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 ASSESMENT

4.1 Introduction

No new assessments are reported for 2009 but standardised CPUE for black oreo were revised and updated for separate spatial areas in FMA 4.

4.2 Black oreo

Investigations were carried out in 2009 using age-based single sex single step preliminary models in CASAL. The data used in these models were four standardised CPUE indices (pre and post GPS in the east and west), and observer length frequencies. Growth and maturity were also estimated in some of the runs.

4.2.1 Estimates of fishery parameters and abundance

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 – 2009 analysis

The CPUE analysis method involved regression based methods on the positive catches only. Sensitivities were run where the zero catch tow and the positive catch tow data were analysed separately to produce positive catch and zero catch indices. All data were included, whether they were target or bycatch fisheries, with the target offered to the model (and not accepted).

The best data-split was investigated using the Akaike Information Criteria (AIC) on a number of potential regressions. Four indices were subsequently used, pre- and post-GPS in the east and west areas respectively. These two areas are very distinct: the west consists of flat fishing and the east of hill fishing, the west area was fished 10 years prior to the east, and there has been a move by the fishery since the early 1990s from the west to the east. However, despite of all these differences, the two series present almost identical patterns of decline in relative standardised CPUEs from the time their exploitation started in earnest (1980 in the west and 1992 in the east) which would suggest that for this fishery CPUE might be a reasonable index of abundance (because less influenced by technology, fishing patterns, hills or flats etc).

The standardised CPUE series and c.v.s are described in Table 2. Over comparable time periods and data sets, the trends from the updated series were similar to those from the 2000 analyses (Coburn *et al.* 2001). The west CPUE reduced to between 5% of 1980 value and 15% of 1981 value by 1990. The post-GPS west series is either flat or slightly increasing. The east CPUE reduced to 4% of 1984 value and 21% of 1985 value by 1990 even though catches were low. The post-GPS east series showed a further steep initial decline with total reduction to 15% of 1993 values by 2008.

Table 2: OEO 4 black oreo standardised CPUE analyses in 2009 (expressed in t / tow).

	pre-GPS east		pre-GPS west			post-GPS east		post-GPS west	
fishing year	index	cv	index	cv	fishing year	index	cv	index	cv
1980			8.97	0.17	1993	0.71	0.15	0.73	0.41
1981			4.00	0.11	1994	0.63	0.13	0.45	0.32
1982			2.24	0.10	1995	0.31	0.15	0.41	0.31
1983			2.20	0.09	1996	0.21	0.15	0.28	0.27
1984	0.47	0.95	1.54	0.10	1997	0.24	0.12	0.61	0.27
1985	0.41	0.28	1.51	0.07	1998	0.20	0.11	0.45	0.23
1986	0.38	0.32	1.28	0.10	1999	0.16	0.12	0.46	0.23
1987	0.65	0.30	0.67	0.10	2000	0.17	0.12	0.68	0.25
1988	0.10	0.18	0.54	0.13	2001	0.14	0.08	0.62	0.24
1989	0.02	0.20	0.48	0.12	2002	0.18	0.07	0.47	0.29
					2003	0.13	0.06	0.49	0.24
					2004	0.13	0.06	0.93	0.24
					2005	0.14	0.07	0.91	0.26
					2006	0.13	0.07	0.68	0.26
					2007	0.12	0.07	1.00	0.27
					2008	0.10	0.09	0.88	0.24

Relative abundance estimates from trawl surveys

The estimates, and their CVs, from the four standard *Tangaroa* south Chatham Rise trawl surveys are 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

Observer length frequencies

Observer length frequencies were available for about 20% of the yearly catch from 1989 to 2008. Analyses conducted on these data indicated they were not representative of the spatial spread of the fishery. When stratified by depth, the length frequencies had double-modes, centred around 28 cm and

38 cm, with inconsistent trends in the modes between years. Alternative stratification by subarea, hill, etc, did not resolve the problem; some tows showed bimodality. These patterns in length frequencies were an issue because the yearly shifts in length frequencies and double mode cannot be representative of the underlying fish population since black oreo is a slow growing long-lived fish. They are more likely linked with discrete spatial sub-groups of the population.

