ANNEX 5

REPORT OF THE FISH STOCK ASSESSMENT WORKING GROUP

(Hobart, Australia, 12–20 October, 1988)

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INTRODUCTION

The Meeting of the Working Group was held at the CCAMLR Headquarters, Hobart Australia from 12 to 20 October, 1988. The Convener (Dr K.-H. Kock, FRG) opened the meeting and the agenda (Appendix 1) was adopted. A list of those attending is given in Appendix 2. Dr J.A. Gulland was appointed as rapporteur. A list of documents considered at the meeting is given in Appendix 3.

GENERAL MATTERS

Presentation of Assessment Results

2. It was noted that standard formats had been established in other Commissions for the presentation of summary results of assessment studies (WG-FSA-88/3). These had clear advantages for both the assessment scientists and for the Commissioners. A standard format has therefore been used in this report for Subarea 48.3, and these summaries are attached as Appendix 4 of this report. For other areas it was not possible to produce summaries at this meeting, but it is planned that such summaries will be produced for all areas in the future, perhaps amended in the light of the particular needs of the Commission.

Data Availability

3. The regular information on catch and effort statistics on STALANT forms and routine biological information was received by the start of the meeting though some STALANT data were received after the 30 September deadline. Summaries of data available for the Working Group are in documents WG-FSA-88/6–12, 17–19, 27 and 25.

4. It was noted that as the database is becoming well established, it is increasingly likely that Members of the Working Group will wish to have access to the database for

intersessional work. This could raise problems of confidentiality, especially in relation to data collected by individual scientists, and not yet included in published studies. At the same time it was very important that when studies were being made for submission to CCAMLR, that the scientists concerned did have access to all relevant material in the Commission database.

5. It was then agreed that where scientists needed data for studies to be submitted to future meetings of the Working Group, data requested by them should be supplied by the Secretariat, who should inform the originators of the data that this was being done. If data are required for other purposes, e.g. for publication in scientific journals, then the Secretariat will, in response to a detailed request, supply the data only after permission has been given by the originators of the data.

6. It was stressed that it was highly desirable that anyone planning data analyses should take advantage of the Working Group meetings to inform other scientists of their plans and promote co-operation in analysis and publication between the suppliers and users of the data.

7. The FRG was going to complete the study (WG-FSA-88/14) reported to the present meeting, Australia was to make a review of *Champsocephalus gunnari*, and the UK would be studying the South Georgia stocks with particular reference to recruitment patterns and dynamics. Poland, Spain and USSR would be reviewing the mesh selectivity data.

Growth Studies

8. It was noted that problems still arose in relation to age determination, especially for *N. rossii* and this made VPA and other routine analyses difficult (see below). A paper by Prof. Radtke, (University of Hawaii) had been submitted to the 1987 Scientific Committee meeting (SC-CAMLR-VI/BG/43) but received too late for discussion. This described the use of microincrements on otoliths (daily rings), and a simple approximation to age determination based on otolith measurements.

9. Use of microincrements (daily rings) was also reported for *Pseudochaenichthys georgianus* at South Georgia (WG-FSA-88/21), by Linkowski and Traczyk (Sea Fisheries Institute, Gdynia) in a paper originally presented at the Sixth European Ichthyological Congress, giving a simple method of examining fish age by taking the weight of its otolith.

10. The use of daily rings has proved very valuable in other species of fish for which ageing by other methods has been difficult. In the case of *N. rossii* and *C. gunnari*, there appear to be discrepancies between the daily ring counts and other methods, the former tending to give the older age. It was impossible to consider this problem at the present meeting and those interested were urged to contact Prof. Radtke during the intersessional period. Approaches to be used could include direct comparisons of age determinations of the same fish and at least for *C. gunnari*, comparison with the progression of modes in the length frequencies.

11. A particular problem has arisen in respect of age/length keys for *N. rossii* and *C. gunnari* reported in some recent years. In some cases there are discrepancies between different keys reported by the same country, apparently because the age determinations have been done by different institutions. These discrepancies have made it very difficult to construct consistent series of catch at age for use in VPA and other studies. The Working Group recommends that the affected age readings be revised as far as possible to obtain consistent readings.

12. The Convener noted that the CCAMLR fish otoliths/scales/bones exchange system was progressing well (WG-FSA-88/30), and that a full report should be presented to the Scientific Committee in 1989.

Distribution of Larval Fish

13. The use of small-meshed samplers attached to bottom trawls used in research vessel surveys was reported by Slósarczyk and Wojcik (Sea Fisheries Institute, Gdynia) (WG-FSA-88/20). These had proved successful in sampling larval and post larval fish (10–30 mm), as well as some 0-group fishes. These samplers appear to provide a useful technique for examining the distribution of these sizes of fish which can be done easily during the course of routine trawl surveys. Construction of an opening and closing sampler would be very valuable in allowing samples to be taken close to the bottom without incidental catches taken in midwater. This bottom zone is normally not sampled because of the danger of damage to, or loss of, plankton nets.

Mesh Selectivity

14. Mesh Selection experiments were reported by Poland and Spain. These showed that there were big differences in the selectivity (as measured by the 50% selection length, L_{50}, or the selection factor (SF) – L_{50}/mesh size) between experiments. The differences could be largely explained by differences in the netting twine, or in the volume of catches, with thick twine and high catches reducing selectivity. This means that care should be taken in applying research results (at low catch rates, generally not more than 500 kg/hour), to commercial conditions (1–1.5 tonnes/hour or more). The selectivity values quoted here should be considered as upper limits to the selection achieved under commercial conditions. In commercial practice it is likely that fewer fish than predicted will be released by a mesh of a given size, and that a larger mesh than predicted would be needed to achieve a given selection effect. In summary, the results were as given in Table 1 (more detailed information is available in an internal working paper):

Table 1: Summary results of mesh selection experiments.

Species	Mesh Size (as measured)	L_{50} cm	SF	Mean catch/hr (kg)
C. gunnari	68	20.0	2.94	583
South Georgia	67	23.5	3.48	1 167
	88	23.0	2.56	970
	124[b]	(21–23)[a]	(1.77)	NA
	125[b]	(21–29)[a]	(1.68–2.32)	NA
S. Orkneys	68	21.3	3.11	87
	125[b]	32	2.56	NA
Elephant Island	68	21.3	3.11	121
and S. Shetlands	88	28.0	3.22	241
	110	31.1	2.82	369
	68	19.7	2.89	70
P. br. guntheri				
Shag Rocks	67	20.0	2.97	1 163
N. gibberifrons	68	19.5	2.87	556
S. Georgia	88	18.2	2.02	971
	124[b]	(30)[a]	(2.42)	NA
S. Orkneys	68	20.8	3.04	81
Elephant Island	68	19.6	2.86	121
and S. Shetlands	68	18.4	2.70	69
	88	19.8	2.28	241
	88	25.0	2.88	750
	110	31.2	2.84	241
	110	23.6	2.10	993
	110	29.4	2.64	8
	124[b]	(16–20)[a]	(1.3–1.6)	NA
C. aceratus	68	(17.9)[a]	(2.63)	615
S. Georgia	88	20.6	2.29	966
	124[b]	(17.5)[a]	(1.41)	NA
	125[c]	(21.0)[a]	(1.75)	NA
S. Orkneys	68	(15.2)[a]	(2.22)	82
	125[c]	(21)[a]	(1.68)	NA
Elephant Island	88	21.5	2.48	241
and S. Shetlands	110	23.0	2.09	434
	124[b]	(20–26)[a]	(1.61–2.1)	NA

[a] selection curve not well defined
[b] with thick twine
[c] chafer

15. For *C. gunnari* the mean SF for the eight experiments with normal twine and no chafer is 3.01; though other factors can be derived by making more adjustments for differences in catch rate, length of tow, stock structure, etc., this appears to be a reasonable estimate for research conditions of low catch rates.

16. For *P. br. guntheri* only one value is available, but this probably gives an acceptable estimate of the selection factor. For *C. aceratus* estimates of selection factor are highly variable, and no clear conclusion can be reached. There are also doubts concerning some of

the values for *N. gibberifrons*, but the selection factors are less variable; the mean of all ten observations with normal twine without chafer is 2.62.

STATISTICAL AREA 48

Subarea 48.3 (South Georgia)

17. The history of the catches in the South Georgia region is given in Table 2. This shows clearly how fishing effort has been switched from one species to another, leading to high variability in annual catches. The 1988 catch was slightly below that in 1987, principally because of a drop in catches of *C. gunnari* in line with the Commission's recommendations.

Notothenia rossii

18. The Commission's recommendations have aimed to keep the catches of this species to as low a level as possible. Reported catches in 1987/88 fell to 197 tonnes, just below the 1987 level.

19. This stock remains at a very low level. The biomass estimated by joint US/Polish research surveys fell from just under 4 000 tonnes in 1986/87 to 1 000 tonnes in 1987/88, though earlier surveys by Spain and FRG gave higher values (11 471 tonnes in 1986/87 and 12 781 in 1984/85 respectively). The differences between surveys and the great apparent drop between 1986/87 and 1987/88 are not easy to explain but may be related to the patchy distribution of this species. However, the surveys are consistent in showing extremely low stock levels compared with those at the beginning of the fishery.

Table 2: Catches of various finfish species from Subarea 48.3 (South Georgia Subarea) by year. Species are designated by abbreviations as follows: TOP (*Dissostichus eleginoides*), NOG (*Notothenia gibberifrons*), NOR (*Notothenia rossii*), NOS (*Notothenia squamifrons*), NOT (*Patagonotothen brevicauda guntheri*), SSI (*Chaenocephalus aceratus*), ANI (*Champsocephalus gunnari*), SGI (*Pseudochaenichthys georgianus*) and LXX (*Myctophidae spp.*).

Split -year	TOP	NOG	NOR	NOS	NOT	SSI	ANI	SGI	LXX	OTHERS	TOTAL
1970	0	0	399 704	0	0	0	0	0	0	0	399 704
1971	0	0	101 558	0	0	0	10 701	0	0	1 424	113 713
1972	0	0	2 738	35	0	0	551	0	0	27	3 351
1973	0	0	0	765	0	0	1 830	0	0	0	2 595
1974	0	0	0	0	0	0	254	0	0	493	747
1975	0	0	0	1 900	0	0	746	0	0	1 407	4 053
1976	0	4 999	10 753	500	0	0	12 290	0	0	190	28 732
1977	441	3 357	7 945	2 937	0	293	93 400	1 608	0	14 630[a]	124 611
1978	635	11 758	2 192	0	0	2 066	7 557	13 015	0	403	37 626
1979	70	2 540	2 137	0	15 011	464	641	1 104	0	2 738[b]	24 705
1980	255	8 143	24 897	272	7 381	1 084	7 592	665	505	5 870	56 664
1981	239	7 971	1 651	544	36 758	1 272	29 384	1 661	0	12 197[c]	9 167
1982	324	2 605	1 100	812	31 351	676	46 311	956	0	4 901	89 036
1983	116	0	866	0	5 029	0	128 194	0	524	11 753[d]	146 482
1984	109	3 304	3 022	0	10 586	161	79 997	888	2 401	4 274	104 742
1985	285	2 081	1 891	1 289	11 923	1 042	14 148	1 097	523	4 238	38 517
1986	564	1 678	70	41	16 002	504	11 107	156	1 187	1 414	32 723
1987	1 199	2 842	216	183	8 810	337	71 141	119	1 102	1 910	87 859
1988	1 809	5 219	197	1 560	13 424	312	34 573	397	14 868	1 456	73 815

[a] Includes 13 724 tonnes of unspecified fish caught by the Soviet Union
[b] Includes 2 387 tonnes of unspecified Nototheniidae caught by Bulgaria
[c] Includes 4 554 tonnes of unspecified Channichthyidae caught by the Federal Republic of Germany
[d] Includes 11 753 tonnes of unspecified fish caught by the Soviet Union

20. Uncertainties on recent age determinations have made it difficult to carry the VPA calculations beyond about 1984/85, but the analysis up to that time, and the low survey biomass estimates confirm the picture of a very low stock. This is related to a very low level of recruitment. Year-class strength as measured at 2 years old seems to have dropped in two rather abrupt steps – from around 50 million individuals annually for the stock observed at the beginning of the fishery, to some 8–10 million fish annually for the year-classes born between 1968 and 1975, and then to 3 to 4 million. The timing of these drops does not coincide exactly with the drops in adult stock caused by the big pulses in fishing.

21. Though the reduction in adult stock must be having an effect on recruitment other factors may be acting, perhaps by increasing the mortality on larval or pre-recruit fish. Until some of the uncertainties concerning recruitment are removed it is difficult to predict the quantitative effect on future recruitment of changes in adult stocks.

22. In view of the uncertainties about this stock it is important that its status should be carefully monitored. This can be done by regular research surveys, but these need to be carefully designed to take account of the highly patchy distribution of the adults, and the fact that the younger year-classes are distributed inshore.

Champsocephalus gunnari

23. Catches in 1987/88 were 34 573 tonnes, just below the catch limit of 35 000 tonnes, and less than half the 71 000 tonnes taken in 1986/87. One trawl survey was carried out, by the joint US/Polish expedition (SC-CAMLR-VII/BG/23), and gave a biomass of 16 533 tonnes in December 1987/January 1988, compared with an estimate of 52 672 tonnes for the similar survey in the same period of 1986/87. Because a bottom trawl with a vertical opening of 4 m was used, it is probable that this underestimates the true biomass.

24. Catch and effort statistics from the Soviet fisheries are available since 1982/83 and these allow an index of abundance to be calculated. These calculations were based on the monthly figures reported on STALANT B forms, and were limited to those months for which *C. gunnari* made up at least 75% of the catch, i.e. was the main target species. The resulting indices of abundance, calculated as the mean of the monthly catch per hour, (in tonnes), for bottom and mid-water trawls, were as follow (bracketed figures are those based on only one month's data, which are probably less reliable).

