ANNEX 6

REPORT OF THE WORKING GROUP ON FISH STOCK ASSESSMENT

(Hobart, Australia, 25 October to 2 November 1989)

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INTRODUCTION

The Meeting of the Working Group was held at the CCAMLR Headquarters, Hobart, Australia from 25 October to 2 November 1989. 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. The report was prepared by Drs J. Beddington, W. de la Mare, I. Everson, K.-H. Kock and K. Sullivan. A list of documents considered at the meeting is given in Appendix 3.

GENERAL MATTERS AND MATERIAL AVAILABLE

Research Vessel Exemption

2. During the past week the Secretariat had received notification that USSR was sending three research vessels (*Slavgorod, Borispol* and *Passat 2*) to the South Georgia region (Subarea 48.3) to undertake a fishery survey lasting one month. The Executive Secretary had responded drawing attention to the requirements to provide information to the Commission six months in advance of research cruises operating under the scientific research exemption provisions (CCAMLR-V, paragraph 60). During the meeting a further message was received indicating that the USSR had withdrawn the three vessels from Subarea 48.3. No information on research objectives or survey design was available to the meeting.

3. Where fishing was according to a randomised design it was clear that the total catch was unlikely to be large. It was noted, however, that target or directed fishing, even for research purposes, by such a group of vessels might result in significant catches being made.

4. The Working Group recommended that the Scientific Committee consider the operation of the Research Vessel Exemption Provisions (CCAMLR-V, paragraphs 59 and 60) paying particular attention to how plans should be circulated, catches should be reported and whether research vessel catches should be considered as part of a TAC.

Catch and Effort Statistics

Statistical Area 48 (Atlantic Ocean Sector)

5. Small catches of *Notothenia gibberifrons* and *Champsocephalus gunnari* had been reported from Subareas 48.1 and 48.2.

6. The largest catches were reported from Subarea 48.3. Prior to the closure of the fishery on 4 November 1988 (Conservation Measure 11/VII) 21 356 tonnes of *C. gunnari*, 838 tonnes of *N. gibberifrons* and 152 tonnes of *Notothenia rossii* had been taken. In addition 13 016 tonnes of *Patagonotothen brevicauda guntheri* were caught during the season.

7. The USSR had undertaken an experimental fishery for *Electrona carlsbergi* (*Myctophidae*) in the Polar Frontal Zone. The total catch of these species within the CCAMLR Convention Area was 30 000 tonnes. Catch rates of 70 to 80 tonnes a day had been achieved during a study to determine the distribution and size of fishable concentrations. Concentrations of *E. carlsbergi* were also found well north of the CCAMLR Convention Area.

8. Longline fishing for *Dissostichus eleginoides* was undertaken by a small fleet of USSR vessels operating in the vicinity of South Georgia and Shag Rocks (Subarea 48.3). A total of 4 138 tonnes had been caught mainly from water deeper than 500 metres. Details of the fishery were not available to the meeting.

9. With respect to the above, the Working Group noted that an accumulated catch of 5 756 tonnes of *D. eleginoides* had been taken from this subarea between 1977 and 1988. Experience in other fisheries outside the CCAMLR Convention Area indicates that assessment of longline fisheries is difficult with little indication of overfishing becoming apparent until the stock is near to collapse.

10. Since analysis of catch-per-unit-effort indices is the only proven method for assessing longline fisheries, it was agreed that appropriate data should be collected as a matter of urgency. The most effective effort indices should include:

- Number and size of hooks on the line;
- The spacing of hooks on the line;
- The time the longline is set (soak time) and recovered;

- Fishing depth;
- Type of bait;
- Precise fishing location (i.e. position) as suitable sites often cover a very restricted area;
- Target species and catch;
- Discarded species and catch; and
- Incidental mortality.

11. Concern was expressed that a longline fishery in the Convention Area might cause significant mortality to certain predators, particularly albatrosses and large petrels, as had occurred in other areas of the world. It was agreed that advice should be sought from the Scientific Committee on data that should be collected to quantify incidental mortality.

12. Currently, CCAMLR has no agreed reporting procedure for longline fisheries. The Working Group recommended that the Secretariat be asked to prepare a suitable data collection format based on those in use in other fisheries agencies and taking account of the items specified above. Given the concerns expressed in paragraph 9, the Working Group agreed that this should be completed for this year's Scientific Committee meeting so data collection procedures from longline operations could be implemented for the 1989/90 season.

Statistical Area 58 (Indian Ocean Sector)

13. The largest reported catches were taken in Division 58.5.1 (Kerguelen) where 23 000 tonnes of *C. gunnari* and 1 500 tonnes of *Notothenia squamifrons* were caught.

14. It was confirmed that catches reported as being of *C. gunnari* from Division 58.4.2 were in fact *Chaenodraco wilsoni*. It was agreed that the STATLANT records should be amended accordingly.

Statistical Area 88 (Pacific Ocean Sector)

15. Fishing on *E. carlsbergi* only was reported from this area. The total reported catch was 1 110 tonnes.

Size and Age Composition Data

16. Length composition data had been provided for the major fisheries. The bulk of the data were from research vessel catches; relatively few data sets were from the commercial fishery. It was again emphasised that more data from the commercial fishery would allow a considerable improvement in the stock assessments.

Age Determination

17. The results of the CCAMLR Otoliths/Scales/Bones Exchange Scheme were outlined by Dr Kock, the organiser (SC-CAMLR-VIII/BG/46). Whilst in some cases the degree of agreement had been good, there were large differences between the results of some workers. These were not necessarily related to the experience of the worker. It was concluded that age/length keys provided by different workers could not be calibrated effectively and that age/length keys from a single source should be used when analysing the fishery of a particular stock. For species such as *C. gunnari*, where there was reasonable consistency in age/length keys for fish aged one to three, it was thought that this was likely to cause fewer problems for stock assessment.

18. It was felt that there was little need to continue the exchange scheme as individual inconsistencies of interpretation could only be resolved by getting together at a Workshop.

19. A comparison of age determination using otoliths and scales from *N. gibberifrons* (WG-FSA-89/13) indicated that scales tended to underestimate age by one year. This was thought to be due to a difference in timing of the formation of the nucleus in each structure.

20. A new technique for age determination of *C. gunnari* involving clearing freshly extracted otoliths with glycerine and storing them in alcohol vapour was described (WG-FSA-89/19).

Other Biological Information

Reproduction

21. Length at first spawning of *C. gunnari* from the South Orkney Islands and the Antarctic Peninsula is approximately 10 cm greater than at South Georgia. There is also a clear relationship between fecundity and location with fewer eggs being produced at the more southerly sites (SC-CAMLR-VIII/BG/16).

22. Although spawning occurs annually in *C. gunnari* around South Georgia not all fish spawn each year. It is estimated that the true spawning stock biomass is only about 80% of the total stock of fish of spawning size. Estimates of spawning stock biomass must therefore be reduced to take account of this factor (SC-CAMLR-VIII/BG/16).

