An annual catch of 1885 t, the likely maximum catch of black oreo for the fished areas (areas 2 and 3), given the current management arrangements, gave a 100% probability that mature biomass would be greater than both 20% B_0 and 27%B_0 (B_{MSY}). The corresponding probabilities for vulnerable biomass are a 65 % probability that it would be greater than 20% B_0 and a 0 % probability that it would be greater than 27 %B_0 (B_{MSY}). The difference between the mature and vulnerable biomass status is a consequence of the current stock assessment that estimates a large biomass of mature black oreo in area 1 that is not fished.

Model biomass estimates are uncertain because of a range of factors, including sensitivity to the target strength of black oreo, uncertainty in the estimates of M, and the assumption that recruitment is deterministic.

Smooth oreo, OEO 3A

The most recent assessment was completed in 2005. Total mature biomass for 2003–04 was estimated to be 29% of the initial biomass (B_0), which is greater than B_{MAY} (25%B_0). Five-year projections to estimate future mature biomass were carried out at different constant annual catches. An annual catch of 1400 t, the maximum catch of smooth oreo under the current management arrangements, gave a 100% probability that mature biomass would be greater than both 20% B_0 and 25%B_0 (B_{MAY}) to 2008–09.

Model biomass estimates are uncertain because of a range of factors, including sensitivity to the target strength of black oreo, uncertainty in the estimates of M, and the sex ratio of the mature biomass (see section 4.3d "Other factors" above). The Plenary considered that the model underestimates uncertainty.

OEO 3A: Summary of estimated catch (t) for the most recent fishing year. Estimated catch was scaled to the reported oreo landings for each fishstock using the reported estimated catch of black or smooth oreo from Tables 2 and 3 of the Fishery Summary section at the beginning of the Oreos report. Reported landings and TACCs for both oreo species combined are in Table 2 of the Fishery Summary section at the beginning of the Oreos report.

Species	2005–06 estimated catch
Black oreo	1888
Smooth oreo	1445

6. FOR FURTHER INFORMATION

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OREOS – OEO 4 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

Black oreo

The assessment was updated in 2000 but not included in this report until 2001. This was the first stock assessments for OEO 4 that included the results from the 1998 acoustic survey.

Assessment of black oreo

The following assumptions were made in the stock assessment analyses carried out to estimate biomasses and yields.

(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 4. 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. (Smooth oreo growth was estimated by the model).
(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 analyses of black oreo and smooth oreo below.
(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 4 were discrete stocks or production units.
(h) The catch histories were accurate.

Smooth oreo

The assessment was updated in 2007 with a new acoustic absolute abundance estimate and length data from a survey carried out in 2005. West and east stocks were modelled separately, and updated standardised CPUE, observer (commercial) length data, and catch history for the years from 2001–02 to 2005–06 were all fitted in the model with the new acoustic data.

Assessment of smooth oreo

The following assumptions were made in the stock assessment analyses carried out to estimate biomass and yields.

(a) The acoustic abundance estimates were unbiased absolute values.
(b) The CPUE analyses provided indices of abundance for smooth oreo in the whole of OEO 4. Most of the oreo commercial catches came from the CPUE study area. Research trawl surveys indicated that there was little habitat for, and biomass of, smooth oreo outside that area.
(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 analyses of smooth oreo below.
(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 population of smooth oreo in OEO 4 was a discrete stock or production unit.
(h) The catch history was accurate.

4.2 Black oreo

Stock assessment

Biomass estimates were made in 2000 using a stock reduction analysis incorporating deterministic recruitment, acoustic absolute abundance estimates from the 1998 survey, relative abundance estimates from new standardised CPUE analyses, relative abundance indices from the south Chatham Rise *Tangaroa* trawl surveys (1991–93 and 1995), life history parameters from Table 1 of the Biology section at the beginning of the Oreos report, and catch history.

(a) <u>Estimates of fishery parameters and abundance</u>

Absolute abundance estimates from the 1998 acoustic survey

Absolute estimates of abundance were available from an acoustic survey on oreos which was carried out from 26 September to 30 October 1998 on *Tangaroa* (voyage TAN9812). Transects on flat ground were surveyed to a stratified random design and a random sample of seamounts were surveyed with either a random transect (large seamounts) or a systematic "star" transect design. For some seamounts the flat ground nearby was also surveyed to compare the abundance of fish on and near the seamount either by extending the length of the star transects or by extra parallel transects. Acoustic data were collected concurrently for flat and seamounts using both towed and hull mounted transducers. The OEO 4 survey covered 59 transects on the flat and 29 on seamounts. A total of 95 tows were carried out for target identification and to estimate target strength and species composition. In situ and swimbladder samples for target strength data were collected and these have yielded revised estimates of target strength for both black oreo and smooth oreo.