A similar double mode was reported for some strata in the same area from the 1994 Tangaroa trawl survey (Tracey & Fenaughty, 1997). It is likely that there is further spatial stock structure that is currently unaccounted for.

4.2.2 Biomass estimates

The 2009 stock assessment of OEO 4 black oreo was inconclusive as assessment models were unable to represent the observer length frequency structure, and were considered unreliable. The CPUE was fitted satisfactorily under a two-stock model but could not be fitted in a single homogeneous stock model. However, the WG agreed that:

1. The CPUE indices are consistent with a two-stock structure or at least a minimally-mixing single stock.
2. The updated CPUE estimates were probably a reasonable indicator of abundance (at the spatial scale of the east and west analyses).

4.2.3 Estimation of Maximum Constant Yield (MCY)

In 2000, 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). The MCY calculation was not updated in 2009.

4.2.4 Estimation of Current Annual Yield (CAY)

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

4.3 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 (Fmax) 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.

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.

4.3.1 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	1 351	1 351	0	1992–93	5 918	1 420	4 498
1979–80	114	114	0	1993–94	6 287	1 069	5 218
1980–81	1 436	1 436	0	1994–95	6 961	1 392	5 568
1981–82	3 465	3 430	35	1995–96	6 364	2 227	4 137
1982–83	3 757	3 757	0	1996–97	6 339	1 712	4 627
1983–84	5 817	5 759	58	1997–98	6 159	1 848	4 311
1984–85	4 736	4 547	189	1998–99	6 025	1 749	4 283
1985–86	4 922	4 380	541	1999–00	6 366	1 670	4 696
1986–87	5 670	4 196	1 474	2000–01	6 484	1 720	4 764
1987–88	7 771	2 642	5 129	2001–02	4 284	1 436	2 848
1988–89	7 225	2 457	4 769	2002–03	4 459	1 332	3 127
1989–90	6 788	1 154	5 634	2003–04	5 653	1 519	4 134
1990–91	6 028	1 808	4 220	2004–05	6 451	1 818	4 633
1991–92	5 504	1 211	4 293	2005–06	5 946	1 302	4 644

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

4.3.2 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 10. For the base case the median estimate of current mature biomass was 57% B_0.

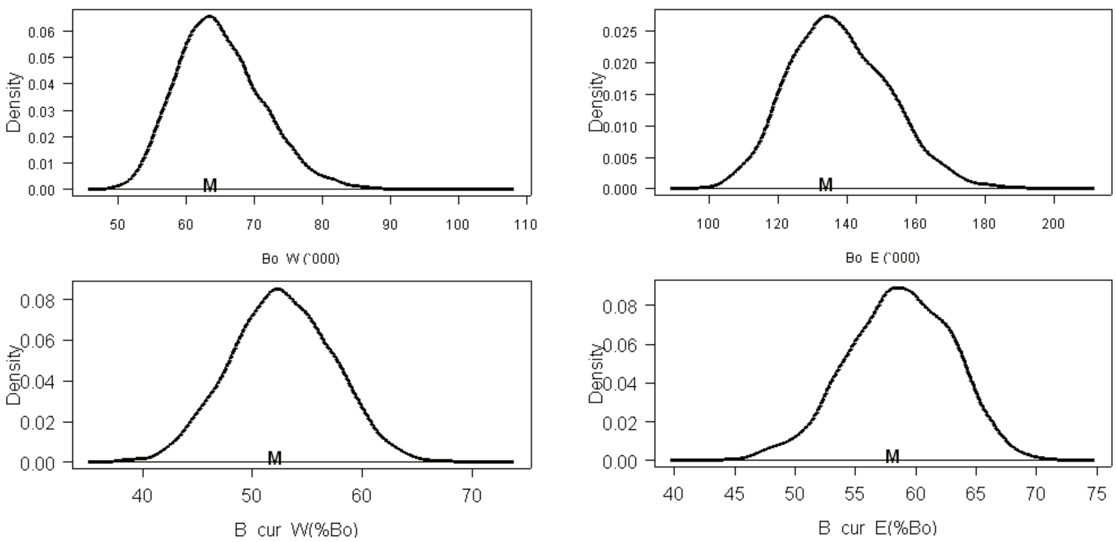


Figure 1: Bayesian posterior distribution of mature biomass estimates for the OEO 4 smooth oreo Base case. Based on 2000 Monte Carlo Markov Chain runs. Upper panels are west (B_0 W) and east (B_0 E) virgin biomass (t) and lower panels are west (B cur W(%B_0)) and east (B cur E(%B_0)) current biomass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