23. The gonad maturity scales used for Antarctic fish thus far are not fully applicable to all species. A five grade scale described by Everson (1982) for use with Nototheniids, based on observations of *Notothenia neglecta,* has been used for all Antarctic fish in recent years. Differences noted between gonad maturity stages of Nototheniidae and Channichthyidae have required the designation of an additional scale for the latter group (WG-FSA-89/7). This channichthyid maturity scale was produced based on observations on the three species, *C. gunnari, Chaenocephalus aceratus* and *Pseudochaenichthys georgianus.* It was recommended that these two scales be used for future assessments, both are set out in Appendix 4.

24. A survey of larval and juvenile fish during the period December 1986 to March 1987 in the Bransfield Strait area had indicated generally low levels of abundance of all species (SC-CAMLR-VIII/BG/36). Avoidance was considered to be a major problem with Bongo and Nansen nets used in the survey.

Estimation of Natural Mortality, M

25. Two types of estimation methods were tested:

(i) Direct methods based on age composition data representing the virgin stock, i.e. data collected before fishing started; and

(ii) Indirect methods or comparative methods, using average values of M estimated for species with similar physiological characteristics and environment.

26. The direct methods are considered the most reliable ones, if based on unbiased data representing a stock in equilibrium, i.e. the average age distribution for several years.

27. This type of data was available for *C. gunnari* in South Georgia waters (WG-FSA-89/20). Using various direct methods (see paragraph 25(i) above) a value of M = 0.5 per year was found. This value, however, is outside the expected range for a species with the biological characteristics of *C. gunnari* and further examinations of the basic data (which were not available to the Working Group) are recommended.

Mesh Selection

28. Results from selectivity experiments undertaken by Poland, Spain and USSR had been discussed during the 1988 Meeting of the Working Group (SC-CAMLR-VII/10, paragraphs 14 to 16). The analyses have been completed and presented in SC-CAMLR-VIII/BG/20 Rev. 1 and are summarised below.

Champsocephalus gunnari

29. The Selection Factor (SF) of 2.95, obtained in the South Georgia area using mesh sizes of 68 and 88 mm, seems appropriate for calculations of mesh size in the commercial trawl fishery for *C. gunnari*.

30. This SF, referred to a nominal mesh of 80 mm, adopted by CCAMLR in 1984 as the minimum mesh size for *C. gunnari*, gives an L_{50} of 23.6 cm. This length is around the mean length at 50% maturity in the South Georgia area (23.4 cm, according to Kock, Duhamel and Hureau, 1985; Balguerias and Quintero, 1987 and Kock, 1989), and well below the length of first spawning, which is estimated at 27 cm (SC-CAMLR-VIII/BG/16). The application of SF = 2.95 corresponds in this case to the minimum mesh size of 92 mm. A mesh size of 108 mm would then correspond to the age at first capture of 4 years (i.e. around 32 cm), which was proposed as the optimum under conditions of high fishing mortality (SC-CAMLR-VII/10).

31. Using the mean SF from South Georgia to calculate the minimum mesh sizes for *C. gunnari* from the South Orkney and South Shetland areas, and applying the length at first spawning estimated at 35 cm (SC-CAMLR-VIII/BG/16), results in the minimum mesh size of 119 mm.

Notothenia gibberifrons

32. Assuming the mean SF of 2.62 for *N. gibberifrons* for the whole of Statistical Area 48, and applying it to the mean lengths at 50% maturity for this species from South Georgia (32.9 cm) as well as from South Orkney Is, Elephant Is and South Shetland Is (29.9cm), gives mesh sizes of 126 and 114 mm respectively. It should be recalled, however, that SF's obtained for *N. gibberifrons* vary considerably between the various areas studied and there is no clear relationship between mesh size increase and growth of the L_{50}. These calculated meshes ought therefore to be taken as provisional figures.

Patagonotothen brevicauda guntheri

33. A Selection Factor (SF) of 3.21 referred to 16 cm, which is the 50% length at maturity of *P.b. guntheri* (SC-CAMLR-VIII/BG/27, WG-FSA-89/21), corresponds to the minimum mesh of 50 mm for this species.

Chaenocephalus aceratus and *Pseudochaenichthys georgianus*

34. Selection parameters for *C. aceratus* differ considerably for various meshes and codends tested and are mostly rough estimates from poorly defined selectivity ogives. It is therefore not possible to advise on an appropriate mesh size. Selectivity data available for *P. georgianus* are also inadequate for the designation of a minimum mesh size.

Summary Conclusions

35. Assuming that the actual size of the twine mesh in commercially used codends is on the average 10% greater than the nominal mesh (SC-CAMLR-VII/BG/11), the introduction of the following mesh sizes in the commercial fishery in Statistical Area 48 should be considered:

(a) Subarea 48.3

(i) Fishery targeted at *C. gunnari*
80 mm, to protect immature fish, or
90 mm, to protect first spawners, or
100 mm, to give an age at first capture of 4 years;

(ii) Fishery targeted at *P.b. guntheri*
50 mm, to protect immature fish;

(iii) Mixed fishery (not targeted at *C. gunnari* or *P.b. guntheri*)
120 mm extended to include *N. gibberifrons, C. aceratus* and *P. georgianus* (in addition to *N. rossii* and *D. eleginoides*, which have had such a mesh regulation since 1984 - Conservation Measure 2/III), to ensure better protection of immature fish;

(b) Subareas 48.1 and 48.2
110 mm, to ensure protection of first spawners of *C. gunnari* and immature *N. gibberifrons*.

In addition to the above, the provision should be included that chafers will not be used and codends will be diamond shaped mesh made of twine, no thicker than 4.5 mm.

36. Further research on mesh selectivity was recommended in order to improve the applicability of these selection factors. It was stressed that such studies needed to reflect selectivity in the commercial fishery and should therefore be undertaken using commercial fishing gear and techniques independently of biomass surveys.

37. It is worth noting that the mean SF of 3.5 for *C. gunnari* and *N. gibberifrons*, obtained in the first Polish experiment using the 60 and 100 mm mesh tape netting, is considerably higher than that of the twine netting currently in commercial use. One of the properties of the tape netting is the constant rectangular shape of meshes (SC-CAMLR-V/BG/29). Satisfactory parameters of fish selection, obtained for this kind of net, should encourage further experiments with this 'open mesh' netting.

38. Recent reports to ICES have indicated that fish which pass through the meshes of a net may be subject to high mortality. No information was available to indicate if this is a

significant problem for Antarctic fish species. It was recommended that studies be undertaken to quantify this form of fishing mortality.

39. Although the Working Group agreed that further work was necessary it was felt that the analyses presented were now at a stage when selection factors could be used as a guide in introducing new mesh sizes.

Other Information

Larval Fish Key

40. A key and catalogue of Antarctic fish larvae have been prepared by A. Kellermann (FRG) and A.W. North (UK) and were expected to be published in January 1990. Funds were provided by CCAMLR for the project.