Acoustic abundance estimates for recruit black oreo from seamounts and flat for the whole of OEO 4 are in Table 1. About 59% of the black oreo abundance came from the background mark-type. This mark-type is not normally fished by the commercial fleet and this implies that the abundance estimate did not cover the fish normally taken by the fishery. In addition the scaling factor to convert the acoustic area estimate to the trawl survey area estimate was 4.3, i.e., the acoustic survey area only had about 23% of the abundance. The magnitude of this ratio suggests that the size of the area surveyed was borderline for providing a reliable abundance estimate.

Table 1: OEO 4 recruit black oreo seamount, flat, and total acoustic abundance estimates (t) and recruit CV (%) based on knife-edge recruitment (23 years).

	Abundance (t)	CV (%)
Seamount	127	91
Flat	13 800	56
Total	13 900	55

Relative abundance estimates from standardised CPUE analyses

The CPUE analysis method was the same as that used for analyses of standardised CPUE for black oreo in OEO 3A and involved regression based methods where the zero catch tow and the positive catch tow data were analysed separately to produce positive catch and zero catch indices. For target fishing a combined index (positive catch and zero catch indices) was calculated. Only the positive catch index was calculated for analysis of bycatch data because the zero catch index was only important for target fishing. The mean CVs for the combined and positive indices (all years) were estimated using a jackknife technique. Data were divided into those from target fishing or from catch taken as bycatch during target fishing for other species, e.g., orange roughy; pre- and post-global positioning system (GPS) time periods, 1979–80 to 1988–89 and 1992–93 to 1998–99 respectively.

Two (of four) potential analyses were chosen where data were adequate and because target was preferred over bycatch analyses (Table 2).

Table 2: OEO 4 black oreo standardised CPUE analyses. Overall CVs of 66 and 104% were calculated for the target and bycatch series respectively.

	Index	CV
(a) Target pre-GPS combined index and jackknife CV (%)		
1980–81	2.80	122.0
1981–82	2.72	94.8
1982–83	1.02	68.1
1983–84	1.00	0.0
1984–85	0.64	60.8
1985–86	0.46	127.0
1986–87	0.41	63.4
(b) Bycatch post-GPS positive index and jackknife CV (%)		
1992–93	1.32	39.2
1993–94	1.31	75.4
1994–95	1.00	0.0
1995–96	0.63	88.1
1996–97	0.95	45.9
1997–98	0.63	39.2
1998–99	0.37	332.0

Relative abundance estimates from trawl surveys

The estimates, and their CVs, from the four standard *Tangaroa* south Chatham Rise trawl surveys were treated as relative abundance indices (Table 3).

Table 3: OEO 4 black oreo research survey abundance estimates (t). N is the number of stations. Estimates were made using knife-edge recruitment set at 33 cm TL. Previously knife-edge recruitment was set at 27 cm and estimates of abundance based on that value are also provided for comparison.

	Mean abundance		CV (%)	N
	27 cm	33 cm		
1991	34 407	13 065	40	105
1992	29 948	12 839	46	122
1993	20 953	6 515	30	124
1995	29 305	9 238	30	153

(b) Biomass estimates

The stock assessment of OEO 4 black oreo was considered unreliable and was not accepted because:

1. The acoustic abundance estimate is uncertain. The acoustic survey was aimed at smooth oreo and consequently the black oreo areas in OEO 4 received only minimal coverage. The estimate of recruit abundance is low and is largely based on background abundance, where the acoustic method performed poorly, rather than from black oreo schools. The poor coverage of black oreo areas by the acoustic survey was compensated by multiplying the acoustic survey area abundance by a scaling factor of 4.3 (based on research surveys) to make the estimate equivalent to the trawl survey area and then by a further 1.06 to estimate a total abundance for OEO 4. In addition only small acoustic abundance estimates were made from the seamounts, which suggests that either black oreo abundance on seamounts was low or the estimate was biased low.