Season	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88
OTM	3.85	3.32	(2.19)	(2.20)	4.75	2.73
OTB	7.12	5.42	(4.44)	no data	2.73	1.99

25. The decline in the index based on the midwater trawl is less than that based on the bottom trawl. It is probable that the bottom trawl index is the more reliable in the early seasons because the midwater trawl technique was still being developed for use of *C. gunnari*. In the most recent years the midwater trawl technique has been well established and the bulk of the catch was taken in midwater trawls. Both series agree in showing a substantial decline (by 43% for midwater and 27% for bottom trawl) between 1986/87 and 1987/77.

26. Catch at age data show that catches in the last two seasons have been provided largely by the 1985 year-class, with a smaller contribution by the 1984 year-class, and older fish have been very scarce. These two year-classes have been largely fished out.

Effects of Uncertainties in Natural Mortality

27. Yield per recruit calculations show that considerable improvements in yield can be achieved by allowing the fish of grow to a larger size. This can be seen by considering the changes in the total biomass of a cohort in the absence of fishing.

Age	1	2	3	4	5	5	6
Fish weight (g)	15	72	152	314	438	571	616
Cohort biomass	(kg per 1 000 recruits at age 1)						
M = 0.40	15	48	68	95	88	77	56
M = 0.35	15	51	76	110	108	100	75
M = 0.25	15	56	92	148	161	163	137

28. Because of the uncertainties that surround the value of the natural mortality, three values were used – 0.35 (as used on the VPA's) and 0.4 and 0.25. These do affect the detailed conclusions, changing the age at which a cohort would achieve its greatest weight from age 4 (if M=0.40) to 6 (if M=0.25). However, in all cases there is a considerable increase in the biomass up to age 4. Thus if a cohort is harvested predominantly at ages 2 and 3 (as was the case for the recently recruited classes), the yield is greatly reduced compared with that if it were taken at higher ages (4–6). The gain, as between harvesting at 3 (76), and 4 (110) for M=0.35 is some 45%. Since the actual catches in the two seasons was over 100 000 tonnes, the gain as compared with harvesting the same year-classes two years earlier, could be around 40 000 tonnes.

Calculations of Yield per Recruit

29. The results of fishing with different ages at first capture can also be presented, for M=0.35, in a more usual table showing yield per recruit as a function of fishing mortality and age at first capture. This is shown in the table below, calculated from the Thompson and Bell model, using ages up to 10.

Fishing Mortality	Age at first capture[(a)]			
	2	3	4	5
1.4	.074	.104	.135	.130
1.2	.076	.105	.133	.127
1.0	.079	.107	.131	.124
0.8	.083	.108	.127	.119
0.7	.085	.108	.125	.115
0.6	.087	.108	.121	.110
0.5	.089	.106	.116	.105
0.4	.089	.103	.109	.097
0.3	.087	.096	.098	.085
0.2	.079	.082	.081	.069
0.1	.056	.056	.052	.044
Value of $F_{0.1}$	.245	.326	.455	.554

[(a)] assuming knife-edged recruitment

30. The pattern of fishing has varied considerably from year to year, but the fishing mortality has been often high (1.0 or even more), with the effective age at fist capture between 2 (as in 1981 and 1985) and 3. These values are underlined in the table. It will be seen that considerable increases in yield per recruit can be achieved by increasing the effective age at first capture. Reducing the fishing mortality will increase the yield per recruit slightly, but will bring other benefits (reduced variability in the annual catches, and the possibility of substantially reduced costs).

Control of the Age at First Capture

31. The degree to which the age at first capture should be increased depends on the level of fishing mortality, but unless there are very substantial reductions in F, the optimum would be 4 years (i.e. around 32 cm, Kock et al., 1985). One standard way of achieving this change is to introduce a larger mesh. Earlier it was shown that under conditions of low catch rates, the selection factor is about 3.0, i.e. a 80 mm mesh corresponds to a mean size at first capture of 24 cm, which is above the mean length at first maturity, but well below the optimum size based on the yield per recruit analysis. A length at first capture of 32 cm would require a 107 mm mesh. However, as suggested earlier, it is possible that under commercial conditions of large catches the selectivity of the net may be much less, so that a correspondingly larger mesh would be required to achieve the desired result. The Working Group did not have the information to quantify the effect of any reduced selectivity at high catch rates.

32. If the use of a mesh size substantially bigger than the present 80 mm does not result in an appreciable increase in the effective size at first capture, then there may be other ways of achieving a broadly similar result. The recruitment is highly variable, so if fishing effort is kept low when a strong year-class is entering the fishery (i.e. is 2 and 3 years old), and is allowed to increase only when the fish are 4 years old, this would allow considerable protection to the young fish of those strong year-classes. Also to the extent that the fishery can target on the more abundant age groups, it should also give some protection to the young fish in the weaker year-classes. Such a consideration would give support to the policy, when setting TAC's, if taking a conservative view of the strength of incoming year-classes. If they turn out to be strong, TAC's in later years can readily be adjusted upwards.

33. Another method, used in the fishing for some species around Kerguelen, is to set a minimum fish size, with the requirement that any incidental catches of undersized fish should be discarded. The Working Group did not have time to evaluate this method.

VPA Calculations

34. Two sets of VPA's were run, using Soviet and Polish age-composition data. The former set was based on the Soviet report (WG-FSA-88/32), and no attempt was made to modify the tuning methods reported in that document to take account of survey and other information. The VPA using Polish data was tuned to the 1987/88 biomass estimate from the joint Polish/US survey.

35. In using the Polish/US survey data it had to be recognised that the use of a bottom trawl gave rise to figures that are underestimates of the true biomass. Assuming that the degree of underestimation was consistent from year to year, the survey biomass estimate of 16 533 tonnes for 1987/88 was increased by a factor of 2.85, the ratio of the 1986/87 survey estimate (52 670 tonnes) to the biomass of 150 000 tonnes agreed by the Working Group at its 1987 meeting based on the Spanish survey in 1986/87 (Balguerias et al., 1987). The resulting figures of biomass at different times were then as follows:

Date	Survey	VPA (Polish data)	VPA (Soviet data)[a]
July 1986		139 565	128 677
Dec 86/Jan 87	150 000		
July 1987		69 836[b]	67 158
Dec 86/Jan 87	47 082		
July 1988		31 377[b]	53 109[c]

[a] Run made in CCAMLR, and differs slightly from original Soviet figures

[b] The 1988 figure, and to a lesser extent, the 1987 figure is too low because no allowance was made for recruitment

[a] Assuming a low level of recruitment of 400 million fish

36. The stock at the beginning of the 1988/89 season was estimated directly from the survey data, using the age-frequencies observed in the surveys, and adjusting the actual numbers of age to match the corrected figures of biomass. Using this method the only assumption that had to be made about recruitment was that the age 1 fish were properly represented in the surveys. To the extent that they are under-represented, the biomass estimates will be too low. This method gave the following estimates of exploitable biomass in July 1988:

(i) based on 1986/87 survey 65 792 tonnes
(ii) based on 1987/88 survey 48 023 tonnes

37. Bearing in mind that the approaches are largely independent the degree of agreement is encouraging, with the Soviet figure being roughly the central estimate. However, all estimates of current biomass are subject of uncertainties concerning the level of recruitment.

Calculation of TAC

38. To produce an estimate for a TAC for 1988/89 several estimates of $F_{0.1}$ were available depending on the vector of F at age, and also on the values of weight at age used. After some discussion the Working Group agreed to use values of $F_{0.1} = 0.313$, and $F_{max} = 0.645$ derived from data given by Borodin and Kochkin (WG-FSA-88/32); these differ slightly from those given in the earlier table, but the difference is not large. The corresponding values of TAC for 1988/89, applied to the Soviet estimate of biomass are:

for $F_{0.1}$ 10 194 tonnes
F_{max} 18 586 tonnes

It was noted that because the fish concerned are small, uncertainties in recruitment will have little effect on these estimates.

Long-Term Management Plans

39. The Working Group stressed that management policy should not be focussed narrowly on the level of catch in the following year, but should give priority to ensuring the long-term productivity of the resource. It drew attention to Figures 3a-3c (SC-CAMLR-VI, Annex 5), which illustrated how reduced levels of fishing mortality gave much improved spawning stock abundance, while, except in the short-term, the reduction in catch would be small. When the stock is currently at a low level, there are a number of alternative strategies, in addition to those involving different constant level of F. For example, F may be kept at a very low level for a number of years (e.g. 5) until the stock is well re-built, and thus increased, to the long-term target. Figure 1 shows the trajectory of relative stock size for three strategies applied to a stock currently at a low level (such as the 1988 *C. gunnari* stock), using an average value of recruitment of 562 million. These strategies were:

$F_{0.1}$; F_{max}; and a low F for 5 years, followed by $F=F_{0.1}$

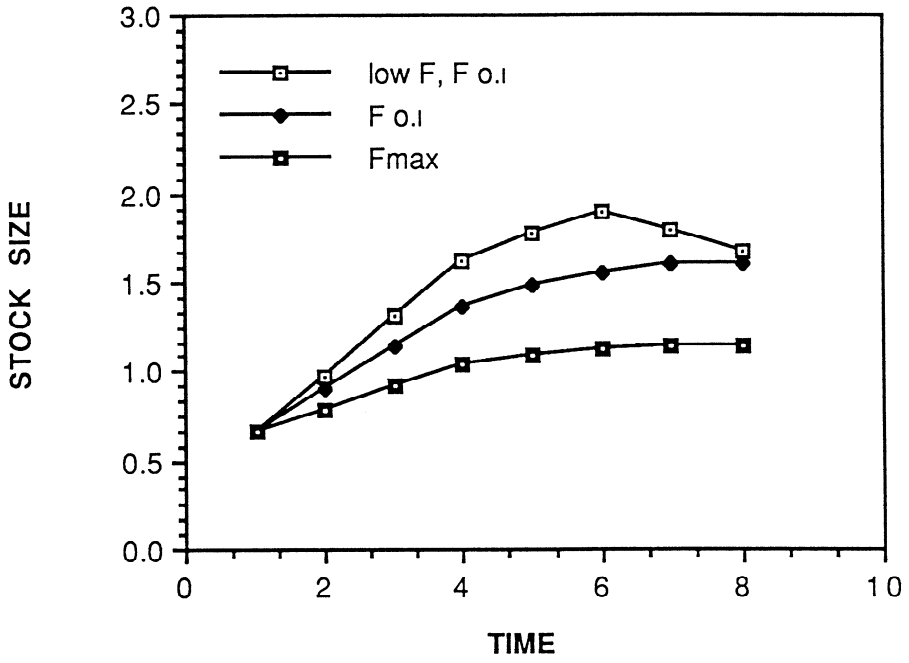

Figure 1: Long-term stock size forecast to compare the effect of different management strategies

Research Requirements

40. The most important research work for management purposes is to obtain early estimates of the strength of incoming cohorts. Since the 0-group is largely pelagic this would require surveying with a mid-water trawl and such surveys are now of high priority. To be of significant value, they would need to be continued over a series of years. The Group noted that a number of bottom trawl surveys have been carried out which have the potential for producing indices of recruitment, which could be calibrated with VPA results, or midwater trawl surveys.

41. At its 1987 Meeting the Commission had requested advice for *C. gunnari* on, *inter alia*, the effect of closed seasons and/or areas to protect young fish and reduce by-catch. The Working Group had no new data concerning this matter which would suggest alterations to the present closed area and closed seasons in Subarea 48.3.

Patagonotothen br. guntheri

42. This is a small species only caught in significant quantities by a directed Soviet fishery in the Shag Rocks area.

43. Length and age data are available for most years. These indicate that the fishery has been largely based on ages 2–4, and there is little indication of much change in age composition during the period. This would suggest a relatively high value of natural mortality, with a moderate or low fishing mortality. An estimate of biomass of 81 000 tonnes is available from the Spanish survey (Balguerias et al., 1987) carried out in 1986/87, and this could help fix the terminal value of F for VPA calculations.

44. Problems were met in calculating VPA's in setting an appropriate value of M, and in the catch-at-age data, where there are some differences between reported data sets. A value of M=0.90 has been used in the Soviet report (WG-FSA-88/33), while Kock and Koester (WG-FSA-88/14) used different catch-at-age data and values of M=0.35 (from Pauly's 1980 equation) and M=0.55 (from a Soviet publication in 1984). It was felt that a value of M as low as 0.35 was not consistent with the observed age-composition at the beginning of exploitation, while M=0.9 seemed rather high. It was not possible in the time available to re-calculate VPA's, but using the variation of fishing mortality with age found in the Soviet report, yield per recruit calculations were made with alternative values of M. This gave the following estimates:

M	0.35	0.55	0.7	0.9
$F_{0.1}$	0.58	0.79	1.04	1.54
F_{max}	1.51	>3	>3	>3

45. In the absence of better estimates of M it is not possible to suggest a TAC that would achieve $F_{0.1}$. An alternative policy, which would serve to ensure that fishing did not expand to an excessive degree might be to limit catches to around the level of recent years.

Research Requirements

46. It would be desirable to recalculate the VPA's tuning them to the biomass estimates, and to examine the early age-composition data to produce a better estimate of M.

Notothenia gibberifrons

47. Moderate catches of this species have been taken in nearly all years, with a peak of over 11 000 tonnes in 1978. There is a suggestion of a decline, with average catches of 6 200 tonnes and 3 000 tonnes in successive 5-year periods, but the 1988 catch was well above the recent average.

48. Catch-at-age data have been estimated from commercial length frequencies and age-length keys for all years up to 1985. This has enabled VPA analyses to be run up to 1985, but the absence of commercial length-frequency data for the 1986, 1987 and 1988 seasons have made it impossible to bring the analyses more up to date. The simple examination of the catch-at-age data shows a very big shift from a fishery based on old fish (mostly over 12 years old) in 1976, to one consisting of younger fish, mainly 7 to 10. This presumably indicates a substantial impact of fishing.