Bibliography

41. A bibliography of Antarctic fish has been prepared by K.-H. Kock and is available as a hard copy and on disc from Bundesforschungsanstalt für Fischerei, Informations und Dokumentationsstelle, Hamburg, FRG.

Assessments Prepared by Member Countries

Statistical Area 48 (Atlantic Ocean Sector)

Standing Stock Estimation

42. The results of two trawl surveys around South Georgia were presented, one undertaken by USA from the research vessel NOAA *Surveyor* during January and a joint UK/Polish survey during February using RV *Profesor Siedlecki* (SC-CAMLR-VIII/BG/35 and WG-FSA-89/6 respectively).

43. The USA study was undertaken using a newly developed small bottom trawl which had a narrower swept area and lower headline height than trawls used commercially. Operational constraints meant that the net could only be fished down to a maximum depth of 250 m.

44. Two methods of analysing the survey data for abundance estimation had been used. The traditional stratified random sampling method had given estimates of mean abundance and variance for some species similar to those from previous surveys. Using the Kriging method, similar estimates of abundance were obtained but with a very much lower variance. The Kriging method requires fitting one of three models to the distribution of two parameters on a semivariogram. Abundance estimates derived from this method assume that there is zero variance about the model chosen. It was concluded that the Kriging method gives an unrealistically low estimate of variance and was therefore inappropriate in the current circumstances.

45. The UK/Polish survey had been undertaken in the same way and using the same gear as on two previous surveys undertaken jointly by USA and Poland. A stratified random sampling method was used for the design and analysis of the data. This survey was therefore directly comparable with the two previous ones and it was agreed could be used for current standing stock estimation.

Parameter Estimation

46. Growth and natural mortality were estimated for *C. gunnari* at South Georgia (WG-FSA-89/20). Bertalanffy growth parameters were consistent with earlier estimates given by Kock (1981) and Kochkin (1985).

47. Natural mortality had been estimated by five methods using both direct and indirect methods. The direct method used data pooled over four seasons. It was felt that variations in recruitment, evident from other analyses undertaken in previous years by the Working Group, meant that these analyses could give a misleading impression of M and that a year by year analysis would be more appropriate. USSR scientists were requested to provide the data for such analyses for the next meeting.

48. Data from recent years in both the South Georgia and Kerguelen fisheries indicated that mortality of the older age classes was very high although no explanation, such as a high post-spawning mortality, was forthcoming. Some indication might be forthcoming from a consideration of condition factors throughout the year.

49. Several different methods are available for estimating 'M' of which those using age composition data directly were the best. The Working Group considered that the Heincke estimator of 'M' should be used. The value for this parameter calculated from the data in WG-FSA-89/20 is 0.56. The Working Group agreed that this value and the one agreed last year (0.35) should be used for subsequent assessment analyses.

50. Growth and natural mortality were estimated using data from the earliest years of the fishery for *P.b. guntheri* at South Georgia (WG-FSA-89/18). The values of the von Bertalanffy growth parameters provided a close fit to observed values and were used for analysis at the Working Group.

51. The age data presented in this paper were used to estimate an average value of M using Heincke's estimation, under the assumption that the age data are representative of an unfished population in equilibrium. The estimate obtained was M = 0.94. However, the age data come from a single year and hence do not average out any fluctuations between age classes from variable recruitment. This reduces the reliability of the estimated value of M. In addition, the age data suggest the possibility of age dependence in natural mortality. While the Heincke estimator correctly estimates the average natural mortality rate in a virgin stock, this is not necessarily the average natural mortality in the stock under exploitation.

52. Pauly's method (paragraph 25) was used to make an independent prediction of the value of M. The result was M = 0.45.

53. Estimates of the age and size at which 50% of the Shag Rocks population of *P.b. guntheri* reach sexual maturity were provided in two papers. Age at sexual maturity can be used to estimate M by the method of Rikhter and Efanov. This information is summarised below:

Length at Sexual Maturity (cm)	Age at Sexual Maturity (years)	M	Reference
15.6 - 16.5	3.7*	0.44	Lisovenko and Pinskaya (cited in WG-FSA-89/21)
16.0	3.7*	0.44	Balguerias and Quintero (SC-CAMLR-VIII/BG/27)
12 - 14	2.5	0.63	Shlibanov (WG-FSA-89/21)

* Estimated from Bertalanffy parameters given in WG-FSA-89/21.

Status of Stocks

54. Analyses of the status of the three target species, *C. gunnari, N. rossii* and *P.b. guntheri* in the Atlantic sector, were presented in SC-CAMLR-VIII/BG/18. These indicated that the stock size of *C. gunnari* around South Georgia was 68 700 or 86 800 tonnes (depending on which of the two data sets are used) at the beginning of the 1988/89 season. The authors suggested that further protection of the stock would be achieved by bringing forward the closed seasons from 1 April to 1 March to protect prespawning aggregations of females and would be warranted. Stock size in *N. rossii* seems to be still less than 5% of the pristine level. Trajectories of stock size of *P.b. guntheri* were largely dependent on the rate of natural mortality M chosen. Values of M = 0.8 indicate a decline in stock size and recruitment whereas M = 0.4 would indicate only minor fluctuations in stock size and recruitment since the onset of fishing.

55. An assessment of the *C. gunnari* stock at South Georgia using Virtual Population Analysis (VPA) was presented (WG-FSA-89/8). The current standing stock used in the analysis was based on the UK/Polish survey in February 1989 and the analysis had been tuned using biomass estimates from other surveys. The paper described several problems, which were encountered in the preparation of other input data because detailed catch information for this stock was not available from all fishing countries of CCAMLR, especially for the early period of the fishery. Problems were also encountered with some age/length keys where ambiguities were found in separate published descriptions of the same data set; such data were not included in the analysis.

56. The results indicate that the current biomass level of *C. gunnari* is very much less than its peak value as estimated from VPA and that the catch levels observed in recent years cannot be sustained.

57. During discussion the point was made that only two age/length keys were used to calculate *C. gunnari* catch age composition for all years of the fishery. However, age/length keys from one year may not reflect the age composition of catches in other years. According to Ricker this can lead to bias in age composition of catches (Whestreim and Ricker, 1978).

58. Analyses reported in SC-CAMLR-VIII/BG/18 using different age/length keys had come to essentially the same conclusions as this study. The differences caused by using different age/length keys were therefore considered only of minor importance in this particular case.

59. In WG-FSA-89/8 data from four trawling surveys have been used for tuning. Trawling surveys have a large standard error. For example, the estimate of abundance of *C. gunnari* from the UK/Polish survey has a coefficient of variation of 49.9%. Hence estimates of terminal fishery mortality based on an individual survey will have high uncertainty (especially for the 2 to 3 age classes).