2. The CPUE abundance estimates are uncertain. There is only a small fishery for black oreo in OEO 4 (about 1100 t per year from 1989–90 to 1998–99) with target fishing largely confined to the west end during the late 1980s and early 1990s.

No estimates of biomass are reported because they were considered unreliable.

(c) Estimation of Maximum Constant Yield (MCY)

MCY was estimated using the equation, MCY = $c*Y_{av}$ (Method 4). There was no trend in the annual catches, nominal CPUE, or effort from 1982–83 to 1987–88 so that period was used to calculate the MCY estimate (1200 t).

(d) Estimation of Current Annual Yield (CAY)

CAY cannot be estimated because of the lack of current biomass estimates.

4.3 Smooth oreo

Stock assessment

Bayesian procedures were used in the assessment to estimate the uncertainties in model estimates of current biomass and in future projections for all model runs. These procedures were conducted with the following steps:

1. Model parameters were estimated using maximum likelihood and the prior probabilities;
2. Samples from the joint posterior distribution of parameters were generated with the Monte Carlo Markov Chain procedure (MCMC) using the Hastings-Metropolis algorithm;
3. A marginal posterior distribution was found for each quantity of interest by integrating the product of the likelihood and the priors over all model parameters; the posterior distribution was described by its median, 5th and 95th percentiles for parameters of interest.

The area was split at 178° 20′ W into a west and an east fishery based on an analysis of commercial catch, standardised CPUE, and research trawl and acoustic results. Oreo catch data showed marked changes in fishing patterns over time. This involved a progression of high catches over time starting in the west and moving east and appeared to represent successive exploitation of new areas. Areas in the west previously exploited did not later sustain high catches. The target species and the type of fishing changed over time with smooth oreo the target species in the west on flat, dropoff, and seamounts from the late 1970s, with a gradual change to target fishing for orange roughy on seamounts in the east from the late 1980s.

Biomass and yield estimates for smooth oreo were made using a CASAL age-structured population model with Bayesian estimation, incorporating deterministic recruitment, life history parameters (Table 1 of the Biology section at the beginning of the Oreos report), and catch history. Estimated model parameters and priors are presented in Table 4. Data fitted in the analysis were the 1998, 2001, and 2005 acoustic survey abundance estimates (Table 6), standardised combined CPUE indices (a, b, & c, Table 8), observer length data (Table 7), and the 2001 and 2005 acoustic survey length data.

Table 4: Estimated parameters and priors of the CASAL assessment model. U, uniform distribution. –, no value or not applicable.

Parameter	Both	Number	Prior
Virgin biomass	Estimated	2	ln B_0 ~U[0, ln (350 000)]
West catchability coefficient [pre-GPS CPUE]	Estimated	1	U[0, 1]
East catchability coefficient [post-GPS CPUE]	Estimated	1	U[0, 1]
West catchability coefficient [post-GPS CPUE]	Estimated	1	U[0, 1]
Age-based selectivity: commercial fishery:			
Age at 50% selected (east & west)	Estimated	2	U[1, 50]
Extra years to 95% selected (east & west)	Estimated	2	U[0,1]

Age-based selectivity: acoustic survey:			
Age at 50% selected (east & west)	Estimated	2	U[1, 50]
Extra years to 95% selected (east & west)	Estimated	2	U[0,1]
Process errors			
Acoustic length data (east)	Estimated	1	U[0,1.5]

The model assumed two independent stocks, one in the west and the other confined to the east with no migration from the east to the west area and a fixed M (0.063). Selectivities were modelled as effectively knife-edged with separate functions for the east and west areas but with no differences between males and females (for both the observer and acoustic survey data). The knife-edge cutoff was obtained by restricting the selectivity parameter where 50–95% of ages were selected to be between 0 and 1 in a logistic function. Acoustic length data were fitted to the model using a log-normal likelihood with process errors, and a robustified binomial distribution was used for the observer length data. Process error for the CPUE series was set to a CV of 0.20.

Three cases (runs) are reported. The Base case used all the data including the three acoustic survey abundance estimates and survey length data, observer length data, and three standardised CPUE index series. The CPUE case used the same data as the base case except that it excluded the acoustic survey abundance and length data. The Acoustic case used the same data as the base case except that it excluded the three CPUE index series.

Bayesian estimates were based on the median of a 2 million long MCMC sampled at each 1000th value, with the first 10% excluded.