VPA Calculations

49. In previous VPA analyses a value of M=0.25 had been used, but such a high value appears inconsistent with the presence of so many old fish in the early years of the fishery, and the VPA calculations were repeated using M=0.125. These two values of M implied different patterns of fishing mortality with age. For M=0.25 it was assumed F increased linearly from 0 at age 1 to full recruitment at age 10. For M=0.125 F increased from 0 at age 1 to full recruitment at age 7.

50. Three estimates of biomass are available from surveys – 15 762 tonnes from an FRG survey in 1984/85, and 13 129 and 7 798 tonnes from Polish/US surveys in 1986/87 and 1987/88. The VPA calculations were tuned to the 1984/85 survey data, and the resulting projections, using median levels of recruitment, for M=0.125 gave a better agreement with the later surveys than those for M=0.25. Using the values of M=0.25 implied that the year-classes supplying the large catches of old fish at the beginning of the fishery must have been distinctly larger than those in recent years, and that there has been a large decline of biomass. Using M=0.125 gives more reasonable results, but still indicates that the stock has been very heavily fished, and that the 1988/89 level is only some 17% of the initial value. The spawning stock biomass has been reduced still more, to some 12% of the initial level.

Management Policies

51. In the long-term, holding the fishing mortality at $F_{0.1}$ would allow the stock to recover to levels at which annual catches (assuming average recruitment) could be maintained at some 2 400–2 900 tonnes annually (for M=0.25 and M=0.125 respectively). Recovery to these levels would take some 30 years, but stock abundance, and annual catches would recover to some 90% of the long-term value within 10–15 years.

52. Yield per recruit calculations indicate that $F_{0.1}$=0.209 (if M=0.25) or 0.0935 (if M=0.125). Corresponding F_{max} values are 0.425 and 0.157 respectively. Recent values of F have been in excess of these values.

53. Recruitment does not seem to have varied greatly so short-term projections using average values of recruitment for the incoming year-classes are probably reasonable. TAC's for 1988/89 to achieve $F_{0.1}$, based on projections of the VPA outputs would be as follows:

	$F_{0.1}$	F_{max}
if M = 0.25	TAC = 259 tonnes	450 tonnes
if M = 0.125	TAC = 443 tonnes	720 tonnes

(Note that though the assumption of M=0.125 implies a lower value of $F_{0.1}$, the TAC is higher because the VPA calculations result in a higher estimate of current biomass). Since *N. gibberifrons* is taken largely as a by-catch, implementation of a TAC could raise problems. These problems are discussed in paragraph 65 below.

Research Requirements

54. Data on commercial length frequencies and age-length keys are required for recent years. Surveys should be continued to monitor the stock.

Pseudochaenichthys georgianus

55. Appreciable catches of this species have been taken in only one year (13 000 tonnes in 1977/78). Otherwise it is only a by-catch. Surveys in 1984/85 (by FRG) and in 1986/87 and 1987/88 (joint Polish/US surveys) have provided estimates of biomass between 4 600 and 11 400 tonnes. Some of this variation is probably due to the substantial variation in year-class strength, as indicated by the length-frequency data which covers most years.

56. No VPA analyses have been attempted, but yield-per-recruit calculations have been presented by Kock et al. (1985) and these indicate a value of $F_{0.1}$ of around 0.3. To achieve this in 1988/89, using a mean biomass of 8 000 tonnes from the survey data, would require a catch of some 1 800 tonnes.

Chaenocephalus aceratus

57. Catches have been small in all years, with a maximum of 2 000 tonnes in 1977/78, nevertheless small catches, probably taken incidentally haven been reported in most years. The biomass is also small, with estimates of 10 820 tonnes and 6 600 tonnes being obtained from the joint Polish/US surveys in 1986/87 and 1987/88 respectively and 11 542 tonnes in FRG survey in 1984/85. There is some indication of a change in size compositions during the history of the fishery, with larger fish becoming less frequent. This is consistent with there being a moderate impact of fishing, as is also indicated from the ratio of mean annual catch to mean biomass (about 0.08).

58. No VPA calculations have been attempted, but yield per recruit calculations have been published by Kock et al. (1985). These indicate values of $F_{0.1}$ of 0.15 (for females) and 0.18 (for males). Applying these to the mean biomass estimates from the surveys (8 000 tonnes) gives a TAC for 1988/89 of some 1 100 tonnes.

Subarea 48.1 (Peninsula) and 48.2 (S. Orkneys)

59. Fishing in Subareas 48.1 and 48.2 have been only sporadic and recent catch levels have been low (Tables 3 and 4). Of the species that have supplied significant catches in the past, no catches of *N. rossii* were reported in any of the last three seasons, and only very small catches of *C. gunnari*. No new assessments were attempted of these stocks.

Table 3: Catch by species in Subarea 48.1

	Notothenia rossii	*Champsocephalus gunnari*	Pisces nei	Total
1979	470	35 930	15 797[1]	52 197
1980	18 763	1 087	6 301[2]	26 151
1981		1 700	4 316[3]	6 016
1982				
1983		2 604	16	2 620
1984				
1985				
1986				
1987		75	62	137
1988			2	2

[1] Mainly *C. wilsoni* and *N. gibberifrons*
[2] Mainly *C. wilsoni*
[3] Unknown species

Table 4: Catch by species in Subarea 48.2

	Notothenia rossii	*Champsocephalus gunnari*	*Notothenia gibberifrons*	Pisces nei	Total
1978	85	138 895	75	2 607	141 662
1979	237	21 439	2 598	3 250[1]	27 524
1980	1 722	5 231	1 398	6 203[2]	14 554
1981	72	1 861	196	3 274	5 403
1982		557	589	2 211	3 357
1983		5 948	1	12 463[3]	18 412
1984	714	4 499	9 160	1 583	15 956
1985	58	2 361	5 722	531	8 672
1986		2 682	341	100	3 123
1987		29	3	3	35
1988		1 336	4 469		5 805

1 Mainly *Champsocephalus gunnari*
2 *Pseudochaenichthys georgianus* and unidentified Nototheniids and Channichthyids
3 Unknown species

60. The only species with significant catches was *N. gibberifrons* with 4 469 tonnes reported from Subarea 48.2 in 1987/88 and a new assessment was attempted using VPA.

61. The database is poor, but sufficient length data and age-length keys were available to estimate the annual catch-ag-age, with interpolation being needed in some years. A survey in 1984/85 season gave an estimate biomass of 12 000 tonnes. Unfortunately, no age or length data were available for the 1987/88 catches. In the VPA the same values of M (0.25 and 0.125) and patterns of fishing mortality with age were used as in South Georgia; and the runs were tuned to the 1984/85 biomass.

62. Projection of the stock to 1989 using median recruitment gave the following results:

Value of M	Stock in 1979		Stock in 1989		Ratio	
	Total	Spawning	Total	Spawning	Total	Spawning
0.125	12 472	5 992	13 515	8 526	1.08	1.42
0.250	20 442	11 733	11 571	4 319	0.57	0.37

These results do not indicate any severe impact of fishing since exploitation started in 1979, especially if natural mortality is low.

63. Yield-per-recruit calculations gave the following results:

	If M=0.125	If M=0.25
$F_{0.1}$	0.108	0.248
F_{max}	0.186	0.515
Mean F (1979–1985)	0.31	0.177

(Although mean F in the period was greater than F_{max}, the effective cessation of fishing in 1985/86 and 1986/87 would have allowed some recovery.)

Research Requirements

64. To provided improved assessment of this stock age and length data from the most recent catches are needed. Another survey, to provide an up-to-date estimate of biomass is also desirable.

General Consideration on the Application of TAC's

65. At both South Georgia and Kerguelen several species are taken in significant quantities as by-catch in fisheries directed at other species. When, as in the case of *N. rossii*, these catches may be comparable with, or even exceed, the desirable TAC for the by-catch species there can be several problems. Restricting the directed fishery on some less heavily exploited species (e.g. *C. gunnari* when a good year-class is present) could lead to losses in the catches of the target species. There has therefore to be some kind of trade-off. If the by-catch is of a species that potentially, once the stock has been rebuilt, can supply substantial catches (e.g. N. *rossii*) some restrictions and losses to the targeted fishery on other species should be accepted as a sound investment for the future. Conversely, if the by-catch species is never likely to provide very large catches (e.g. *N. gibberifrons*) some excess over the desired TAC may have to be accepted in order to optimise the directed fishery on the more valuable species, provided that this does not lead to further significant depletion of the stock.

STATISTICAL AREA 58

Introduction

66. In this area fishing takes place only in Subareas 58.4 and 58.5.

67. No results from mesh selectivity investigations are available for Statistical Area 58. Such results are necessary to formulate recommendations for management of the basis of the yield-per-recruit analyses of the major stocks.

68. A summary of catches reported from Area 58 is given in Table 5. It will be seen that up to the 1979/80 season very few data are available that give the subarea of capture. From that time onwards reported catches have been largely from Division 58.5.1 (Kerguelen), with small catches of *N. squamifrons* from Division 58.4.4 (Ob and Lena Banks). Detailed analyses have therefore been restricted to those stocks, but some information is available from other subareas, which are discussed first.

69. A recent exploratory survey in Subarea 58.6 (Crozet) (SC-CAMLR-VII/BG/28) indicates that stocks of *N. squamifrons* and *N. larseni* do not contain fish of commercially exploitable size. Two small concentrations of *D. eleginoides* were found but do not appear to be sufficiently large to support a direct fishery. It is recommended therefore that Subarea 58.6 should remain closed to all fishing and that in the interest of obtaining information on an essentially unexploited stock another survey should be undertaken in 5–6 years time.

70. As far as 58.7 (Prince Edward Islands) in concerned, it was noted that South Africa will probably undertake an exploratory fishing survey around the Prince Edward Islands within the next two years. It was agreed that such a survey would be important for the determination of natural mortality in what have been hitherto unexploited stocks.

Table 5: Total catches by species and subarea in Area 58. Species are designated by abbreviations as follows: TOP (*Dissostichus eleginoides*), NOR (*Notothenia rossii*), NOS (*Notothenia squamifrons*), ANS (*Pleuragramma antarcticum*), ANI (*Champsocephalus gunnari*), LIC (*Channichthys rhinoceratus*), MZZ (Unknown), SRX (*Rajiformes spp.*).

Split	TOP				NOR			NOS			ANS		ANI			LIC	MZZ			SRX
Year	58	58.4	58.5	58.6	58	58.4	58.5	58	58.4	58.5	58	58.4	58	58.4	58.5	58.5	58	58.4	58.5	
1971	XX				63636			24545					10231				679			
1972	XX				104588			52912					53857				8195			
1973	XX				20361			2368					6512				3444			
1974	XX				20906			19977					7392				1759			
1975	XX				10248			10198					47784				575			
1976	XX				6061			12200					10424				548			
1977	XX				97			308					10450				11			
1978	196	-	2	-	46155			31582		98	234		72643		250	82	261			
1979	3	-	-	-				1307					*101				1218			
1980		56	138	-			1742		4370	11308				*14	1631	8		239		
1981		16	40	-		217	7924		2926	6239					1122	2		375	21	
1982		83	121	-		237	9812		785	4038		50			16083			364	7	
1983		4	128	17			1829		95	1832		229			25852			4	17	1
1984		1	145	-		50	744		203	3794					7127				**611	17
1985		8	6677	-		34	1707		27	7394		966		*279	8253			11	7	4
1986		8	459	-		-	801		61	2464		692		*757	17137					3
1987		34	3144	-		2	482		930	1641		28		*1099	2625			22		
1988		4	554	488		-	21		5302	41		66		*1816	159					

* Probably wrong identification (might be *C. wilsoni*)
** Mainly RAJIDS

NB Before 1979/80 catches reported in Area 58 mainly concern Division 58.5.1 (Kerguelen Subarea)

Subarea 58.4

71. It was agreed that reporting of catches of *P. antarcticum* in Subarea 58.4 were not sufficiently detailed to establish where such catches were taken and whether these were from one or more stocks. Both fine-scale reporting and analysis of catch levels is needed to establish the distribution of *P. antarcticum* stocks in Subarea 58.4 as a whole. Some reported catches in 1985 and 1986 indicate that a fishery is beginning for the species but available data are insufficient to assess stocks.

72. The review of available catch statistics for Division 58.4.1 and 58.4.2 indicated that certain Channichthyids may have been incorrectly reported. For example, it is probable that fish reported as *C. gunnari* for 1980 and for 1985 to present in the catch summaries (SC-CAMLR-VII/BG/2, pp 64–66) for Subarea 58.4, were *C. wilsoni*. It is therefore recommended that care should be taken in the future to report catches by species correctly.

73. Additional data on all exploited stocks of Channichthyids (see Table 3) are required urgently for assessments at the next meeting of the Working Group.

Division 58.4.4 (Ob and Lena Bank)

74. Catches of three species (*N. rossii*, *N. squamifrons* and *D. eleginoides*) are reported for the whole of Subarea 58.4 (see Table 5). Of these only *N. squamifrons* is caught in significant levels.

Notothenia squamifrons

Table 6:

Split year ending	Recommended TAC	Agreed TAC	Actual landings (tonnes)	Spawner biomass (tonnes)	Mean F
1980			4 340	NA	NA
1981			2 926	NA	NA
1982			785	NA	NA
1983			95	NA	NA
1984			203	NA	NA
1985			27	NA	NA
1986			61	NA	NA
1987			930	NA	NA
1988			5 302	NA	NA

The Fishery

75. Catches are variable (Table 6) and appear to reflect diversion of effort from the Kerguelen finfish fishery (see Tables 5 and 8) or the Antarctic krill fishery in the southern Indian Ocean. At present it is not possible to determine the proportionate composition of the total catch as being from either Ob or Lena. It appears that the stocks of *N. squamifrons* on these two seamounts should be considered separately.

Conservation Measures in Force

76. 80 mm mesh size restrictions for directed fishing on *N. squamifrons* (Conservation Measure 2/III).

77. All other conservation measures are applicable in this subarea as outlined for Division 58.5.2 (see below).

Data Assessments

78. Attempts were made to assess the stock, using a VPA, but problems were met owing to the lack of biomass estimates to tune the VPA, uncertainties concerning M, and the lack of separation between the catches from the Ob and Lena stocks. No reliable results could therefore be obtained.