60. An assessment of *P.b. guntheri* in Subarea 48.3 using VPA was presented in WG-FSA-89/21. Information on growth and natural mortality were as described in WG-FSA-89/18. The estimated current standing stock was 117.5 thousand tonnes and a Total Allowable Catch (TAC) at $F_{0.1}$ = 1.12 of 28 300 tonnes was derived.

61. During discussion it was noted that the mean weight at age used for the analysis changed dramatically after the 1985/86 season. The reported mean weight at age for most year classes had almost doubled after that time. Such an increase seems biologically unlikely and could be the result of problems in methods in ageing.

62. The annual catches used for the analysis were, for the most part, higher than those reported to CCAMLR (SC-CAMLR-VII/10, Table 2). The catch data used in WG-FSA-89/21 were calculated by multiplying the number at age by the mean weight at age. These calculated values differ from the reported catch by a factor equal to the difference between the mean weight of fish of a given year class in the month in which they are caught and the mean weight of fish of that year class over the year. It was agreed that the catches reported to CCAMLR in the standard formats should be used for the analyses.

63. It was noted that there had been some changes in the reported classes of fishing vessels over the period of the study. It was confirmed that STATLANT 08B data reported by USSR from 1983 to 1986 with vessel code of 7 should be attributed to vessel code 10 (2 000 – 4000 tonnes). The CCAMLR Data Manager was requested to make the appropriate changes to the records in consultation with the USSR Data Manager.

64. Clarification was sought for the differences noted in WG-FSA-89/21 between the length at sexual maturity for *P.b. guntheri*.

65. An assessment of *C. gunnari* at South Georgia using VPA was presented in WG-FSA-89/22. Using the Laurec-Shepherd method of tuning the VPA and data from Soviet fishing vessels, a value for biomass of 139 900 tonnes was obtained.

66. Input data on growth and mortality were derived from WG-FSA-89/20 and have been commented on in paragraph 42 and 43 of this report. Six further points were made in discussion of this paper.

(i) The effort time series chosen to tune the VPA was derived from midwater trawl data. An alternative time series was available for bottom trawls, but was not used as there was a data point missing. The series used showed effectively no decline over the period. By contrast the other series indicated a decline in CPUE to about 25% of the original level. The use of a series which shows no trend to tune the VPA results in a very high estimate of stock size. In essence, catches are seen by the estimation technique to be having little effect on the stock, hence the stock must be large. If the other CPUE series had been used it is likely that a much smaller stock estimate would have been obtained. This would be in accord with the survey estimates which indicate recent stock levels of around one third of the estimate in WG-FSA-89/22.

(ii) The data on catch at age for 1987/88 were different from the catch at age presented for the USSR fishery by Borodin and Kochkin (WG-FSA-88/32) although data for all other years were the same. The effect of the new data was to raise the CPUE for that year and hence estimates of recent stock size. The Working Group agreed that there was a need to resolve this problem.

(iii) The point was made that in October 1988 the fishery appears to have concentrated on two year old fish. However, the estimate of partial recruitment used comes from a period when other age classes were abundant in the fishery,

with the result that two year olds were then not specifically targeted by the fishery. Accordingly, applying this historical partial recruitment estimate to the recent predominantly two year old catches could lead to substantial over-estimates of biomass for the coming season.

(iv) Catch and effort data used for this study were taken from SC-CAMLR-VII/10, paragraph 24 which gives no catch and effort data for bottom trawl fishing during 1985/86. Consequently these data are missing from subsequent analyses and from the paper currently under consideration. However, these missing data have been supplied to CCAMLR in the STATLANT 08 format and were also used in another study reported to this meeting of the Working Group (WG-FSA-89/8).

(v) The STATLANT data also indicated that there had been a change in the size of vessels during the period. It was explained that an incorrect code had been used to report the same size of vessel (see paragraph 63).

(vi) The CPUE data used for the assessment came from pooling different sets of months in different years and hence may not be compatible.

(vii) There are consistent differences between the age composition of the catches obtained using midwater trawls and bottom trawls. Midwater trawls catch a much higher proportion of one and two year old fish than bottom trawls. These differences need to be incorporated into assessments involving CPUE.

Potential Yield

67. Two papers (SC-CAMLR-VIII/BG/42 and SC-CAMLR-VIII/BG/47) were tabled in response to the request by the Commission for advice on the likely trajectories of catch and total biomass under different patterns of fishing and mortality (CCAMLR-VII, paragraphs 113 and 114).

68. An analysis was made of the potential yield of *C. gunnari* around South Georgia under varying recruitment (SC-CAMLR-VIII/BG/42). The simulations indicated that at levels of fishing mortality equal to the maximum yield per recruit (F_{max}) or $F_{0.1}$, the expected yield of *C. gunnari* would be in the region of 20 000 to 40 000 tonnes per annum once recovery of the stock occurred. At conservative, sustainable levels of harvesting the

variability in catches between years is lower than when harvesting rates are high, and the probability of the spawning stock falling to dangerously low levels, is reduced. Closure of the fishery for at least one year would have substantial benefits in increased yields and decreased uncertainty.

69. The paper SC-CAMLR-VIII/BG/42 used the results of WG-FSA/89/8 as a basis for its analysis on the variability of recruitment and the variation of recruitment with stock size. The main criticisms of this paper were that it assumed recruitment was a random variable with a log normal distribution. Similar analyses, reported in another paper (SC-CAMLR-VIII/BG/18) which had taken account of cyclical changes in standing stock and recruitment, indicated essentially similar trends in standing stock size. On balance it was considered that the analyses reported in SC-CAMLR-VIII/BG/42 had presented an optimistic view of the implications of different management possibilities as it assumed that stock size and fishing mortality could be assessed without error.

70. A further study (SC-CAMLR-VIII/BG/47) examined the effects of a number of harvesting strategies on *C. gunnari* for a period of 30 years. The strategies chosen were:

- different levels of constant fishing mortality ($F_{0.1}$, F_{max}, 2 x F_{max});
- harvesting constantly at 50% $F_{0.1}$ with an increase of F 3 or 5 years after a good recruitment;
- pulse fishing at an interval of 3 years with no fishing in between; and
- a shift in partial recruitment values due to changes in net selectivity.

Recruitment was assumed to follow the historical pattern.

71. The study indicated that pulse fishing was the least preferable strategy. In the absence of regular recruit surveys, constant fishing at $F_{0.1}$ is most likely to be the most profitable and least risky strategy compared to higher levels of fishing mortality. The establishment of regular recruit surveys would offer the possibility of adjusting fishing mortality to the strength of the incoming year class. An increased F should not occur until at least four years after a good recruitment. Decreased partial recruitment of the youngest age classes as a result of a one year forward shift in partial recruitment values would not alter yield significantly when fishing at $F_{0.1}$ and F_{max} but would lead to a higher spawning biomass.

72. These two studies, although based on different approaches, were seen as providing essentially similar advice with regard to the South Georgia, *C. gunnari* fishery (i.e. a pause of 1–2 years to let the spawning stock recover and a conservative fishing mortality rate not higher than $F_{0.1}$).