(a) Estimates of fishery parameters and abundance

Catch history

A catch history for OEO 4 split into east and west areas was developed by scaling the estimated catch to the QMS values. The west fishery was larger from 1978–79 to 1986–87 but east was more important from 1987–88 onwards, Table 5.

Table 5: Catch history for OEO 4 smooth oreo (t)

Year	OEO 4	West	East	Year	OEO 4	West	East
1978–79	1351	1351	0	1992–93	5918	1420	4498
1979–80	114	114	0	1993–94	6287	1069	5218
1980–81	1436	1436	0	1994–95	6961	1392	5568
1981–82	3465	3430	35	1995–96	6364	2227	4137
1982–83	3757	3757	0	1996–97	6339	1712	4627
1983–84	5817	5759	58	1997–98	6159	1848	4311
1984–85	4736	4547	189	1998–99	6025	1749	4283
1985–86	4922	4380	541	1999–00	6366	1670	4696
1986–87	5670	4196	1474	2000–01	6484	1720	4764
1987–88	7771	2642	5129	2001–02	4284	1436	2848
1988–89	7225	2457	4769	2002–03	4459	1332	3127
1989–90	6788	1154	5634	2003–04	5653	1519	4134
1990–91	6028	1808	4220	2004–05	6451	1818	4633
1991–92	5504	1211	4293	2005–06	5946	1302	4644

Absolute abundance estimates from the 1998, 2001, and 2005 acoustic surveys

Absolute estimates of abundance were available from three acoustic surveys:

(i) 26 September to 30 October 1998 on *Tangaroa* (voyage TAN9812);

(ii) 16 October to 14 November 2001 using *Tangaroa* for acoustic work (voyage TAN0117) and *Amaltal Explorer* (voyage AEX0101) for trawling; and

(iii) 3–22 November 2005 using *Tangaroa* for acoustic work (voyage TAN0514) and 3–20 November 2005 using *San Waitaki* (SWA0501) for mark identification trawling.

Acoustic abundance estimates for total smooth oreo from seamounts and flat for the whole of OEO 4 are in Table 6. The 1998 and 2001 estimates for the mixed species mark-types were adjusted to match the larger contribution for non-smooth oreo species in these mark types from the trawl net used in 2005. The assessment used the estimates for the east and west areas separately.

Table 6: Estimated absolute abundance (t) from acoustic surveys in 1998, 2001, and 2005 by east, west and for the combined area. CVs are in brackets (%).

	1998	2001	2005
West	22 600 (52)	43 000 (35)	32 200 (31)
East	127 000 (37)	183 000 (22)	91 800 (30)
Total	146 600 (33)	218 165 (22)	115 500 (28)

One of the major uncertainties in the assessment is from the large contribution to the total acoustic abundance estimate from smooth oreo estimated to be in the layers (about 72% of the total abundance for the 1998 survey, 47% for the 2001 survey, and about 45% for the 2005 survey). The contribution of large (greater than 31 cm) smooth oreo to the total backscatter in these layers was typically less than 10% of the total abundance, with the remainder composed of a number of associated bycatch species and smaller smooth oreo in 1998 and 2001. The layer acoustic abundance could be biased because the contribution made by the suite of other fish species present in the layers may be mis-specified, thus adding to the overall uncertainty in the biomass estimates from the assessment. The contribution of large smooth oreo to the total backscatter in the schools was typically greater than 75% in 1998 and 2001. Therefore, the acoustic smooth oreo abundance estimates from the schools were considered to be better estimated than the equivalent acoustic estimates from the layers.

Observer length frequencies

Observer length data were extracted from the observer database. These data were stratified by season (October-March and April-September) and into west and east parts. The length frequencies were combined over strata by the proportion of catch in each stratum.

The assessment included data for all years where there were more than 5 tows for the year for both strata combined, more than 30 fish were measured in each stratum, and there were data for both females and males in the stratum (Table 7).

Table 7: Observer length frequencies for the west and east areas: number of tows with length data by season strata, and whether the data for each year were used in the stock assessment. †, updated data.