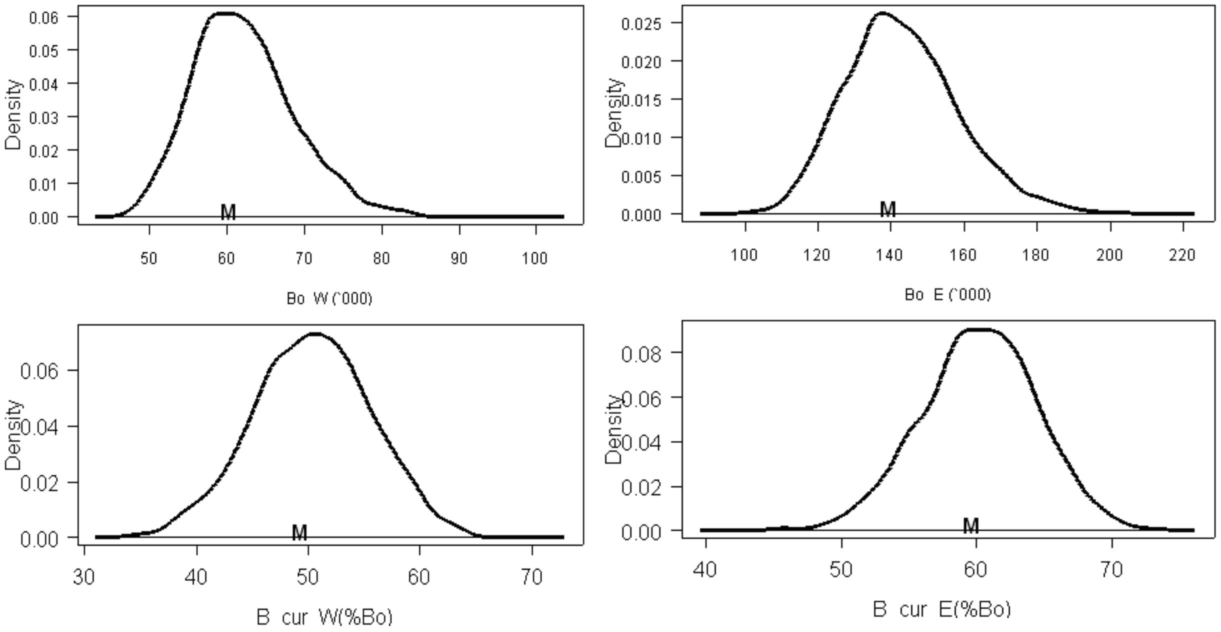


Figure 2: Bayesian posterior distribution of mature virgin biomass (t) estimates for the OEO 4 smooth oreo Acoustic case. Based on 2000 Monte Carlo Markov Chain runs. Upper panels are west (B_0 W) and east (B_0 E) virgin biomass (t) and lower panels are west (B cur W(%B_0)) and east (B cur E(%B_0)) current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