Comparison of Semipelagic and Bottom Trawls

73. Preliminary observations on the suitability of semipelagic trawl gear in the *C. gunnari* fishery were described in SC-CAMLR-VIII/BG/26. The semipelagic trawl used during the 'Antartida 8611' expedition had been more effective in catching *C. gunnari* than bottom trawls. The semipelagic net was very much less effective for catching *N. gibberifrons*.

74. It was agreed that estimates based on haul by haul data, collected, if possible, at the same time, would provide better indicators of the relative effectiveness of various types of trawls (bottom, semipelagic or midwater), because of the unknown vertical distribution of various age groups of *C. gunnari* as well as the patchiness observed in the horizontal distribution of the several Antarctic fish species. Such values could also be used to estimate differences in the by-catch taken using these types of gear.

Statistical Area 58 (Indian Ocean Sector)

Standing Stock Estimation

75. No new demersal fish surveys from the Kerguelen region were reported. Previous surveys have indicated that *N. rossii* is still at a low level although trammel net hauls in the coastal region indicate that there is an increase in juveniles of this species. *C. gunnari* stock is subject to cyclical fluctuation in recruitment while the *N. squamifrons* stock appears to be declining (WG-FSA-89/9).

Parameter Estimation

76. Growth and natural mortality of *N. squamifrons* were described from three locations in the Indian Ocean sector (WG-FSA-89/16 and WG-FSA-89/17). Parameters of the von Bertalanffy growth equation were similar to those reported earlier (Duhamel, 1987). For discussion of natural mortality see Appendix 5.

ASSESSMENTS

(Summary Assessments are provided in Appendix 10)

Statistical Area 48

Subarea 48.3 (South Georgia)

77. The history of catches around South Georgia is given in Table 1. This demonstrates how fishing has shifted from one species to another which in conjunction with a high variability in recruitment of *C. gunnari* has lead to a high variability in annual catches. The 1988/89 catch was only slightly below that in 1987/88. Catch of *C. gunnari* exceeded the $F_{0.1}$ and F_{max} levels estimated by the Working Group in 1988 by approximately 10 000 tonnes and 3 000 tonnes respectively but was well below the levels of 1987/88. Catch of *P.b. guntheri* exceeded the TAC of 13 000 tonnes set by the Commission in 1988 (Conservation Measure 12/VII) by 16 tonnes. However, catches of *D. eleginoides* and myctophids (*Electrona carlsbergi*) increased by factors of more than 2, to 4 138 and 29 673 tonnes respectively. For the first time longlining has been used inside the Convention Area to catch *D. eleginoides*.

Table 1: Catches of various finfish species from Subarea 48.3 (South Georgia Subarea) by year. Species are designated by abbreviations as follows: SSI (*Chaenocephalus aceratus*), ANI (*Champsocephalus gunnari*), SGI (*Pseudochaenichthys georgianus*) and LXX (*Myctophidae spp.*), TOP (*Dissostichus eleginoides*), NOG (*Notothenia gibberifrons*), NOR (*Notothenia rossii*), NOS (*Notothenia squamifrons*), NOT (*Patagonotothen brevicauda guntheri*). 'Others' includes Rajiformes, unidentified Channichthyidae, unidentified Nototheniidae and other Osteichthyes.

Split year	SSI	ANI	SGI	LXX	TOP	NOG	NOR	NOS	NOT	OTHERS	TOTAL
1970	0	0	0	0	0	0	399704	0	0	0	399704
1971	0	10701	0	0	0	0	101558	0	0	1424	113713
1972	0	551	0	0	0	0	2738	35	0	27	3351
1973	0	1830	0	0	0	0	0	765	0	0	2595
1974	0	254	0	0	0	0	0	0	0	493	747
1975	0	746	0	0	0	0	0	1900	0	1407	4053
1976	0	12290	0	0	0	4999	10753	500	0	190	28732
1977	293	93400	1608	0	441	3357	7945	2937	0	14630[a]	124611
1978	2066	7557	13015	0	635	11758	2192	0	0	403	37626
1979	464	641	1104	0	70	2540	2137	0	15011	2738[b]	24705
1980	1084	7592	665	505	255	8143	24897	272	7381	5870	56664
1981	1272	29384	1661	0	239	7971	1651	544	36758	12197[c]	9167
1982	676	46311	956	0	324	2605	1100	812	31351	4901	89036
1983	0	128194	0	524	116	0	866	0	5029	11753[d]	146482
1984	161	79997	888	2401	109	3304	3022	0	10586	4274	104742
1985	1042	14148	1097	523	285	2081	1891	1289	11923	4238	38517
1986	504	11107	156	1187	564	1678	70	41	16002	1414	32723
1987	339	71151	120	1102	1199	2844	216	190	8810	1911	87882
1988	313	34620	401	14868	1809	5222	197	1553	13424	1387	73794
1989	1	21 359	1	29673	4 138	838	152	927	13016	55	70160

[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 GDR
[d] Includes 11 753 tonnes of unspecified fish caught by the Soviet Union

78. Information from two fishery-independent surveys carried out by UK/Poland (WG-FSA-89/6) and the US (SC-CAMLR-VIII/BG/35) was available to the Working Group. However, both vessels involved used very different bottom trawls. The UK/Polish survey used the same commercially-sized trawl as during the previous US/Polish surveys whereas the US survey used a trawl with a mouth opening of only $^1/_4$ of that of the Polish trawl. This may have biased the catches considerably towards smaller species and smaller individuals. Furthermore the US survey covered only part of the depth range (50 – 250 m) of the commercially exploited species. After extensive discussion the Working Group decided that it would only take estimates from the UK/Polish survey into account in its assessments.

79. The Working Group noted that the Member's Activities Report of the USSR contained biomass estimates of the commercially exploited species around South Georgia. However, the Working Group was unable to include these estimates in the assessments as no descriptions were available on how the estimates were obtained. The Working Group recommended these USSR results be submitted to next year's meeting for further consideration.

Notothenia rossii in Subarea 48.3

80. The Commission's conservation measures have aimed to keep the catches of the species to as low a level as possible. Reported catches in 1988/89 were 152 tonnes, 45 tonnes below the 1987/88 level.

81. There were no new data available from the commercial fishery. However, the biomass estimate from the joint UK/Polish research survey of 2 439 tonnes which was in line with biomass estimates from previous US/Polish surveys of 1 049 to 4 582 tonnes indicates that the stock remains at a very low level.

82. Although the reduction in stock size to levels below 5% of the pristine state must be having an effect on recruitment the apparent, however slow, recovery of the Kerguelen population of *N. rossii* after the cessation of directed fishing since 1984 (WG-FSA-89/9) indicates that there may be ecological factors influencing the recovery of the South Georgia population. Increased predation by fur seals (*Arctocephalus gazella*) which started to recolonise the mainland of South Georgia in the 1970's in increasing numbers might be among the reasons for continuous low recruitment. Food studies on fur seals indicate that they feed principally on *E. superba*. However, the proportion of fish, including *N. rossii*, in the diet increases in winter (SC-CAMLR-VIII/BG/18 for references).