	West			East		
Year	**Oct-Mar**	**Apr-Sep**	**Used**	**Oct-Mar**	**Apr-Sep**	**Used**
1987	2	1		0	0	
1989	10	5	Y	1	0	
1990	4	0		0	0	
1991	16	0		26	4	Y
1992	6	0		45	8	Y
1993	0	0		22	16	Y
1994	1	0		64	33	Y
1995	1	0		42	30	Y
1996	9	10	Y	6	6	Y
1997	11	0		28	3	Y
1998	2	9	Y	20	9	Y
1999	0	7		30	21	Y
2000	3	15	Y	14	0	
2001	8	14	Y	44	5	Y
2002†	0	3		24	16	Y
2003†	3	4	Y	28	6	Y
2004†	1	6		27	3	Y
2005†	3	3		18	46	Y
2006†	3	14	Y	3	14	Y

Acoustic survey length frequencies

Length data collected during the 2001 and 2005 acoustic survey were used to generate population length frequencies for the east and west areas separately. Each frequency was estimated using the length data from trawls in each mark-type sub-stratum weighted by the catch rates and the proportion of acoustic abundance in the sub-stratum. These frequencies were normalised over both male and female frequencies so that the sum of the frequencies over both sexes summed to 1. The data for the two areas separately were used in the assessment.

Relative abundance estimates from standardised CPUE analyses

The CPUE analysis method was the same as that described above (Section 4.2) for OEO 4 black oreo except that a revised method was used to convert the index values to a canonical form by dividing each value by the geometric mean of the index series following the suggestion of Francis (1999) and resulted in the index value for the reference year being a value other than 1. Annual CVs for the combined indices were estimated using a jackknife technique (Doonan et al., 1995a) but the method was revised by using the canonical index values to calculate the jackknife CV values and resulted in the reference year CV having a value other than 0. The target SSO pre-GPS series (Table 8 a) used data from the both east and west areas but most of the data were from the west. The assessment used east and west indices (Table 8 a, b, & d).

Table 8: OEO 4 smooth oreo time series of combined and positive catch abundance indices from standardised CPUE analyses used in the assessment.

Year	Combined index	Jackknife CV
(a) Target SSO pre-GPS (east + west but mainly west data)		
1981–82	1.40	15
1982–83	1.36	19
1983–84	1.04	21
1984–85	0.84	20
1985–86	1.00	44
1986–87	0.99	28
1987–88	0.89	20
1988–89	0.68	22
(b) Target OEO/SSO post-GPS (west)		
1992–93	0.50	29
1995–96	0.53	53
1996–97	0.99	17
1997–98	0.80	74
1998–99	0.82	19
1999–00	1.12	30
2000–01	1.04	13
2001–02	1.07	54
2002–03	1.38	54
2003–04	1.40	8
2004–05	1.65	31
2005–06	1.47	38
(c) Bycatch post-GPS (east)		
Year	**Positive catch index**	**Jackknife CV**
1992–93	1.56	33
1993–94	1.29	27
1994–95	1.18	16
1995–96	0.96	57
1996–97	1.52	18
1997–98	0.96	28
1998–99	1.03	22
1999–00	1.10	71
2000–01	0.93	8
2001–02	0.83	10
2002–03	0.92	21
2003–04	1.00	31
2004–05	0.64	34
2005–06	0.57	24

(b) Biomass estimates

The estimates of biomass from the Base case (Figure 1) and the Acoustic case (Figure 2) are very similar. The mature virgin biomass estimates from the CPUE case have a long tail on the right hand side of the distribution and the current biomass estimates are wide 90% confidence bounds (Figure 3). All estimated parameters for the three cases achieved MCMC convergence. Biomass point estimates are in Table 9. For the base case the median estimate of current mature biomass was 57% B_0.