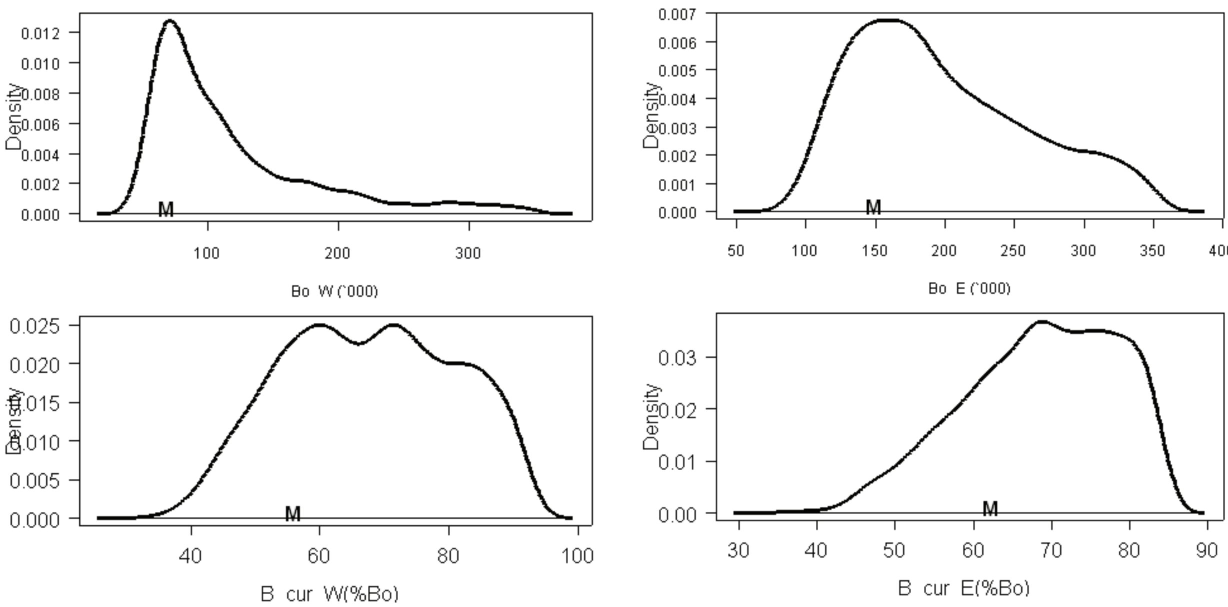


Figure 3: Bayesian posterior distribution of mature virgin biomass (t) estimates for the OEO 4 smooth oreo CPUE case. Based on 2000 Monte Carlo Markov Chain runs. Upper panels are west (B_0 W) and east (B_0 E) virgin biomass (t) and lower panels are west (B cur W(%B_0)) and east (B cur E(%B_0)) current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