Recruitment

79. No information on recruitment is available.

State of the Stock

80. This in unknown at present and given the current availability of data, improved fine-scale data submission will improve the state of knowledge concerning *N. squamifrons* stocks on Ob and Lena. An estimate of biomass from surveys is needed to tune the VPA calculations.

Management Advice

81. Exploratory scientific surveys to assess the biomass of the stocks are required for this subarea. In addition, it is recommended that fine-scale reporting and submission of data should be carried out so as to enable separate assessments of the stocks on Ob and Lena respectively.

Division 58.5.1 (Kerguelen)

Notothenia rossii

Table 7:

Split year ending	Recommended TAC	Agreed TAC	Actual landings (tonnes)	Spawner biomass (tonnes)[c]	Mean F[a]
1971			63 636		
1972			104 588		
1973			20 361		
1974			20 906		
1975			10 248		
1976			6 061		
1977			97		
1978			46 155		
1979			0		
1980			1 742		0.393
1981			7 924		1.358
1982			9 812	5 396	1.132
1983			1 829	3 327	0.362
1984			744	2 936	0.760
1985		0[b]	1 707	1 876	
1986		0[b]	801		
1987		0[b]	482		
1988		0[b]	21		

a Mean F for ages 4 to 13+
b Avoidance of direct fisheries (CCAMLR Resolution 3/IV) and by-catch only allowed (Franco-Soviet Fishery Contract)
c Derived from VPA

The Fishery

82. There was a steady decline in catches from high level at the start of the fishery in 1970/71 to a low of 97 tonnes in 1976/77, with an isolated high catch in 1978, just before the declaration of an EEZ (Table 7). After a closure of the area from July 1978 to October 1979, the fishery recommenced at a moderate level, and then declined to low catches. Only the adult part (age 5+ years) of the stock has been exploited. Since 1985 directed fishing has been prohibited and by-catches have declined steadily.

Conservation Measures in Force

83. (i) Fishing other than for scientific purposes is prohibited in waters within 12 nautical miles around Kerguelen. (Arrêté N°: 18, 16.05.80).

(ii) Minimum mesh size of 120 mm for trawls used in directed fishing (Arrêté N°: 20, 2-08-85 taken in application of Conservation Measure 2/III).

(iii) Directed fishing on stock of *N. rossii* in Statistical Subarea 58.5 has been prohibited since 1985. (In application of Resolution 3/IV).

(iv) Maximum allowed by-catch of 500 tonnes in 1987 and 1988 (i.e. total landings in these years are by-catch).

(v) All the fishing grounds in Division 58.5.1 are closed yearly in May and June, Sector 4 (west of 69°30'E and south of 49°30'S) is closed in April and Sector 1 (east of 69°30'E and south of 50°S) is closed from 15 September to 1 November (Arrêté N°: 32 of 22-10-84).

(vi) There is a system for the weekly reporting of catches. Catch statistics and data are reported daily on a trawl-by-trawl basis (logbooks provided by the French authorities).

(vii) A system of inspection and observation was established in 1980.

(viii) Only a limited number of trawlers is allowed on the fishing grounds (number revised each year).

Data and Assessments

84. Data from several sources (biomass surveys, CPUE indices of abundance, yearly length frequency distribution, VPA analysis) lead to a similar assessment. Estimates of stock size from VPA on short period data (1980 to 1984) (Fig.2) and swept area biomass surveys in 1987 and 1988 (WG-FSA-88/22 Rev. 1) give figures of 18 000 to 28 00 tonnes. Analysis of CPUE data shows a steady decline in abundance from 1980 to 1982 due to a direct fishery on the spawning ground and a slight rise from then until 1986 after cessation of direct fishing. The present stock size represents a dramatic decline from the early years of the fishery, when 168 000 tonnes were caught in the first two years of exploitation. In addition, the 1987 and 1988 surveys show that adult fish comprise only about 25% of the stock, i.e. 5 000 to 6 000 tonnes.

Management Advice

85. The slight rise in stock abundance indicated by CPUE results suggests that the stock is beginning to recover (Fig. 3). However, the very low stock size compared to its original state suggests that even with zero catch, recovery will be a long process (WG-FSA-87/8 Rev. 1 and 87/15).

86. Prohibition of a directed fishery on this species should continue for the foreseeable future to allow the stock to recover. In addition the by-catch should be kept as low as possible for the same reason. The current permitted by-catch of 500 tonnes (see paragraph 83 (iv)) represents 10% of the estimated adult biomass.

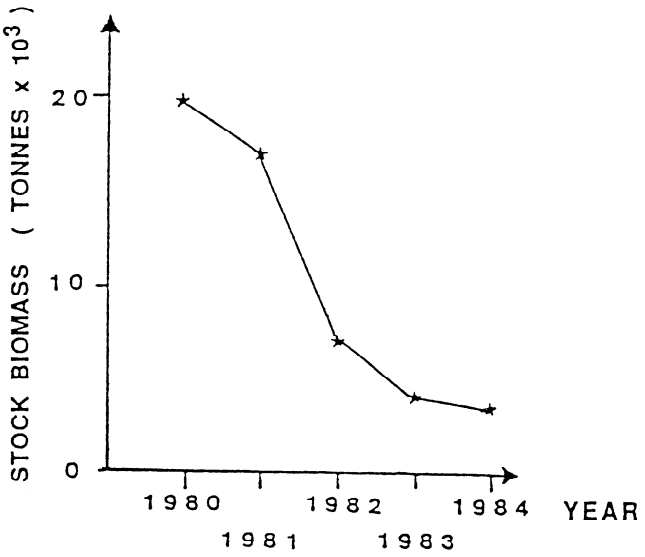

Figure 2: Short term tendencies in the Total Biomass (tonnes x 10^3) for the *Notothenia rossii* Kerguelen Shelf stock. VPA analysis (Duhamel, 1987).

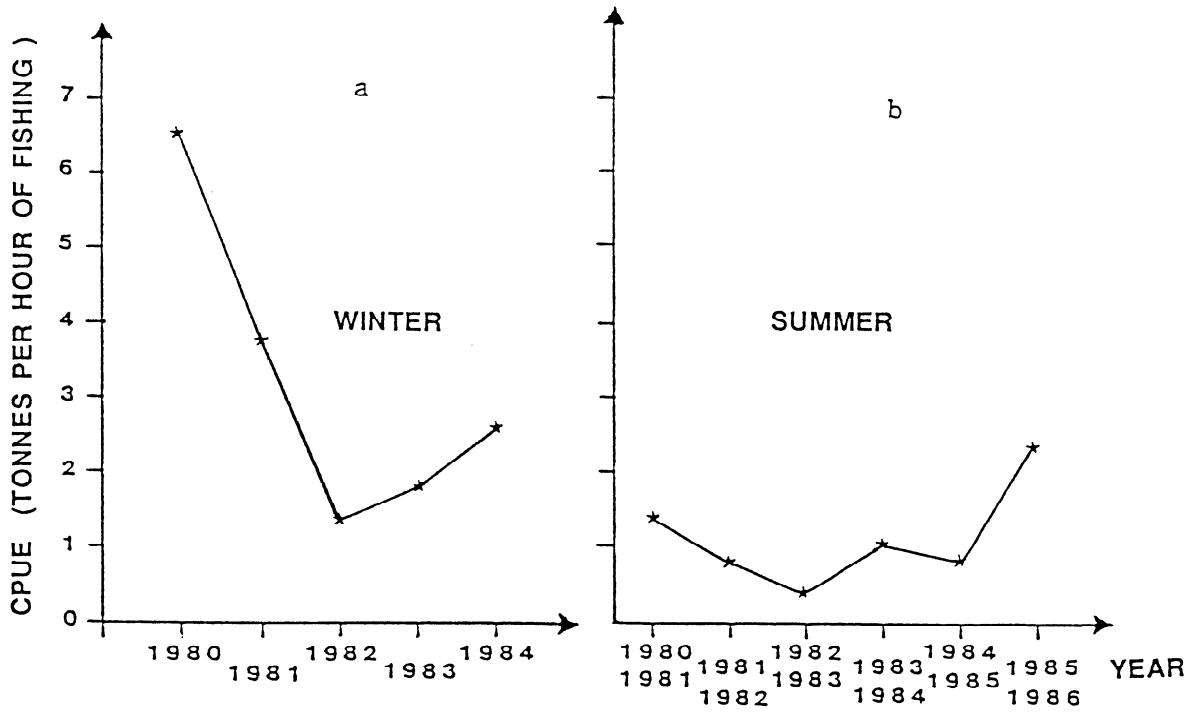

Figure 3: Yearly values of CPUE index of abundance (tonnes/hour) in the *Notothenia rossii* Kerguelen Shelf stock - (a) Southern Winter (b) Southern Summer (Duhamel, 1987).

Research Requirements

87. Since there is no direct fishery, it will be useful to establish a program to study pre-recruits in coastal waters to assess the stocks and detect any changes in abundance of the juvenile portion of the population.

Champsocephalus gunnari

Table 8: Assessment Summary for *C. gunnari* in Division 58.5.1

Split Year Ending	TAC	Skif Bank			Kerguelen Shelf			
		Actual Landing (tonnes)	Cohort (Yr)	Mean F	Actual Landings (tonnes)	Cohort (Yr)	Spawner Biomass (tonnes)	Mean F
1971					10 231			
1972					53 857			
1973					6 512			
1974					7 392			
1975					47 784			
1976					10 424			
1977					10 450			
1978					72 893	‘76		
1979					0			
1980		1			1 630	‘76		
1981		992	‘78	2.53	130	‘79		
1982		1 024	‘78	1.00	15 059	‘79		0.49
1983		4		0.01	25 848	‘79		1.86
1984		904	‘81	1.84	6 223	‘79		1.00
1985	x	223	‘81	1.00	8 030	‘82		0.52
1986	x	0			17 137	‘82		1.00
1987	16 000[a]	2 625	‘84	7.48	0			
1988	12 500[b]	2			157	‘85		

[a] refers to period 1 October 1986 – 31 December 1987 for Division 58.5.1
[b] refers to period 1 January 1988 – 31 December 1988 for Division 58.5.1

The Fishery

88. There are two separate stocks in Division 58.5.1 (Skif Bank and Kerguelen Shelf) (Duhamel, 1987). Catches are variable and reflect fairly closely a three-year cycle in recruitment (Figures 4 and 5). Since the declaration of an EEZ in 1978, maximum catches on the Kerguelen Shelf were taken in 1983 and 1986 on the 1979 and 1982 cohorts respectively (see Table 8).

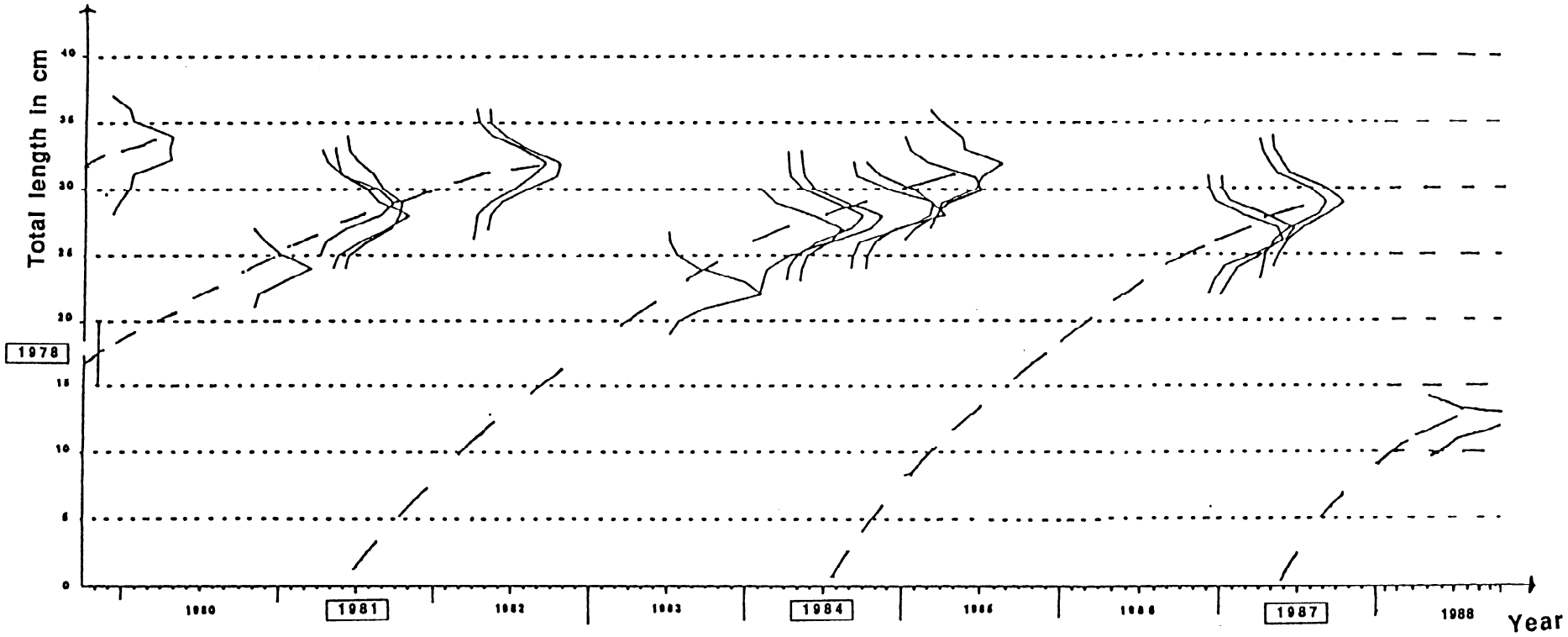

Figure 4: Length frequency distribution (cm) obtained for the Skif Bank *Champsocephalus gunnari* stock from 1979 to 1988. Mean growth curve showing the successive cohorts (Duhamel, 1987).