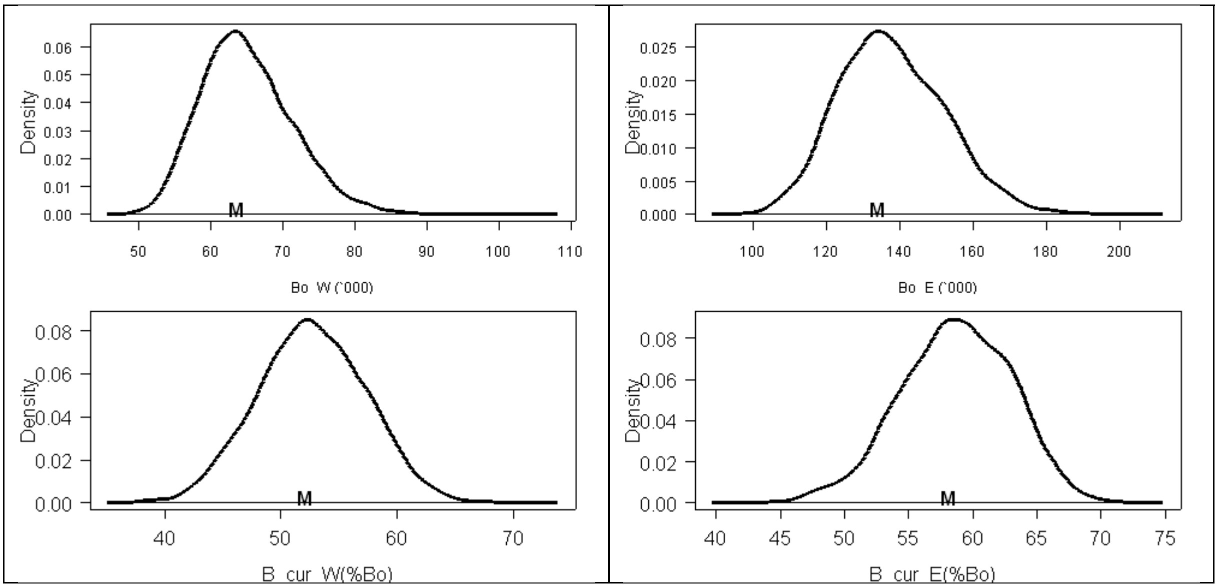

Figure 1: Bayesian posterior distribution of mature biomass estimates for the OEO 4 smooth oreo Base case. Based on 2000 Monte Carlo Markov Chain runs. Upper panels are west (B_0 W) and east (B_0 E) virgin biomass (t) and lower panels are west (B cur W(%B_0)) and east (B cur E(%B_0)) current biomass as a percentage of virgin biomass. M is the MPD point estimate.

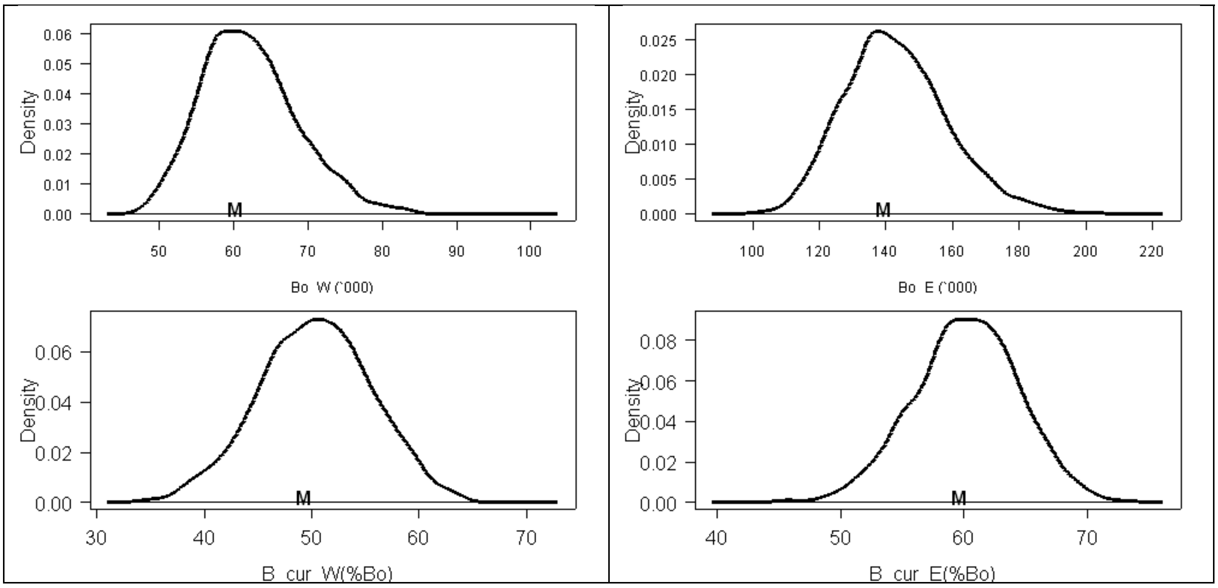

Figure 2: Bayesian posterior distribution of mature virgin biomass (t) estimates for the OEO 4 smooth oreo Acoustic case. Based on 2000 Monte Carlo Markov Chain runs. Upper panels are west (B_0 W) and east (B_0 E) virgin biomass (t) and lower panels are west (B cur W(%B_0)) and east (B cur E(%B_0)) current biomass as a percentage of virgin biomass. M is the MPD point estimate.