83. In view of the low level at which the stock has been for a number of years, its status needs to be carefully monitored. Biomass estimates and age length keys from recent years were available from research vessels surveys. However, the Working Group noted with concern that there is a lack of data from the commercial fishery. Albeit its annual catch has been comparatively small after the establishment of conservation measures by the Commission, the Working Group strongly recommended that biological information (length composition, age length keys) should be collected and provided to the Working Group to assist in assessing the present status of the stock.

Management Advice

84. In view of the current low level of the stock *N. rossii*, all conservation measures should be kept in force.

Champsocephalus gunnari in Subarea 48.3

85. The total catch in 1988/89 was 21 356 tonnes which was taken in 35 days after the reopening of the fishery on 1 October 1988. As a result of catches reported to CCAMLR-VII, the Commission adopted Conservation Measure 11/VII which prohibited directed fishery on *C. gunnari* from 4 November 1988 to 20 November 1989. Catches taken before the closure of the fishery were already above the level corresponding to F_{max} and over twice the catch level at $F_{0.1}$, the preferred target fishery level decided by CCAMLR-VI.

86. Throughout the history of the fishery, catches have fluctuated in accordance with the appearance of strong year classes in the population, and the subsequent movement of these cohorts through the fishery. However, the fishery was regulated for the first time by CCAMLR in 1987/88, when a TAC of 35 000 tonnes was set. In that year the TAC was almost fully taken, with reported catches of 34 632 tonnes. This catch mainly comprised fish from the strong 1983/84 and 1984/85 cohorts. These two year-classes had been largely fished out by 1988/89 when the catch was dominated by the 1986/87 cohort (aged 2 years).

87. The UK/Poland trawl survey (WG-FSA-89/6) in 1989 gave a stock biomass estimate of 21 069 tonnes. This compares to 50 414 tonnes for a similar survey in 1986/87 and 15 086 tonnes in 1987/88. As these three surveys all used the same bottom trawl nets the results are fairly comparable. However, they are all thought to under-represent the abundance of 1 and 2 year old fish which are probably found higher in the water column. An earlier survey in 1986/87 with a semipelagic trawl gave an estimate of stock size of 151 293 tonnes.

88. The series of catch and effort statistics from the Soviet fishery using bottom and midwater trawls was updated to 1988/89. Some Members expressed the view that the CPUE estimated for the last two years when the fishery has been regulated may not be directly comparable with the data from earlier years. Other Members stated that these CPUE are reliable enough to be used.

89. Yield-per-recruit calculations in last year's Working Group report (SC-CAMLR-VII, Annex 5) show that improvements in yield can be achieved by exploiting the fish at older ages than currently. The pattern of fishing has varied in recent years, with the effective age at first capture now at 2 years. An increase in the mesh size to 110 mm would theoretically increase the age of first capture to the optimum of 4 years (see paragraphs 30 to 36). This would also provide protection to the first time spawners, thereby increasing the spawning stock biomass, and also result in higher catch rates. For a value of natural mortality M = 0.35, it would increase the value of $F_{0.1}$ from 0.245 to 0.455. For a value of natural mortality M = 0.55, it would increase the value of $F_{0.1}$ from 0.384 to 0.766. F_{max} is not found for most of these cases.

90. There were two assessments of the stock of *C. gunnari* which are described in detail in WG-FSA-89/27 and WG-FSA-89/22 Rev. 1.

91. WG-FSA-89/27 based the assessment on the UK/Polish survey in 1988/89 and presented a calibration of the surveys made by the US/Polish teams in 1986/87 and 1987/88 which permitted a correction to be made for the possible under-representation of 1 and 2 year old fish in the surveys. Terminal F values were then derived for the corrected age compositions and VPA runs produced for two values of natural mortality, M = 0.35 and 0.55. For comments on the reliability of the biomass estimates from this survey prepared by the USSR Delegation, see Appendix 6.

92. WG-FSA-89/22 Rev. 1 used the Laurec-Shepherd method for tuning VPA to catch and effort data. An interpolation had been made for the year 1984/85 as data were considered by the authors to be unreliable. The interpolation was made on the basis of a rough calculation of the average of the preceding and succeeding year's CPUE. The only consistent time series was for October where CPUE data were available for each year (see Table 2). For comments on the reliability of the use of CPUE data in VPA tuning prepared by the UK Delegation, see Appendix 7.

Table 2: CPUE for *C. gunnari* (tonnes/hours) for USSR in Subarea 48.3, bottom trawl. Monthly catch of *C. gunnari* ε 75% of total catch (<75% in brackets).

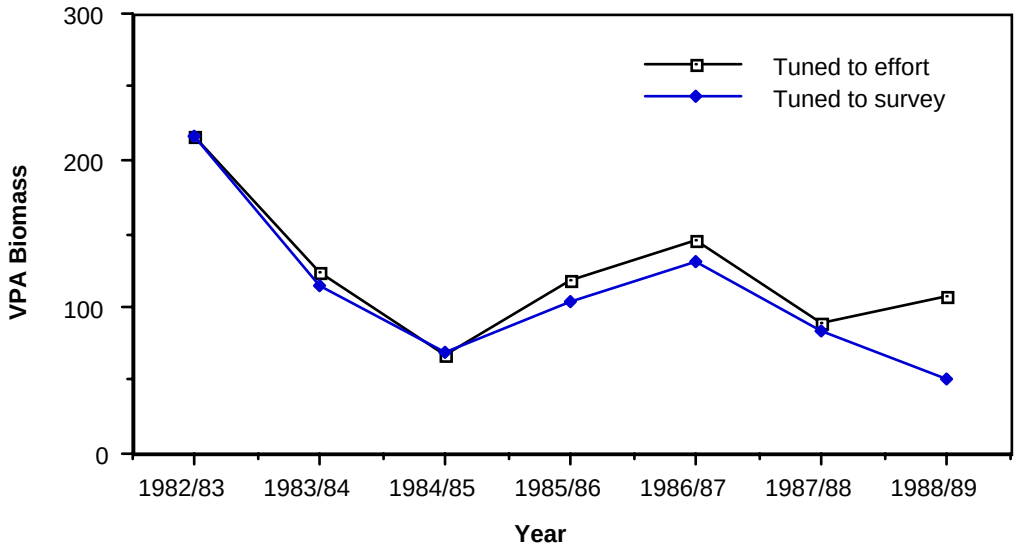
Split-Year	1983	1984	1985	1986	1987	1988	1989
July		2.372	4.442			1.675	
August						1.969	
September			(0.263)		2.875	(1.944)	
October	5.556	8.444	[0.261]*	2.358	2.992	2.018	3.207
November		4.820			(0.389)	(1.185)	(1.299)
December		(0.402)			3.117	(0.192)	
January	4.461	(0.408)			2.080	(0.387)	
February	10.740	6.828			2.255	(0.306)	
March	9.519	4.667			2.355	(0.594)	
April	7.683				2.268		
May	4.699			1.422	2.804		
June	1.457	4.955			2.821		
(July)		4.442					