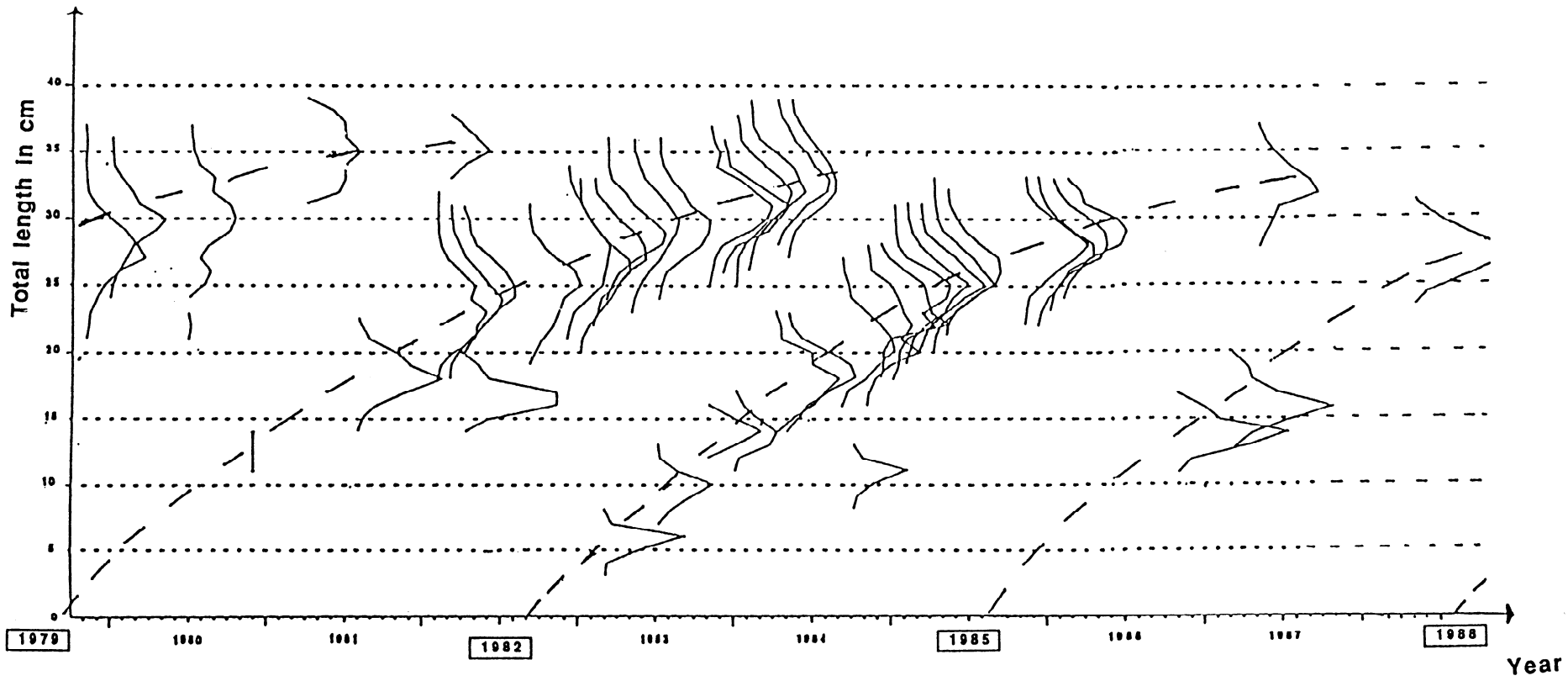

Figure 5: Length frequency distribution (cm) obtained for the Kerguelen Shelf *Champsocephalus gunnari* stock from 1979 to 1988. Mean growth curve showing the successive cohorts (Duhamel, 1987).

Conservation Measures in Force

89. (i) Minimum mesh size of 80 mm for trawls used during directed fishing on *C. gunnari* (Arrêté N° 20 of 2-08-85 taken in application of Conservation Measure 2/III).

(ii) Minimum size limit of 25 cm (Arrêté N° 20 of 2-08-85).

(iii) Catch quotas set from 1985 onwards under the joint French-Soviet agreement (see Table 8).

(iv) Conservation measures as for *N. rossii* in Division 58.5.1 (see subitems (i), (v), (vi), (vii) and (viii) in paragraph 83 above).

Data Used in Assessments

90. Comprehensive length and age data for both Skif and Kerguelen Shelf since 1980.

91. Survey estimates of biomass for both stocks in 1987 and 1988 (WG-FSA-88/22 Rev. 1).

92. Indices of abundance from catch-per-unit-effort data since 1980 for both stocks (Figs 6 and 7).

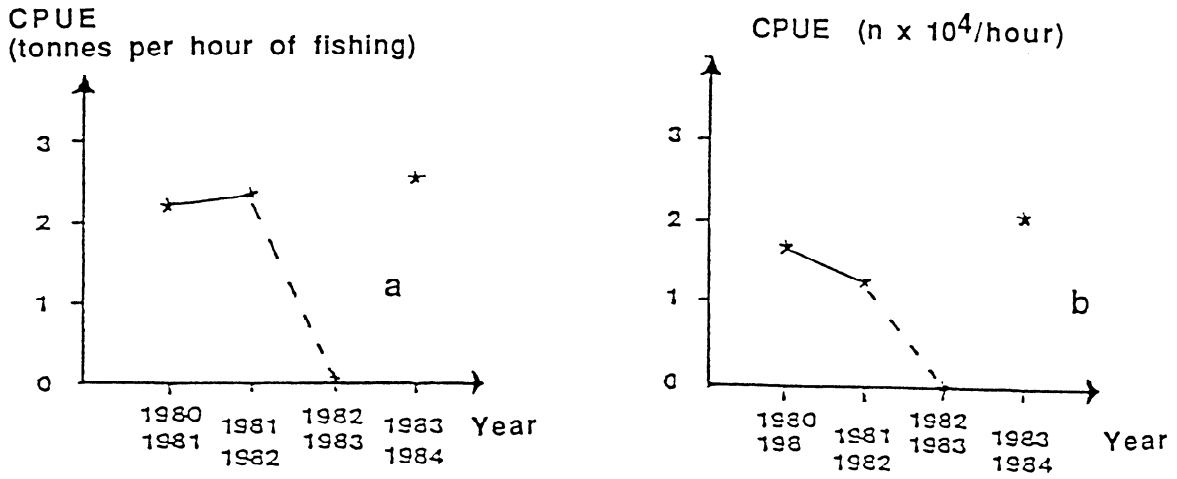

Figure 6: Yearly values of CPUE indices of abundance (a) tonnes/hour; (b) n x 10^4/hour obtained for the *Chaenocephalus* Skif Bank stock (Duhamel, 1987).

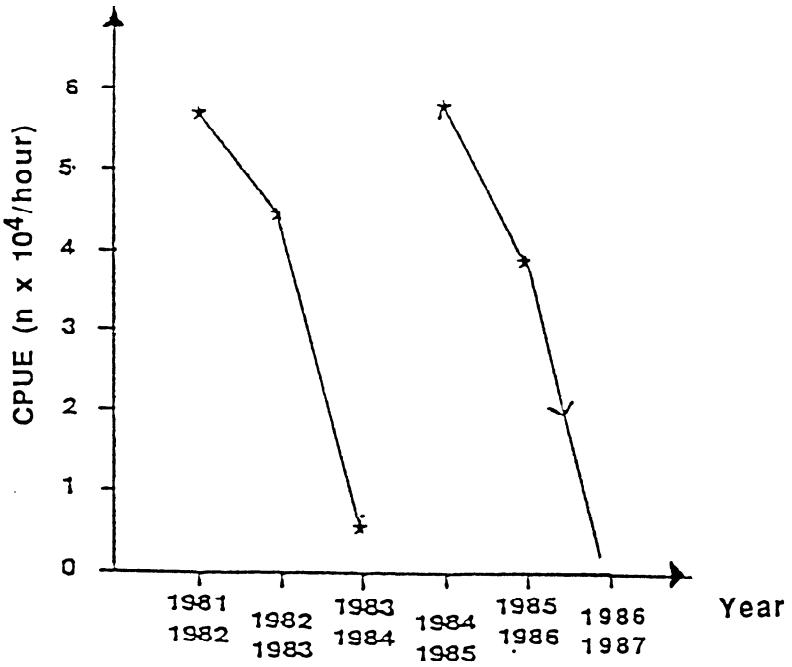

Figure 7: Yearly values of CPUE index of abundance (n x 10^4/hour) for the *Champsocephalus gunnari* Kerguelen Shelf stock in the NE sector (Duhamel, 1987).

93. The strengths of the three outstanding cohorts in the two areas can be calculated by simple cohort analysis, using M=0.35 (see Table 9). The 1984/85 cohort was tuned to the biomass survey, and all other cohorts were assumed to be exhausted by age 5 since no fish 5 or older were found in samples of the catch.

Fishing Pattern

94. Fishing mortality affects age classes 3+ with the age of maturity being 3 years. Fishing mortality is greater on the Skif Bank than on Kerguelen Shelf. The fishery is directed on specific cohorts (see Table 9) up to a maximum age of four years.

Table 9: Cohort sizes of the major cohorts of *C. gunnari* in the Kerguelen Area.

	Kerguelen Shelf	
	Cohort Size x 10^7 (at age 1)	Remarks
1979/80	117.0	Assuming that the Cohort exhausted at Age 5
1982/83	55.2	Assuming that the Cohort exhausted at Age 5
1985/86	1 149	From Biomass Survey 429 052 tonnes - Age 2[1]
	Skif Bank	
1977/78	4.4	Assuming that the Cohort exhausted at Age 5
1980/81	2.7	Assuming that the Cohort exhausted at Age 5
1983/84	5.7	Assuming that the Cohort exhausted at Age 5

1 Age 2 fish are calculated to be of mean weight 75.2 g. Derived from a mean length of 24.4 cm and length weight relationship $w_t = 0.0013688L_t^{3.4163}$

Recruitment

95. Good year classes are produced every 3 years over a period of 10 years. The production of one good year-class appears to coincide with the time of peak spawning of the previous year-class. The variable recruitment prevents the elucidation of underlying causes or relation to stock size. No direct investigations of recruitment have been undertaken.

State of Stock

96. Once a strong cohort recruits to the fishery it is heavily exploited. Fish older than 4–5 years are not found in the fishery. Catch levels depend on the strength of the recruiting cohort. Estimation of the stock biomass should be undertaken on pre-recruit fish of 3 years since younger animals are pelagic and therefore likely to be underestimated by bottom trawl surveys (see WG-FSA-88/22 Rev. 1).

Management Advice

97. Reduction in fishing effort would increase the number of cohorts available to the fishery. The structure of the present stocks and the current minimum size limit in force do not allow continuous exploitation of either Kerguelen Shelf of Skif Bank. A pattern of 'pulsed' fishing effort appears to give an appropriate exploitation policy provided that exploitation of a strong cohort is not allowed to start until the fish have grown to the size at sexual maturity.

Notothenia squamifrons

Table 10:

Split year ending	Recommended TAC	Agreed TAC	Actual landings (tonnes)	Spawner biomass (tonnes)	Mean F
1971			24 545[a]	NA	
1972			52 912[a]	NA	
1973			2 368[a]	NA	
1974			19 977[a]	NA	
1975			10 198[a]	NA	
1976			12 200[a]	NA	
1977			308[a]	NA	
1978			31 582[a]	NA	
1979			1 307[a]	NA	
1980			11 308	13 157	0.89
1981			6 239	5 726	0.63
1982			4 038	4 334	0.40
1983			1 832	4 542	0.18
1984			3 794	6 395	0.33
1985			7 394	5 916	1.12
1986			2 464	2 173	0.65
1987		5 200[*]	1 635	1 662	0.72
1988		2 000[*]	39	1 233	NA

[a] Includes catches from Division 58.4.4 and possibly Subarea 58.6
[*] See notes (a) and (b) in Table 5

The Fishery

98. Prior to the declaration of an EEZ around Kerguelen by France (3 February 1978), it is not possible to separate catches taken in Subarea 58.5 from those in Subarea 58.4. Since 1980 there has been a steady decline in catches with an indication of a small increase in 1984 and 1985. This probably resulted from a re-direction of fishing effort in relation to a low level abundance of *C. gunnari*, the main target species of the Kerguelen fishery (see Table 8).

Conservation Measures in Force

99. (i) Prohibition of fishing on *N. squamifrons* (and to other species) between 15 September to 1 November for protection of spawning stock (area south of 50°S and east of 69°30'E) (Arrêté N°: 32 of 22/10/1984).

(ii) Minimum mesh size of 80 millimetres for trawls used in directed fishing for *N. squamifrons* (for protection of young fish) (Arrêté N°: 20 of 2/08/1985 in application of Conservation Measure 2/III).

(iii) Catch limits have been set since 1987 under the joint French/Soviet agreement (see Table 10).

(iv) Conservation Measure as for *N. rossii* in Division 58.5.1 (see subitems (i), (v), (vi), (vii) and (viii) in paragraph 83 above).

Data and Assessments

100. Comprehensive length frequency distribution data are available from the commercial fisheries (Fig. 9). Other available data were an index of abundance from catch and effort data (Fig. 10), and biomass survey estimates of stock abundance in 1987 and 1988 (WG-FSA-88/22 Rev. 1).

101. VPA analysis was preformed using terminal fishing mortality rate of 0.72 derived from a total mortality estimated from a catch-curve in the final year of exploitation minus natural mortality. Figure 8 shows the trends in biomass obtained from this VPA.