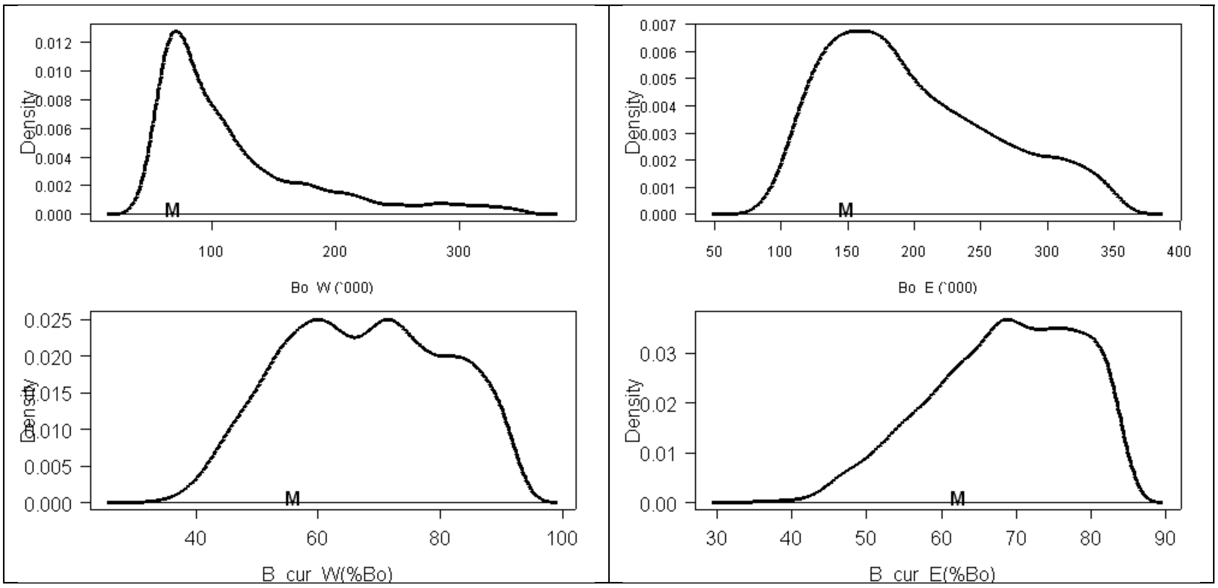

Figure 3: Bayesian posterior distribution of mature virgin biomass (t) estimates for the OEO 4 smooth oreo CPUE case. Based on 2000 Monte Carlo Markov Chain runs. Upper panels are west (B_0 W) and east (B_0 E) virgin biomass (t) and lower panels are west (B cur W(%B_0)) and east (B cur E(%B_0)) current biomass as a percentage of virgin biomass. M is the MPD point estimate.

Table 9 Mature biomass, estimates for OEO 4 smooth oreo. –, not estimated or na.

	Median	**CV**	**90% C.I.**
(a) Base case			
B_0 (t)	202 000	8	178 000–231 000
$B_{current}$ (t)	115 000	14	91 600–144 000
$B_{current}$ (%B_0)	57	6	51.3–62.4
(b) Acoustic case			
B_0 (t)	204 000	8	180 000–235 000
$B_{current}$ (t)	118 000	15	92 900–148 000
$B_{current}$ (%B_0)	58	6	52–63
(c) CPUE case			
B_0 (t)	300 000	29	194 000–491 000
$B_{current}$ (t)	214 000	40	107 000–405 000
$B_{current}$ (%B_0)	71	12	55–82

(c) Estimation of Maximum Constant Yield (MCY)

No estimates of MCY are available.

(d) Estimation of Current Annual Yield (CAY)

No estimates of CAY are available.

(e) Estimation of Current Surplus Production (CSP)

No estimates of CSP are available.