* Interpolated value

93. The results of the two analyses can be readily summarised in Figure 1.

Figure 1

C. gunnari (Subarea 48.3)
VPA Biomass Analysis



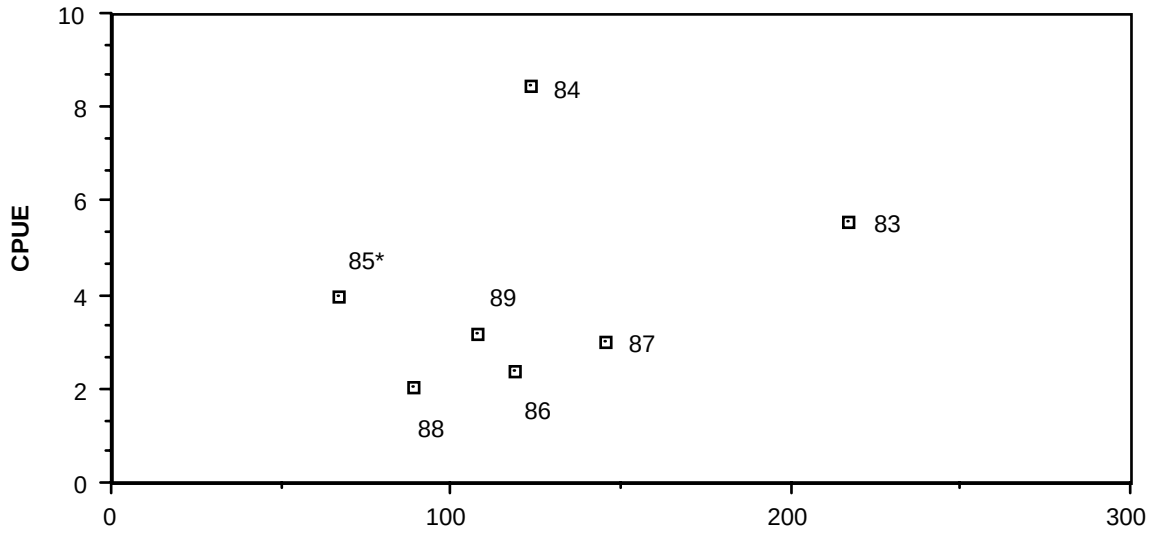
94. In essence, they differ only in the estimation of abundance for the 1988/89 season. There are problems with both techniques. The estimates of stock biomass from trawl surveys

have a high level of uncertainty, the coefficient of variation of the 1988/89 survey estimate was around 50%. Accordingly the stock size could be substantially above or below the estimate.

95. In principle, the tuning method should involve statistical averaging and hence decrease the level of uncertainty used. The method implicitly assumes a linear relationship between stock size and CPUE, however, while Figure 2 illustrates the relationship derived from the results presented in WG-FSA-89/22 Rev. 1 effectively similar results would be obtained from WG-FSA-89/27. There is a poor relationship, $r^2 = 0.1$, between CPUE and biomass and the interpolated value for 1985 does not appear to be reasonable. The view was expressed that a more appropriate comparison of the adequacy of the tuning method would be to compare the relationship between fishery mortality and effort. Another view was that there were sufficient free parameters in the method to ensure that this relationship was guaranteed to be close and that the comparison of CPUE and biomass was a sensible measure of the reliability of the results. The Working Group could not agree on a way of assessing the reliability of these results.

Figure 2

C. gunnari (Subarea 48.3)
Biomass and CPUE Relationships



VPA -
or Estimated Biomass

Management Advice

96. The large differences between the two analyses for the final year pose serious problems in presenting management advice to the Commission.

97. The TAC's at different target F levels that have been derived from the two assessments are given in Table 3. They differ substantially.

Table 3: TAC levels (tonnes) for *C. gunnari*, Subarea 48.3, calculated from assessments presented in WG-FSA-89/27 and WG-FSA-89/22 Rev. 1 (M = 0.35).

	Assessment presented in WG-FSA-89/27	Assessment presented in WG-FSA-89/22 Rev. 1
$F_{0.1} = 0.313$	6 545	22 235
$F_{max} = 0.645$	11 961	40 273

98. In essence, if the trawl survey and the analysis based on it is correct, a TAC based on the CPUE tuned VPA will lead to a substantial depletion of the stock.

99. If the analysis based on the CPUE tuned VPA is correct and a TAC is set on the basis of the trawl survey results, the stock will increase substantially.

Notothenia gibberifrons in Subarea 48.3

100. The total catch in 1988/89 decreased to 838 tonnes compared to the previous year when 5 219 tonnes were caught. The closure of the fishery around South Georgia from 4 November 1988 prevented further exploitation of *N. gibberifrons*. Catches in the 1988/89 year were mainly by-catch of the *C. gunnari* fishery, although directed fishing has occurred in previous years. Despite the reduction in catch in 1988/89, the catch was higher than the level corresponding to F_{max}, and nearly twice the level at $F_{0.1}$.

101. This species has many age classes in the population and has low productivity. The stock was much more abundant in the early 1970's than it is now. Trawl survey estimates in 1984/85 (15 762 tonnes) and 1986/87 (13 544 tonnes) were higher than the more recent surveys (7 189 tonnes in 1987/88, 8 510 tonnes in 1988/89). This series suggests that abundance was reduced by catches in 1986/87 and 1987/88.

102. The results of the trawl surveys were used to calibrate the VPA up to 1987/88. It is apparent from the VPA results that biomass has continued to decline. The VPA suggests that

current biomass is only 20% of the level during the mid 1970's. The VPA is also useful in determining the size of recruiting age classes to the population. A strong relationship between stock size and recruitment was found for the period 1978 to 1986 (Figure 3).