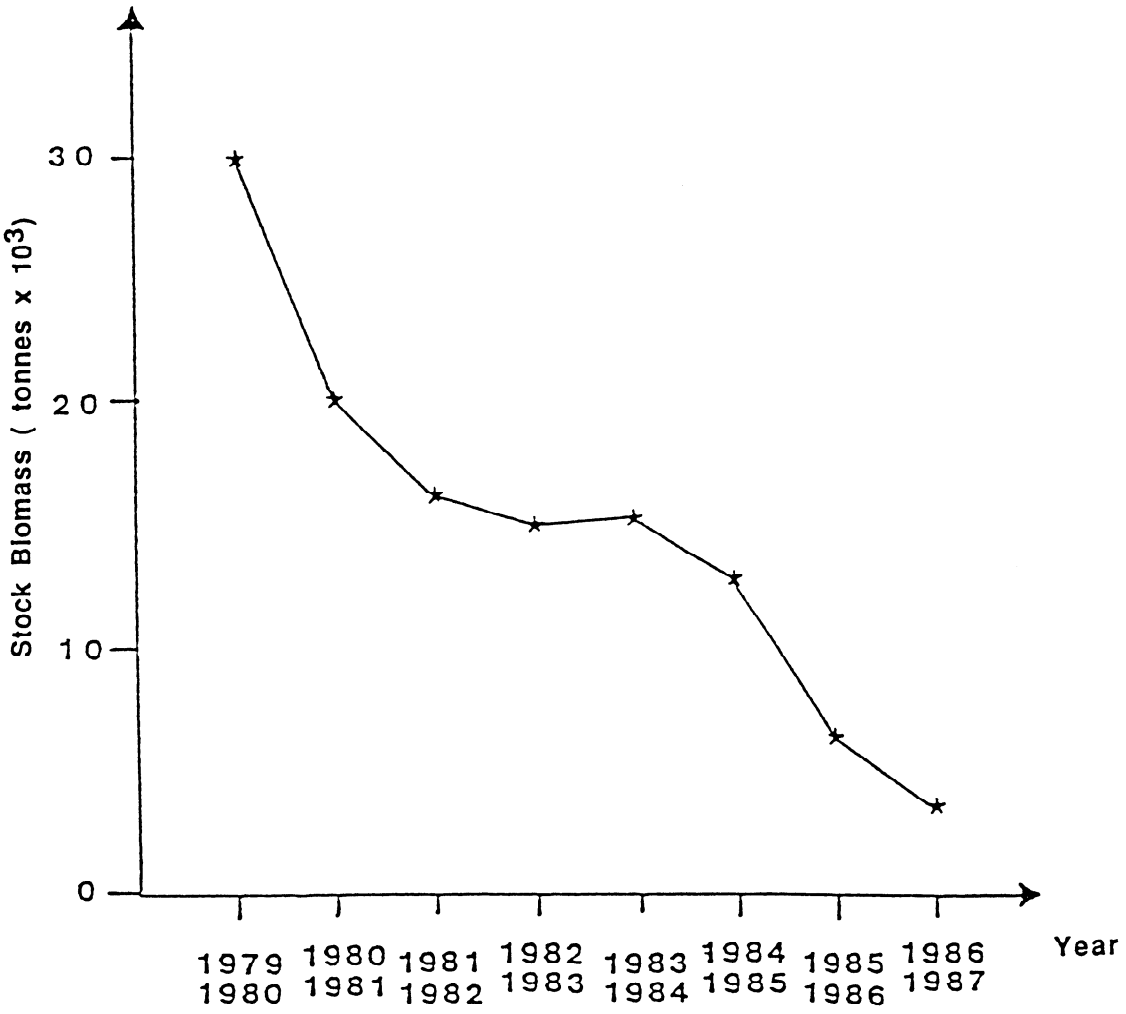

Figure 8: Tendencies in the total biomass (tonnes x 10^3) in the *Notothenia squamifrons* Kerguelen Shelf stock. VPA analysis (Duhamel, 1987).

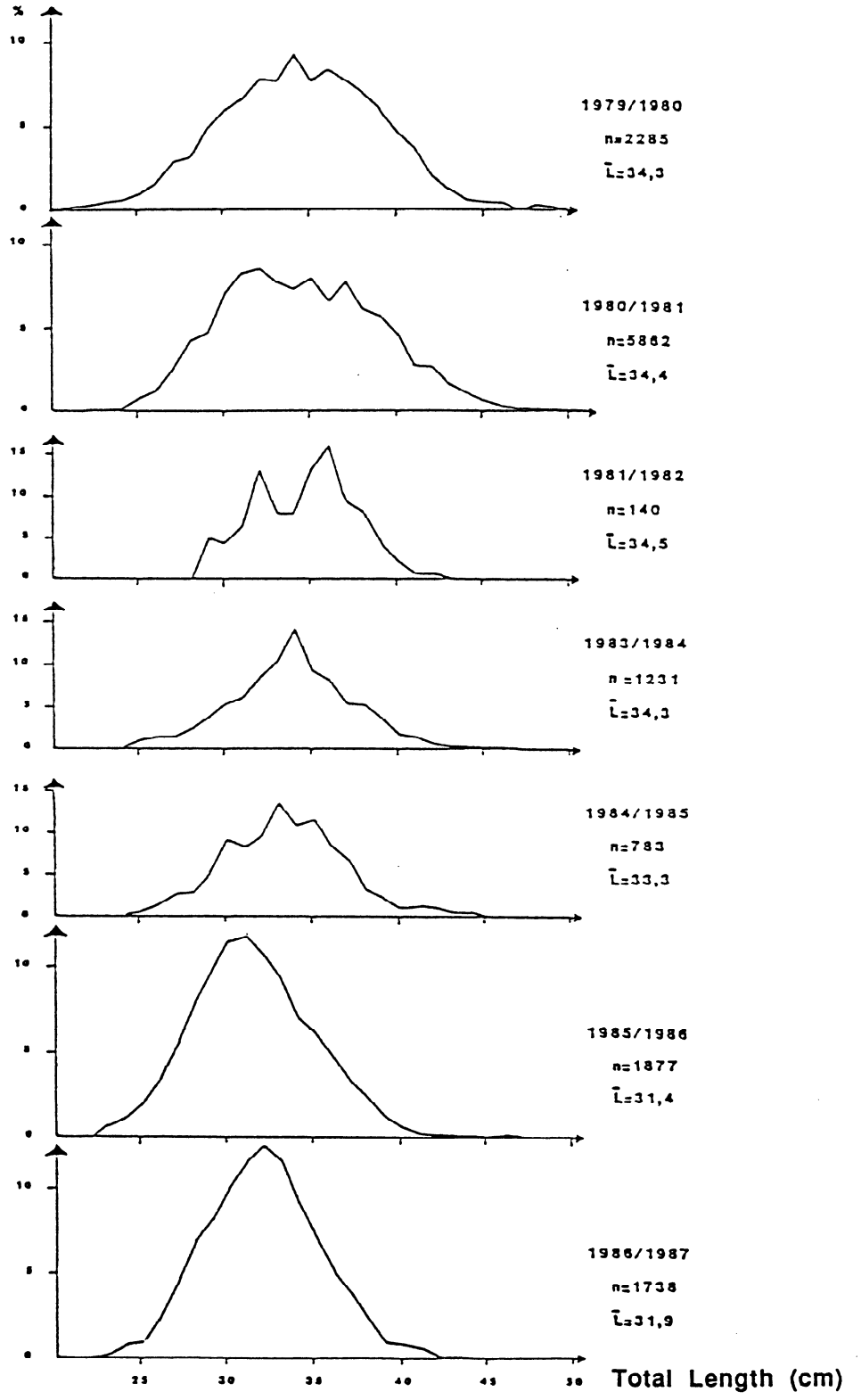

Figure 9: Yearly summer length frequency distribution for *Notothenia squamifrons* Kerguelen Shelf stock from 1979 to 1987 in the Southern sector (Duhamel, 1987).

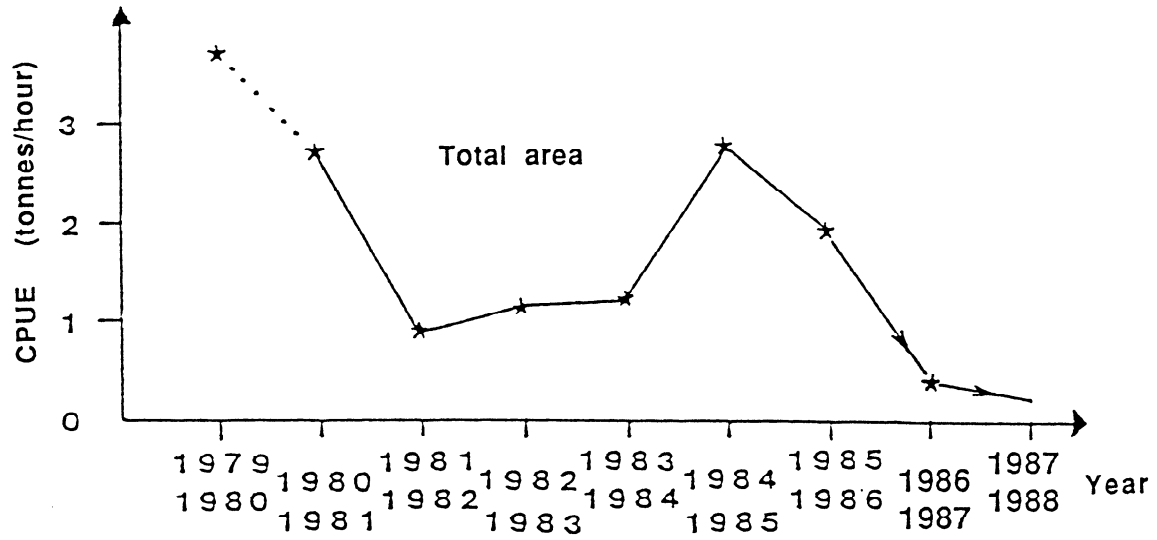

Figure 10: Yearly values of CPUE index of abundance (tonnes/hour) for the *Notothenia squamifrons* Kerguelen Shelf stock (Duhamel, 1987).

Fishing Pattern

102. Fishing mortality affects age classes 5+ with the age of maturity being 9 years.

Recruitment

103. No information is available concerning trends in recruitment (whether constant or variable) for this species.

State of the Stock

104. Both CPUE data (Fig. 10) and catch levels indicate that the stock remains at a low level. Catches in the last two years have been less than catch limits for those seasons.

105. The relatively long VPA time series also indicates that the stock biomass has decreased substantially except for the elevation observed in 1984 (see above). The VPA based stock estimate for 1986/87 was less than 5 000 tonnes which agrees quite closely with

stock estimates of 9 000 and 5 500 tonnes obtained by direct survey (swept area method) in 1987 and 1988 respectively.

Management Advice

106. A lack of information on recruitment patterns makes it difficult to provide objective predictions of future stock trends. However, given the observed trends in exploitation and present status of stock the future potential of the stock will be protected by closure of the direct fishery on *N. squamifrons* in Division 58.5.1. Similarly, recovery of an already depleted stock will be facilitated.

107. Given that about 15% of the current total stock biomass is comprised of adults and that fishing on other species in the area will continue, then an acceptable level of by-catch should be selected. As the current quota levels have not been attained, it is recommended that any future by-catch levels should be substantially lower than the present quotas.

Research Requirements

108. Data are required on the following:

- recruitment patterns
- mesh selectivity to improve management advice based on yield-per-recruit calculations
- some off-shore banks may harbour unexploited stocks in Division 58.5.1. Surveys need to be undertaken prior to any exploitation in order to determine natural mortality.

Other Stocks

109. *D. eleginoides* has been exploited since 1985. The annual catch has dropped from 6 677 tonnes in 1985 to 554 tonnes in 1988 (see Table 5). The available estimate of stock biomass (WG-FSA-88/22 Rev. 1) probably represents an over-estimate given that the species is patchily distributed and that only the juvenile and sub-adult portions of the stock were

surveyed. The trend in catch is similar to that for other main *Notothenііd* stocks. This would imply that strong conservation measures are required immediately and that adequate data collection procedures should be implemented.

110. *C. rhinoceratus*. No direct fishery is conducted on this species and it is considered to represent a by-catch species. There are no separate catch statistics for *C. rhinoceratus* as these are included in the catch data for *C. gunnari*. The estimation of biomass by trawl surveys (1987 and 1988) indicate that the stock appears to be stable (WG-FSA-88/22 Rev. 1) but the level is low (±20 000 tonnes).

Division 58.5.2 (Heard Island)

111. Few data are available for this area. It is thought that some fishing was carried out prior to the establishment of an EEZ by Australia in 1979. In 1977/78 43 744 tonnes of the 54 252 tonnes of *C. gunnari* caught in Area 58 were attributed to Division 58.5.1 (Kerguelen). It is thought the remanning 10 508 tonnes were taken in the Division 58.5.2.

112. Since 1979 no fishing has taken place in the area. A joint Soviet/Australian research cruise in 1987 (SC-CAMLR-VI/BG/16) encountered some small stocks of *C. gunnari*, but very low catches of other species were taken. Before any exploitation can take place much more work is necessary to determine the size of the stocks and their identity. There are already some indications that the stocks of *C. gunnari* on outlying banks are separate from those on the main Heard Island Shelf.

Conservation Measures in Force

113. (i) Directed fishery in the stocks of *Notothenia rossii* in Statistical Subarea 58.5 is prohibited (Resolution 3/IV).

(ii) 80 mm mesh size restriction for direct fishery on *C. gunnari* and *N. squamifrons* (Conservation Measure 2/III).

(iii) 120 mm mesh size restriction for directed fishery on *D. eleginoides* and *N. rossii* (Conservation Measure 2/III).

FUTURE WORK

Data Requirements

114. The Working Group noted that although there had been a general improvement in the availability of data for stock assessments, there were still deficiencies in the data submitted for some stocks as well as problems with the dates on which some data were received by the Secretariat.

115. It was agreed that there was a general need for representative length composition data from the commercial fisheries. It is possible to use other biological data (e.g. age/length, maturity and mean weight at age data) collected during research or exploratory fishing but length composition data from the commercial fisheries are necessary for assessment work. The Group recommended that the Scientific Committee take the necessary action to ensure that these data are submitted to the Secretariat.

116. There was some concern that analyses presented by the USSR representatives had been carried out using different data than those available in the CCAMLR database. The USSR representative informed the Group that the biological data submitted to the Secretariat had been collected during research and exploratory fishing and that they had subsequently been able to obtain length composition data for their analysis that had been collected during commercial fishing. These data should be reported to CCAMLR.