(f) Other factors that may modify assessment results

The WG considered that there were a number of other factors that should be considered in relation to the stock assessment results presented here:

- This assessment still has the uncertainties that were identified in the 2003 assessment analysis. The main uncertainty is that substantial proportions of the abundance in each survey are attributed to layer marks which are generally not fished by the commercial fishery. That uncertainty results from apportioning the observed acoustic backscatter to the range of different species caught by bottom trawl in layer marks. The acoustic surveys probably do a good job of estimating the abundance of school or high density marks which were observed by trawling to comprise mostly smooth oreo.

- The 2007 assessment was an update of the 2003 NIWA assessment and gave a similar overall result to the previous assessment for the base case, i.e., 55% (45–61) in 2003 and 57% (51–62) of mature B_0 (90% CI) in 2007. But the 2007 assessment differed from the previous assessment because the increasing trend in the west post-GPS standardised CPUE did not fit the model, and seemed in conflict with the declining trend in the east bycatch post-GPS standardised CPUE series.
- The assessment estimated the current stock size at 57 (51–62) % of the mature virgin level. The CV of 6% is unrealistic and only indicates that there is enough data to achieve a precise estimate for each case, which does not represent the true level of uncertainty in the stock assessment. Some of the additional uncertainty is apparent when looking across the three cases. There are a number of structural assumptions in the model that result in the true uncertainty of the model biomass estimates being underestimated. These include the assumption that the acoustic biomass estimates for smooth oreo are absolute (scaling coefficient = 1) and that there was no variability in recruitment (deterministic recruitment was used).
- There are also a number of factors that are outside the model and the analyses that add uncertainty to the model estimates of biomass. These include the large smooth oreo acoustic abundance estimated to be in layers (mentioned above) which are not normally fished by the commercial fleet, sensitivity of the acoustic biomass estimate to the low value of the target strength of smooth oreo, and uncertainty in the estimates of M and growth rates.
- The 2003 NIWA assessment estimated M within the model to achieve fits for both the length and abundance data. This indicated inconsistencies between the data and the model structure. The 2007 analysis showed that fitting the right hand side of the observer length frequency distribution gave poor fits to the model and that the profile of those data are inconsistent with other data, e.g., M, average recruitment, or growth. The 2007 analysis therefore fitted only the left hand side of the observer length frequency distribution to estimate selectivity. Fitting the right hand side would require estimates of recruit deviates to provide a quality fit to the model.
- This assessment suggests that there is no immediate sustainability issue for OEO 4 smooth oreo. But the decline in the standardised CPUE for the East bycatch post-GPS, assumed to index the larger east fishery, from 1.56 in 1992–93 to 0.57 in 2005–06 suggests that future monitoring of the stock would be wise. This decline is in contrast to the West target post-GPS fishery which shows increasing CPUE.
- Anecdotal evidence of large catches of small smooth oreo in the research trawl survey in 1990 suggests the possibility of a pulse of recruitment in the late 1980s, while the lack of large catches of small smooth oreo from recent acoustic surveys, e.g. 2005, suggests the possibility of poor recent recruitment.

5. STATUS OF THE STOCKS

Black oreo

The stock assessment of OEO 4 black oreo was considered unreliable and was not accepted. However, abundance indices from standardised CPUE analysis suggests that there has been a decline in the stock over time. It is not known if recent catch levels or the current TACC are sustainable or if they are at levels that will allow the stock to move towards a size that will support the maximum sustainable yield.

Smooth oreo

The OEO 4 smooth oreo stock assessment was updated in 2007. Three final runs are reported for the stock.

The model estimates of mid-year mature biomass in 2005–06 was 57% (51–62) of mature B_0 and suggests that there is not an immediate sustainability issue with this stock. However, there are considerable uncertainties associated with this assessment described in section 4.3 (f) above. The main uncertainty is that substantial proportions of the abundance in each acoustic survey are attributed to layer marks which are generally not fished by the commercial fishery. Also, standardised CPUE in the larger east fishery has declined in recent years.

OEO 4: Summary of yield estimates (t) and estimated catch (t) for the most recent fishing year. Estimated catch was scaled to the reported oreo landings for each fishstock using the reported estimated catch of black or smooth oreo from Tables 2 and 3 of the Fishery Summary section at the beginning of the Oreos report. Reported landings and TACCs for both oreo species combined are in Table 2 of the Fishery Summary section at the beginning of the Oreos report. –, not available.

Species	CAY	Long-term MCY	2005–06 estimated catch
Black oreo	–	1200	882
Smooth oreo	–	–	5946

6. FOR FURTHER INFORMATION

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