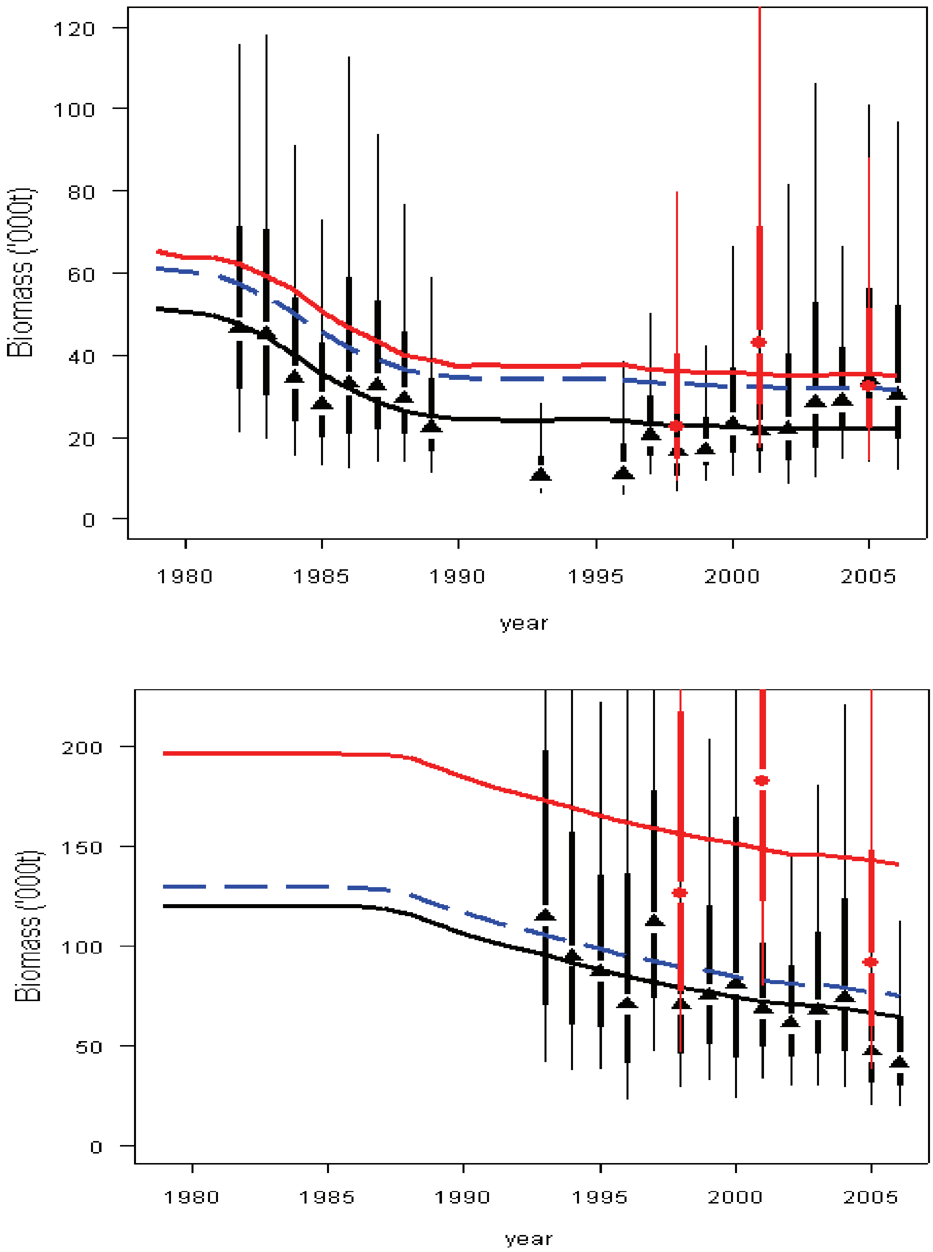


Figure 4: Fits of the abundance data in the base case for the west (top) and east (bottom) areas for the 2007 assessment (MPD solution, base case). Ovals are the acoustic (absolute) estimates. Triangles are the CPUE indices scaled by catchabilities to abundance. Curved lines are the model estimates of biomass (t), solid top line is the abundance that the acoustics measures, dashed line is the mature abundance, and the bottom solid line is the vulnerable (to fishing) abundance. Vertical thinner error bars for acoustic and CPUE estimates are ± 2 S.D., the thicker bars are ± 1 S.D

4.3.3 Estimation of Maximum Constant Yield (MCY)
No estimates of MCY are available.

4.4.4 Estimation of Current Annual Yield (CAY)
No estimates of CAY are available.

4.3.5 Estimation of Current Surplus Production (CSP)
No estimates of CSP are available.

4.3.6 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

There are no new assessment results in 2010 for these oreo stocks.

Stock Structure Assumptions
The two oreo stocks on the Chatham Rise are assessed separately but managed as a single stock. For black oreos the population has been found to be genetically similar to other oreo stocks and it is likely that some mixing occurs. Smooth oreos are assumed to be distinct from OEO1+6 stocks but may mix with the 3A stock.

- **OEO4 (Black Oreos)**

Stock Status	
Year of Most Recent Assessment	2009
Assessment Runs Presented	No quantitative stock assessment model
Reference Points	Target(s): 40% B_0 Soft Limit: 20% B_0 Hard Limit: 10% B_0
Status in relation to Target	Unknown
Status in relation to Limits	Unknown
Historical Stock Status Trajectory and Current Status <No plot available>	

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	CPUE has been stable for the last 5 years, after initial substantial decline during the 1980s and 1990s.
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	Unknown
Probability of Current Catch or TACC causing decline below Limits	Soft Limit: Unknown Hard Limit: Unknown

Assessment Methodology		
Assessment Type	Level 2 – Partial quantitative stock assessment	
Assessment Method	Age-based model in CASAL	
Main data inputs	- 4 standardised CPUE indices (pre/post GPS and east/west) - Observer length frequencies	
Period of Assessment	Latest assessment: 2009	Next assessment: Unknown
Changes to Model Structure and Assumptions	None.	
Major Sources of Uncertainty	- Assessments unable to represent observer length frequency data. - CPUE could be fitted to a two-stock model but not a homogenous model. - A portion of the abundance estimates were based on data from areas not normally covered by the trawl fishery, and the surveyed area was scaled by a factor of 4.3 – the area surveyed was borderline for providing a reliable abundance estimate.	