117. The Group welcomed this improvement and looked forward to early submission of the commercial length composition data to the CCAMLR database. It was emphasised, however, that earlier notification regarding the availability of theses data would have avoided a considerable amount of unnecessary work in the preparation of the old data by other participants at the Meeting. Members were urged to keep the Convener and Secretariat informed of the work they were undertaking for future meetings so as to minimise the amount of time wasted in redundant preparations and analyses.

118. Representatives drew attention to some problems that had arisen with regard to the collection and submission of fine-scale biological data. The major concern was with the amount of work involved in the aggregation and submission of age/length, mean length, mean weight and sexual maturity data by ten day periods and fine-scale grids.

119. The Group agreed that it was desirable to continue reporting length composition data by ten day periods and fine-scale grids as currently prescribed but that other forms of biological data (i.e. age/length, weight and sexual maturity data) could be aggregated and reported by larger temporal and spatial scales (i.e. months and subarea or divisions). It was pointed out that some provision should be made on the form for identification of the stock from which the data were obtained. The Data Manager was directed to discuss the problem with participants and to develop specific proposals for revision of the forms and instructions for reporting fine-scale biological data.

Data Analyses Required Prior to Next Meeting

120. The Group expressed satisfaction with the preparations for the current meeting and agreed that in general the same should be done for next meeting.

Workshop for Refinement of Biomass Estimates

121. The need for such a meeting was identified last year and tentative plans were made but did not come to fruition. It was agreed that participants would consider, during the intersessional period, the issues and problems that might be addressed during a workshop concerned with biomass estimation and that specific proposals concerning the scope of such a workshop would be discussed at the Working Group's next meeting.

New Approaches to Assessment Work

122. It was suggested that virtual population analyses should be carried out on the basis of time steps smaller than one year for species that grow quickly (e.g. *P. br. guntheri* and *C. gunnari*) but there were some questions as to whether the necessary data were available. It was agreed, however, that software and data for such analyses should be prepared by the Secretariat for use at the Working Group's next meeting.

123. The Working Group recommended that the Scientific Committee undertake the work of co-ordinating prerecruit abundance surveys for important fish stocks so that such surveys could commence as soon as possible.

124. It was suggested that the Working Group make use of stochastic projections based on historical recruitment levels in the formulation of management advice. It was agreed that software for such simulation analyses should be prepared by the Secretariat for use at the Working Group's next meeting.

125. It was suggested that the Working Group should, in the future, pay more attention to statistical details in its assessment work (e.g. determination of confidence intervals for biomass estimates) and that sensitivity analyses should be routinely employed to determine the effects of analytical uncertainties on management advice.

126. It would be desirable if a computer capable of operating MS-DOS with 5 and $3^1/_2$ inch disks were available, to enable participants to operate their own programs and to exchange data.

Organisation of Next Meeting

127. It was agreed that the timing of the current meeting was satisfactory and that its duration was adequate. It was recommended, however, that in future meetings of other working groups not be scheduled so as to occur between the meeting of the Fish Stock Assessment Working Group and the meeting of the Scientific Committee because such arrangements effectively reduce the amount of time available for assessment work.

128. There was general agreement that subgroups had been able to deal effectively with the assessment work for all of the stocks. It was suggested, however, that the entire Working Group needed to spend additional time reviewing input data prior to the assessment work by the subgroups and that the Working Group as a whole should spend more time reviewing the assessments themselves.

129. The Group expressed great satisfaction with the preparations made by the Data Manager (Larry Jacobson) and his staff, for the present meeting, and agreed that the Data Manager, the Convener of the Working Group and the Chairman of the Scientific Committee should meet and discuss preparations for the next meeting during the intersessional period.

130. Dr Karl-Hermann Kock agreed to continue as Convener of the Working Group for another year.

APPENDIX 1

AGENDA FOR THE MEETING

Working Group on Fish Stock Assessment
(Hobart, 12–20 October, 1988)

1. Opening of the meeting

2. Adoption of the agenda

3. Review of material for the meeting
   - 3.1 Data confidentiality
   - 3.2 Catch and effort statistics
   - 3.3 Size and age composition data
   - 3.4 Other available biological information
   - 3.5 Mesh selection experiments
   - 3.6 Assessments prepared by Member countries and the Secretariat
   - 3.7 Other relevant documents

4. Questions raised and information needed by the Commission

5. Demonstration of software for assessment work

6. Organisation of assessment work

7. Policy advice

8. Management advice
   - 8.1 Mesh size regulations
   - 8.2 Closed areas/seasons
   - 8.3 Catch quotas
   - 8.4 Other approaches to controlling fishing mortality
   - 8.5 By-catch in directed fisheries
   - 8.6 Uncertainties in the advice and policy alternatives

9. Future work
    - 9.1 Data requirements
    - 9.2 Data analyses required prior to the next meeting
    - 9.3 Workshop for the refinement of biomass estimates
    - 9.4 New approaches to assessment work
    - 9.4 Organisation of the next meeting

10. Other business

11. Adoption of the report

12. Closure of the meeting.

APPENDIX 2

LIST OF PARTICIPANTS

Working Group on Fish Stock Assessment
(Hobart, 12–20 October, 1988)

Dr K.-H. Kock (Convener, FRG)

Dr I. EVERSON (S.C. Chairman, UK)

Mr E. BALGUERIAS (Spain)

Dr J. BEDDINGTON (UK)

Dr R. BORODIN (USSR)

Dr G. DUHAMEL (EEC)

Dr W. DE LA MARE (Australia)

Dr J. GULLAND (EEC)

Prof. J.-C. HUREAU (France)

Mr S. IGLESIAS (Spain)

Mr A. MAZZEI (Chile)

Mr D. MILLER (South Africa)

Dr B. OVERHOLTZ (USA)

Mrs N. PRUSOVA (USSR)

Dr K. SHUST (USSR)

Dr W. SLOSARCZYK (Poland)

Dr K. SULLIVAN (New Zealand)

Dr R. WILLIAMS (Australia)

Dr. L. JACOBSEN (CCAMLR Secretariat)

Dr. E. SABOURENKOV (CCAMLR Secretariat)

Dr D. POWELL (CCAMLR Secretariat)

APPENDIX 3

LIST OF DOCUMENTS

Working Group on Fish Stock Assessment
(Hobart, Australia, 12–20 October, 1988)

Meeting Documents:

WG-FSA-88/1	Draft Agenda
WG-FSA-88/2	Annotated Draft Agenda
WG-FSA-88/3	Sample of Standard Format for Presenting Assessment Results (Prepared by the Convener of the Working Group on Fish Stock Assessment and the Secretariat)
WG-FSA-88/4	List of Documents
WG-FSA-88/5	List of Participants
WG-FSA-88/6	Summary of Length Composition Data Submitted Prior to 1988: *Champsocephalus gunnari*, Subarea 48.3 (Secretariat)
WG-FSA-88/7	Summary of Length Composition Data Submitted Prior to 1988: *Patagonotothen brevicauda guntheri*, Subarea 48.3 (Secretariat)
WG-FSA-88/8	Summary of Length Composition Data Submitted Prior to 1988: *Notothenia gibberifrons*, Subarea 48.3 (Secretariat)
WG-FSA-88/9	Summary of Length Composition Data Submitted Prior to 1988: *Chaenocephalus aceratus*, Subarea 48.3 (Secretariat)
WG-FSA-88/10	Summary of Length Composition Data Submitted Prior to 1988: *Pseudochaenichthys georgianus*, Subarea 48.3 (Secretariat)
WG-FSA-88/11	Summary of Length Composition Data Submitted Prior to 1988: *Notothenia rossii*, Subarea 48.3 (Secretariat)

WG-FSA-88/12	Summary of Length Composition Data Submitted Prior to 1988: *Dissostichus eleginoides*, Subarea 48.3 (Secretariat)
WG-FSA-88/13	MT *Lord Shackleton* Antarctic Voyage to South Georgia, 8 to 24 January, 1988 (United Kingdom)
WG-FSA-88/14	The State of Exploited Fish Stocks in the Atlantic Sector of the Southern Ocean in 1988 (K.-H. Kock and F.-W. Köster)
WG-FSA-88/15	Age Determination of *Notothenia gibberifrons* from the South Shetland Islands, Antarctic Peninsula Subarea (Subarea 48.1) (Esteban Barrera-Oro, Argentina)
WG-FSA-88/16	Major Biological Parameters of the Antarctic Fish in the Convention Area (USSR Delegation)
WG-FSA-88/17	Availability of Catch and Biological Data (Secretariat)
WG-FSA-88/18	Data and Stock Assessments for Fish Stocks in the Convention Area (Secretariat*) *This is an exact copy of the document by the same name distributed at the Working Group's 1987 meeting as WG-FSA-87/4
WG-FSA-88/19	Summary of Length Composition Data Submitted Prior to 1988: *Notothenia squamifrons*, Subarea 58.4.4 (Secretariat)
WG-FSA-88/20	Results of Fish Larvae Sampling by Means of Fine-Meshed Samplers Attached to a Bottom Trawl (W. Slósarczyk and I. Wójcik, Sea Fisheries Institute, Gdynia, Poland)
WG-FSA-88/21	Age and Growth of *Pseudochaenichthys georgianus* Norman, 1937 (Channichthyidae) from the South Georgia Area (T.B. Linkowski and R. Traczyk, Poland)
WG-FSA-88/22	Distribution, Abundance and Evaluation of the Biomass of Nototheniid and Channichthyid Species on the Kerguelen Shelf (Area 58.5.1) During the Summer Seasons (February – April) 1987 and 1988 (G. Duhamel, France, EEC Representative)

WG-FSA-88/23	Using the Eve Editor on the VAX (Secretariat)
WG-FSA-88/24	Summary of Length Composition Data Submitted Prior to 1988: *Champsocephalus gunnari*, Subarea 48.2 (Secretariat)
WG-FSA-88/25	Fine-Scale Length Composition Data Submitted During 1988 (Secretariat)
WG-FSA-88/26	Separable Virtual Population Analysis Program - User's Guide (Secretariat)
WG-FSA-88/27	Virtual Population Analysis Program - User's Guide (Secretariat)
WG-FSA-88/28	Software for Fish Stock Assessment (Secretariat)
WG-FSA-88/29	Format Specifications for Reporting Fine-Scale Biological Data to the CCAMLR Secretariat (Secretariat)
WG-FSA-88/30	CCAMLR Antarctic Fish Otoliths/Scales/Bones Exchange System Progress Report (Submitted by the Convener of the Fish Stock Assessment Working Group)
WG-FSA-88/31	Preliminary Results of a Bottom Trawl Survey Around Elephant Island in October and December 1987 (K.-H. Kock)
WG-FSA-88/32	*Champsocephalus gunnari* Stock Status in the South Georgia Area (R. Borodin, P. Kochkin)
WG-FSA-88/33	*Notothenia (p.) gibberifrons* Stock Status and TAC Estimation in the Area of Shag Rocks (Subarea 48.3) (K. Shust and R. Borodin)
WG-FSA-88/34	Evaluation of the Results of Trawl Selectivity Experiments by Poland and Spain in 1978/79 and 1986/87 (W. Slósarczyk, E. Balguerias, K. Shust, S. Iglesias)

Other Documents:

SC-CAMLR-VII/BG/11	Selectivity of Standard Polish commercial Trawl Codends on Antarctic Fishing Grounds (J. Zaucha, Poland)
SC-CAMLR-VII/BG/23	Results of Fish Stock Assessment Survey, South Georgia, December 1987 – January 1988 (United States of America)
SC-CAMLR-VII/BG/24	Shifts in the Demersal Fish Community of South Georgia (United States of America)
SC-CAMLR-VII/BG/28	Results of an Exploratory Fishing Cruise in the Area 58.6 (G. Duhamel, France, EEC Representative)

Other Papers Referred to in the Report:

BALGUERIAS, E., J. BRUNO, E. DAROCA y M.E. QUINTERO. 1987. Estimación de la biomasa de algunas especies capturadas durante la campaña 'Antartida 8611'. *Actas del Segundo Simposio Español de Estudios Antárticos*: 269–285.

DUHAMEL, G. 1987. Ichtyofaune des secteurs indien occidental et atlantique oriental de l'océan Austral: Biogiographie, cycles biologiques et dynamique des populations. Thése de doctorat d'Etat Université Paris VI: 687 p.

RADTKE, R. 1987. Age determination of the Antarctic fishes *Champsocephalus gunnari* and *Notothenia rossii* from South Georgia. SC-CAMLR-VI/BG/43.

KOCK, K.-H., G. DUHAMEL, J.-C. HUREAU. 1985. Biology and status of exploited Antarctic fish stocks. Biomass Scientific Series 6: 143 p.

Report of the Ad Hoc Working Group on Fish Stock Assessment, 1987. SC-CAMLR-VI, Annex 5: 185–234.

APPENDIX 4

ASSESSMENT SUMMARIES FOR FINFISH SPECIES IN SUBAREA 48.3

(South Georgia Subarea)

ASSESSMENT SUMMARY FOR *CHAMPSOCEPHALUS GUNNARI* IN SUBAREA 48.3

Split-Year Ending	Recommended TAC[a]	Agreed TAC	Actual Landings (tonnes)	Biomass (tonnes) [e]	[f]	Mean F[b] [f]
1971	-	-	10 701	na	na	
1972	-	-	551	na	na	
1973	-	-	1 830	na	na	
1974	-	-	254	na	na	
1975	-	-	746	na	na	
1976	-	-	12 290	na	241 000	0.06
1977	-	-	93 400	108 000	192 000	0.68
1978	-	-	7 557	21 000	49 000	0.16
1979	-	-	641	33 000	55 000	0.01
1980	-	-	7 592	94 000	89 000	0.02
1981	-	-	29 384	164 000	146 000	0.17
1982	-	-	46 311	169 000	207 000	0.18
1983	-	-	128 194	215 000	223 000	1.12
1984	-	-	79 997	117 000	114 000	1.48
1985	-	-	14 148	59 000	67 000	0.17
1986	-	-	11 107	100 000	106 000	0.09
1987	-	-	71 142	129 000	167 000	0.69
1988	31 500	35 000	34 573	67 000	72 000	0.88

[a] TAC = Total Alowable Catch
[b] mean F (instantaneous rate of fishing mortality) for ages 2–9
[c] na = not available
[d] at $F_{0.1} = 0.21$
[e] based on VPA
[f] based on VPA using Polish data, M=0.35

The Fishery:

High variability in recruitment makes the stock abundance vary greatly. During years of high abundance (1977, 1983/84, 1987) there is an important directed fishery.