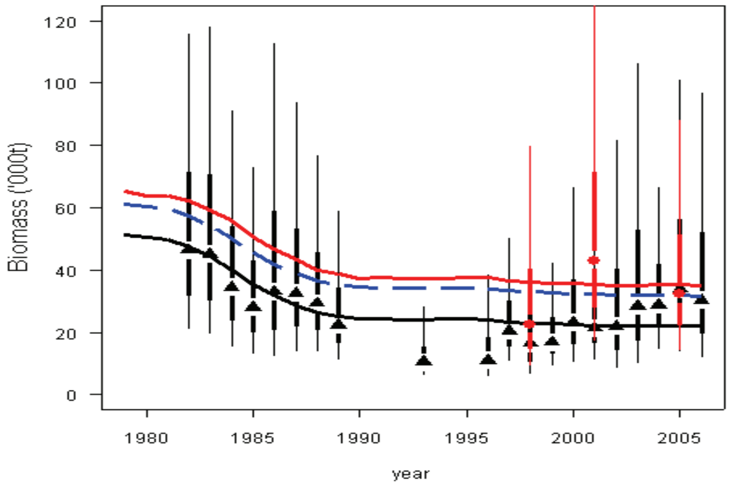
Qualifying Comments
The WG agreed that the stock might be split into east and west areas that were independent or at least minimally mixing for future assessments.

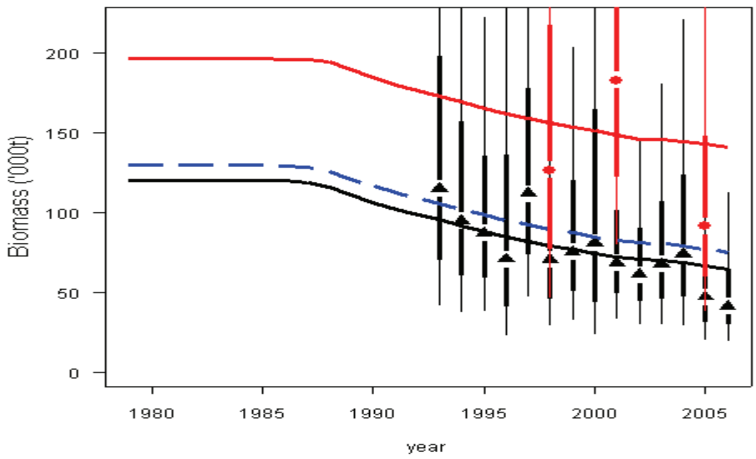
Fishery Interactions
Both species of oreo are sometimes taken as bycatch in orange roughy target fisheries and in smaller numbers in hoki target fisheries. Target fisheries for oreos do exist, with main bycatch being orange roughy, rattails and deepwater sharks. Bycatch species of concern include deepwater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

- **OEO4 (Smooth Oreos)**

Stock Status	
Year of Most Recent Assessment	2007
Assessment Runs Presented	A 2 area (E-W) base case with 2 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_{2007} was estimated at 57% B_0; Likely (> 60%) to be at or above the target.
Status in relation to Limits	B_{2007} is Very Unlikely (< 10%) to be below either the Soft or Hard Limits.

Historical Stock Status Trajectory and Current Status





Fits of the abundance data in the base case for the west (top) and east (bottom) areas for the 2007 assessment (MPD solution, base case). Ovals are the acoustic (absolute) estimates. Triangles are the CPUE indices scaled by catchabilities to abundance. Curved lines are the model estimates of biomass (t), solid top line is the abundance that the acoustics measures, dashed line is the mature abundance, and the bottom solid line is the vulnerable (to fishing) abundance. Vertical thinner error bars for acoustic and CPUE estimates are ± 2 S.D., the thicker bars are ± 1 S.D.

Fishery and Stock Trends	
Recent Trend in Biomass or Proxy	Biomass in the east area appears to be decreasing slowly, while that in the west area is stable.
Recent Trend in Fishing Mortality or Proxy	Unknown
Other Abundance Indices	-
Trends in Other Relevant Indicators or Variables	The results of recent acoustic surveys (e.g 2005) suggest the possibility of poor recruitment up to the present time.

Projections and Prognosis	
Stock Projections or Prognosis	No projections were made due to conflicting information in the data.
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	- Three acoustic absolute abundance data (1998, 2001, 2005) - Revised and updated standardised CPUE data - New survey and updated observer length data - Catch history	
Period of Assessment	Latest assessment: 2007	Next assessment: 2011
Changes to Model Structure and Assumptions	-	
Major Sources of Uncertainty	- Recruitment assumed to be deterministic. - Large proportions of the abundance in each survey attributed to layer marks not targeted commercially. - Estimates of growth and *M* - Standardised CPUE in the eastern fishery declining in recent, years, in contrast to western fishery which shows a slight increase in CPUE. - Right hand side of the observer length frequency distribution had poor fit and was therefore discarded – estimates of recruit deviates required. For more information see section 4.3.6.	

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

Bull, B.; Francis, R.I.C.C.; Dunn, A.; Gilbert, D.J. (2002). CASAL (C++ algorithmic stock assessment laboratory): CASAL User Manual v1.02.2002/10/21. NIWA Technical Report 117. 199 p.

Coburn,RP., Doonan IJ., McMillan PJ. 2001. Smooth oreo abundance indices from standardised catch per unit of effort data for OEO 4. New Zealand Fisheries Assessment Report 2001/11. 39p.

Coburn RP., Doonan IJ., McMillan PJ. 2001. Black oreo abundance indices from standardised catch per unit of effort data for OEO 4. New Zealand Fisheries Assessment Report 2001/39. 24p.

Doonan IJ., McMillan PJ., Coburn RP., Hart AC. 2003. Assessment of OEO 4 smooth oreo for 2002–03. New Zealand Fisheries Assessment Report 2003/50. 55p.

Doonan IJ., McMillan PJ., Coburn RP., Hart AC. 2001. Assessment of OEO 4 smooth oreo for 2000–01. New Zealand Fisheries Assessment Report 2001/21. 37p.

Doonan IJ., McMillan PJ., Coburn RP., Hart AC. 2001. Assessment of OEO 4 black oreo for 2000–01. New Zealand Fisheries Assessment Report 2001/30. 32p.

Doonan IJ., McMillan PJ., Hart AC. 2001. The use of mean length data for stock assessments of black oreo and smooth oreo in OEO 4. New Zealand Fisheries Assessment Report 2001/34. 16p.

Doonan IJ., Coombs RF., McMillan PJ., Dunn A. 1998. Estimate of the absolute abundance of black and smooth oreo in OEO 3A and 4 on the Chatham Rise. Final Research Report for Ministry of Fisheries Research Project OEO9701. 47p.

Doonan IJ., McMillan PJ., Coburn RP., Hart AC. 1997. Assessment of Chatham Rise smooth oreo (OEO 3A and OEO 4) for 1997. New Zealand Fisheries Assessment Research Document 1997/21. 26p.

Doonan IJ., McMillan PJ., Coburn RP., Hart AC. 1996. Assessment of Chatham Rise smooth oreo (OEO 3A and OEO 4) for 1996. New Zealand Fisheries Assessment Research Document 1996/17. 21p.

Doonan IJ., McMillan PJ., Coburn RP., Hart AC., Cordue PL. 1995. Assessment of smooth oreo for 1995. New Zealand Fisheries Assessment Research Document 1995/12. 31p.

Francis RICC. 1999. The impact of correlations in standardised CPUE indices. New Zealand Fisheries Assessment Research Document 1999/42. 30p.

Francis RICC. 1992. Recommendations concerning the calculation of maximum constant yield (MCY) and current annual yield (CAY). New Zealand Fisheries Assessment Research Document 1992/8. 27p.

McMillan PJ., Doonan IJ., Hart AC., Coburn RP 1998. Oreo stock assessment. Final Research Report for Ministry of Fisheries Research Project OEO9702. 16p.

McMillan PJ., Doonan IJ., Coburn RP., Hart AC. 1996. Is the south Chatham Rise trawl survey providing an index of smooth oreo abundance in OEO 4?. New Zealand Fisheries Assessment Research Document 1996/16. 18p.

McMillan PJ., Hart AC. 1991. Assessment of black and smooth oreos for the 1991–92 fishing year. New Zealand Fisheries Assessment Research Document 1991/10. 29p.