Conservation Measures in Force:

(1) Fishing, other than for scientific purposes, prohibited in waters within 12 nutical miles around South Georgia (Conservation Measure 1/III).

(2) Minimum mesh size of 80 millimetres for trawls used in directed fishing for *C. gunnari* (for protection of young fish) (Conservation Measure 2/III).

(3) Total allowable catch of 35 000 tonnes for 1987/88 fishing season (Conservation Measure 8/VI).

(4) System for reporting catches on the basis of 10-day period (Conservation Measure 9/VI).

(5) Prohibition of a directed fishing on *C. gunnari* between 1 April and 1 October, 1988 for protection of young fish (Conservation Measure 10/VI).

Data and Assessments:

Good age and length data are available for most seasons, and Soviet catch/effort from STALANT forms from 1982/83. Several estimates of biomass are available from research surveys, inlcuding the 1987/88 season (joint US/Polish survey). These allow standard yield per recruit calculations to be made, and VPA to be run, tuned to most recent surveys.

Fishing Pattern:

Fishing mortality has been very high from age 2 onward in several seasons and tends to be targeted on the most abundant age-groups.

Recruitment:

Good year classes are believed to be produced at intervals of 3–4 years. The high variability in recruitment prevents however, identification of a clear trend, or relation to stock size. The most recent good year class was that born in 1985.

State of the Stock:

Because of the high fishing mortality older fish (5+), which were common at the beginning of the fishery, are now very scarce. The abundance of the stock depends on the strength of the youngest age-groups (2 and 3). The strong 1985 year class gave a good abundance at the beginning of the 1987 season, but this has been largely fished out.

Management Advice:

The average gross yield would be increased, the year-to-year variability in catches decreased, by allowing the fish to grow to a larger size before being caught. This might be done either by reducing the overall fishing mortality, or by incresing the mean size of first capture.

Unless there are very substantial reductions in fishing mortality the age (size) at first capture should be increased to around 4 years (32 cm). For a selection factor of 3.0 this would require the use of mesh size of about 107 mm mesh.

If there is no change in the present age at frist capture, the to achieve target fishing mortalities in 1988/89 would require the following TACs:

for $F_{0.1}$ 10 194
for F_{max}18 586

Data Requirements:

Estimates are neede of this strength of recruiting year-classes. This might be best done by surveying with a midwater trawl.

At its 1987 Meeting the Commission had requested advice for *C. gunnari*, on *inter alia*, the effect of closed seasons and/or areas to protect young fish and reduce by-catch. The Working Group had no new data concerning this matter which would suggest alterations to the present closed area and closed seasons in Subarea 48.3.

ASSESSMENT SUMMARY FOR *NOTOTHENIA GIBBERIFRONS* IN SUBAREA 48.3 (SOUTH GEORGIA SUBAREA)

Split-Year Ending	Nominal Catches (tonnes)	Estimates Biomass [a]	Mean F[a]
1976	4 999	44 000	0.20
1977	3 727	39 000	0.13
1978	11 758	36 000	0.70
1979	2 540	27 000	0.15
1980	8 143	29 000	0.60
1981	7 971	23 000	1.00
1982	2 605	17 000	0.36
1983	0	17 000	0
1984	3 304	19 000	0.24
1985	2 081	16 000 (15 762)[c]	0.15
1986	1 678	14 000	NA
1987	2 842	13 129[b]	NA
1988	5 219	7 798[b]	NA

[a] from VPA using M=0.125
[b] from joint Polish/US surveys
[c] from FRG Survey

The Fishery:

Moderate catches have been taken in most years with a peak of 11 000 tonnes in 1978.

Conservation Measures in Force:

General conservation measures for Subarea 48.3 apply.

Data and Assessments:

Length and age data are available for most years up to 1985, but are not available for the 1986, 1987 and 1988 seasons.

Fishing Mortality:

Fishing mortality is moderately high, with recruitment being spread between ages 1–7.

Recruitment:

There is no clear indication of any trend in recruitment.

State of the Stock:

The stock has been depleted by heavy fishing, with current stock in some 17% of the initial population.

Forecast:

Holding fishing mortality at $F = F_{0.1}$ would enable the stock to recover to a level yielding a sustained annyal catch of some 2 400–2 900 tonnes. Recovery to some 90% of this level would take some 10–15 years.

TACs for achieving $F_{0.1}$ and F_{max} would be:

	$F_{0.1}$	F_{max}
if M=0.25	259 tonnes	450 tonnes
if M=0.125	443 tonnes	720 tonnes

Since *N. gibberifrons* is taken largely as a by-catch, implementation of a TAC could raise problems. These problems are discussed in paragraph 64 below.

Recommendations:

Data on commercial length and age composition are needed for recent years. Surveys should be continued.

ASSESSMENT SUMMARY FOR *CHAENOCEPHALUS ACERATUS*
IN SUBAREA 48.3 (SOUTH GEORGIA SUBAREA)

Split-Year Ending	Nominal Catches (tonnes)	Biomass	Fishing Mortality
1977	293		NA
1978	2 066		NA
1979	464		NA
1980	1 084		NA
1981	1 272		NA
1982	6 76		NA
1983	0		NA
1984	161		NA
1985	1 042		NA
1986	504		NA
1987	338	10 816[(a)]	NA
1988	312	6 642[(a)]	NA

[(a)] from joint Polish/US surveys

Catches:

Catches in all seasons have been small. This species is only taken incidentally a fisheries directed to other species.

Conservation Measures in Force:

The general conservation measures for Subarea 48.3 apply.

Data and Assessments:

Length composition data are available for most years. Biomass estimates from surveys are available for 1986/87 and 1987/88. No VPA calculations have been attempted.

Fishing Mortality:

No reliable information.

Recruitment:

No reliable information.

State of the Stock:

There is some indication of an effect of fishing on the length compostion. Large fish (50–60 cm) were the commenest group in the early years, but are now less abundant.

Recommendations:

Kock et al. (1985) Table 54 gives a value fo $F_{0.1}$ for a mean age at first capture of 0.15 for females and 01.8 for males. This mean age applied to the recent biomass (ca 8 000 tonnes) implies a TAC of around 1 100 tonnes. Length data should be continued to be collected, and up-to-date age-length keys developed.

Data Requirements:

Length sampling of commercial catches shall be continued.

ASSESSMENT SUMMARY FOR *PSEUDOCHAENICHTHYS GEORGIANUS* IN SUBAREA 48.3 (SOUTH GEORGIA SUBAREA)

Split-Year Ending	Nominal Catches (tonnes)	Biomass	Fishing Mortality
1977	1 608		NA
1978	13 015		NA
1979	1 104		NA
1980	665		NA
1981	1 661		NA
1982	956		NA
1983	0		NA
1984	888		NA
1985	1 097	8 134[(a)]	NA
1986	156		NA
1987	120	4 579[(b)]	NA
1988	397	11 412[(b)]	NA

[(a)] from FRG survey
[(a)] from joint Polish/US surveys

Catches:

Large catches have been taken in only one season (1977/78). Otherwise this species is mostly taken on by-catch.

Conservation Measures in Force:

General conservation measures for Subarea 48.3 apply.

Data and Assessments:

Estimates of biomass are available from surveys. Good length frequency data are available for 1977/78 and some age length frequencies in other years. Age determinations have been made by microincrements (daily rings) and other methods. No VPA calculations have been attempted.

Fishing Mortality:

No reliable information, but presumably small in recent years.

Recruitment:

There are suggestions from year-to-year changes in length frequency that recruitment varies considerably. It also appears that a strong year-class, (modal length around 45 cm during the 1987/88 survey) is now present in the stock.

State of the Stock:

The species appears to be fairly short-lived. Chatches have been very light since 1978, so it is probable that the stock is not far from its unexploited state.

Recommendations:

The yield per recruit information in Kock et al. (1985), (Figures 57 and 58 and Table 54) suggest the $F_{0.1}$ for the likely age at first capture (3), is around 0.3. Using hte mean biomass of the 3 recent surveys (ca 8 000 tonnes), would imply a TAC of around 1 800 tonnes.

ASSESSMENT SUMMARY FOR *NOTOTHENIA ROSSII* IN SUBAREA 48.3 (SOUTH GEORGIA SUBAREA)

Split-Catches Ending	Nominal Biomass (tonnes)	Spawner Estimates[c] (tonnes)[a]	Biomass Mean F[b]	Year
1970	399 704	566 927		1.56
1971	101 558	122 137		2.65
1972	2 738	14 557		0.53
1973	0	16 598		0.004
1974	0	22 333		0.00
1975	0	31 047		0.0007
1976	10 753	39 333	35 682[d]	0.65
1977	8 365	38 196		0.62
1978	2 192	35 881	9 325[d]	0.48
1979	2 137	35 643		0.52
1980	24 897	31 150		2.96
1981	1 651	6 486		0.74
1982	1 100	6 890		0.42
1983	866	9 420		0.27
1984	3 022	11 743		0.69
1985	1 891	10 376	12 781[d]	0.37
1986	70	10 378		0.01
1987	216		11 471[e] 4 528[f]	0.04
1988	197		1 049[r]	

[a] based on VPA with M = 0.2, biomass was adjusted to 1984/85 biomass estimation from FRG survey (Kock, 1985)

[b] Mean F for ages 5–12 in VPA

[c] from research vessel survey

[d] FRG

[e] Spain

[f] US/Polish

Catches:

A very large directed fishery took place in the 1970/71 and 1971/72 seasons and smaller directed fisheries in 1976 and 1980. Otherwise catches have been taken as by-catch in fisheries based largely on other species.

Conservation Measures in Force:

(1) Fishing other than for scientific research purposes is prohibited in waters within 12 nautical miles of South Georgia (Conservation Measure 1/III).

(2) the use of pelagic and bottom trawls having the mesh-size in any part of the trawl less than 120 mm is prohibited (Conservation Measure 2/III).

(3) Directed fishing on *N. rossii* in 48.3 is prohibited. By-catches of *N. rossii* in fisheries directed to other species shall be kept to the level allowing the optimum recruitment to the stock (Conservation Measure 3/IV).

(4) The total catch of *C. gunnari* in the 1987/88 season shall not exceed 35 000 tonnes in 48.3 After such time as that total catch ahs been reached *C. gunnari*, *N. rossii*, *N. gibberifrons*, *C. aceratus* and*P. georgianus* shall not be taken in 48.3 except for scientific purposes (Conservation Measure 8/VI).

(5) Directed fishing on *C. gunnari* in 48.3 from 1 April until 1 October 1988 is prohibited. During the protected period*C. gunnari*, *N. rossii*, *N. gibberifrons*, *C. aceratus* and *P. georgianus* shall not be taken in 48.3 except for scientific research purposes (Conservation Measure 10/VI).

Data and Assessments:

Length and age data are available for most seasons, and biomass estimates have been made from a number of research surveys, more recently in 1987/88.. Problems with interpretation make the age data unsuitable from 1985 onwards, but VPA have been run up to that date.

Fishing Mortality:

Fishing mortality has been very high from age 4 onwards in the seasons of directed fishing. The younger fish are largely in the fjords and unaccessible to fishing.

Recruitment:

Recruitment is now very much lower than it must have been in the 1960's. The decrease seems to have taken place in abrupt steps, and though this has occurred during a period when the stock was in decline, the relation between stock abundance and recruitment does not appear to be simple.

State of the Stock:

Stock abundance is now very low and will not improve appreciably until recruitment increases.

Management Advice:

No significant catches can be taken until recruitment increases and the stock begins to recover. Any fishing on the depleted stock will delay the recovery and reduce the probability of better recruitment.

Research Requirements:

The current doubts about age determination should be resolved. More needs to be understood about possible factors affecting recruitment. It would also be desirable to establish methods of monitoring the younger, pre-recruit fish.

ASSESSMENT SUMMARY FOR *PATAGONOTOTHEN BREVICAUDA GUNTHERI* IN SUBAREA 48.3 (South Georgia Subarea)

Split-Year Ending	Nominal Catches (tonnes)	Estimated Biomass [(a)]	Estimated Biomass [(b)]	Mean F [(b)]
1979	15 011		96 000	1.09
1980	7 381		101 000	0.48
1981	36 758		108 000	1.35
1982	31 351		76 000	1.91
1983	5 029		59 000	0.45
1984	10 586		57 000	1.02
1985	11 923		70 000	0.54
1986	16 002		79 000	0.83
1987	8 810	81 000	121 000	0.96
1988	13 424		122 000	

[(a)] from Spanish survey
[(b)] from Soviet survey

Catches:

This is only caught in a Soviet directed fishery in the Shag Rocks area.

Conservation Measures in Force:

(1) The general measures for Subarea 48.3 apply.

Data and Assessments:

Length and age data are available for most years and a VPA has been calculated. An estimate of biomass of 81 000 tonnes in 1986/87 is available from a Spanish survey.

Fishing Mortality:

Fishing mortality appears to be moderately high with ages 2–4 predominantly in the catches.

Recruitment:

There is no indication of any trend in recruitment.

State of the Stock:

It does not appear that fishing is having a serious impact on the stock.

Forecast:

There are uncertainties about the value of M which made it difficult to make forecasts.

Recommendations:

No estimate could be made of a TAC corresponding to target fishing mortalities. An alternative strategy would be to hold catches at the level of recent years.

Data Requirements:

VPAs need to be tuned to the biomass estimates. Early age composition data should be examined to produce better estimates of M.