N. gibberifrons (Subarea 48.3)
Stock Recruitment Relationship

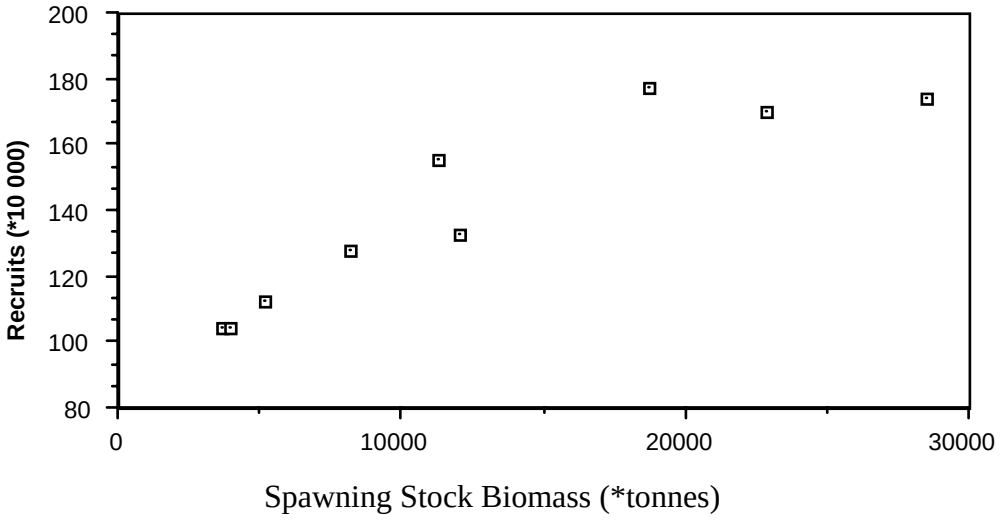


Figure 3: Number of 2 year old recruits each year from 1978 to 1986 plotted against the Spawning Stock Biomass (SSB) two years previously (from VPA results M = 0.125).

Management Advice

103. Because of the current stock size and the evidence for a stock recruitment relationship, it is inappropriate to recommend catches at the level of $F_{0.1}$. Catches should be kept to a minimum to increase the stock size as much as possible. The Working Group recommended that there should be no directed fishery for *N. gibberifrons* and by-catch should be restricted to not more than 300 tonnes.

Pseudochaenichthys georgianus in Subarea 48.3

104. Except in 1977/78 when 13 000 tonnes were reported, this species has usually been taken as a by-catch. Some additional catches in the late 1970's and early 1980's, however, may have been contained in categories 'channichthyids nei' and 'marine fishes nei'. Annual catches in the most recent five years were less than 1 000 tonnes. No catches were reported

in 1988/89. However, some catches were mentioned in the Member's Activities Report of the USSR (CCAMLR-VIII/MA/8).

105. Research vessel surveys in 1984/85 (FRG), 1986/87, 1987/88 (joint US/Polish) and 1988/89 (joint UK/Polish) have provided biomass estimates of 8 134 tonnes, 5 220 tonnes, 9 461 tonnes and 8 278 tonnes respectively which are all well below the level prior to exploitation and in the first years of fishing. Length frequency data indicate a considerable variation in year class strength which may explain some variation in the biomass estimates.

106. No VPA analyses could be attempted. Yield-per-recruit calculations assuming knife-edge recruitment have been carried out on data from the late 1970's available in scientific literature (Kock et al., 1985). These indicate a value of $F_{0.1}$ of around 0.3. Using a mean biomass of approximately 8 000 tonnes from the research vessel survey data this would correspond to a catch of approximately 1 800 tonnes. It is unlikely, however, that this catch could be taken without a substantial 'by-catch' of other species (*C. gunnari*, especially *C. aceratus* and *N. gibberifrons*) which would exceed the catch of *P. georgianus*.

Chaenocephalus aceratus in Subarea 48.3

107. Reported catches have been relatively small in all years, exceeding 2 000 tonnes only in 1987/88. Some additional catch, however, might have been contained in the categories 'channichthyids nei' and 'marine fishes nei' in the late 1970's/early 1980's. Biomass estimates obtained during research vessel surveys of the FRG (1984/85), joint US/Polish (1986/87 and 1987/88) and UK/Polish (1988/89) were 11 542 tonnes, 8 621 tonnes, 6 209 tonnes and 5 770 tonnes respectively. This indicates a continuous decline in biomass although catches in those years were only in the order of a few hundred tonnes. Biomass estimates are substantially lower than for the period prior to fishing or the early years of fishing.

108. No VPA calculations have been attempted. Applying earlier estimates of $F_{0.1}$ of around 0.16 (Kock et al., 1985) to the most recent biomass estimates of 6 000 tonnes gives a TAC for 1989/90 of approximately 800 tonnes. Given the rather even distribution of this species over the area and its co-occurrence with other species (e.g. *N. gibberifrons* and *P. georgianus*) it is unlikely that this catch could be taken without a substantial 'by-catch' of these species.

Management Advice for *Pseudochaenichthys georgianus* and *Chaenocephalus aceratus*

109. In view of the 'by-catch' problem associated with the catch of these species, it's likely detrimental effects on other species with a low stock size (e.g. *N. gibberifrons*) and an apparent stock-recruitment relationship in the case of *C. aceratus*, the Working Group recommended that no directed catches of these species be taken and by-catches be reduced to a minimum to allow the recovery of these stocks.

Notothenia squamifrons in Subarea 48.3

110. *N. squamifrons* inhabit the deeper parts on the shelf and the upper slope around South Georgia including Shag Rocks. Catches of this species have been reported as early as 1971/72 and almost each year thereafter. Annual catches usually vary between several hundred and a few thousand tonnes.

111. Despite the comparatively long catch history virtually no information on length and age of fish in the catch has been submitted to CCAMLR. Length compositions were available from the Spanish research vessel survey in 1986/87, the US/Polish surveys of 1986/87 and 1987/88 and the joint UK/Polish survey in 1988/89. Catches in 1986/87 consisted primarily of adults (> 30 cm) whereas in the other years juveniles (< 30 cm) predominated in the catches. Biomass estimates were 13 950 tonnes (1986/87), 409 tonnes (1987/88) and 121 tonnes (1988/89). These estimates, however, may be biased to an unknown extent as the surveys covered only part of the bathymetric range of the species.

112. Biological characteristics of the closely related Kerguelen population indicate that *N. squamifrons* is a long living species with a larger number of age classes present in the fishery. No information on recruitment or mortality estimates for this species at South Georgia was available to the Working Group to assess the state of the stock.

113. Due to the catch restrictions likely to be imposed on other species in the area, *N. squamifrons* may be of growing interest to the fishery in the near future. Information on length and age of historical and current commercial catches as well as biomass estimates from research vessel surveys are urgently needed to assess the state of this stock.

Management Advice

114. As the status of this stock is unknown, the Working Group was unable to recommend a TAC.

Dissostichus eleginoides in Subarea 48.3

115. Catches of *D. eleginoides* have been reported since 1976/77. Until 1985/86 they made up several hundred tonnes annually except in 1977/78 when 1 920 tonnes were taken. Most of the catches were probably obtained in the Shag Rocks/Black Rocks area where the species is a common by-catch in the fishery on *P.b. guntheri.* Since 1985/86 annual catches have gradually increased from 564 tonnes to 4 138 tonnes in 1988/89. Up to 1987/88 the fishing was trawl-based. In 1988/89 longlining was introduced and almost all catches were reported to have been taken by that fishery.

116. No information on the length and age composition from the commercial catches (past and recent) has been available to the Working Group. Length compositions from research vessel surveys of the FRG in 1975/76, 1977/78 and 1984/85 indicate that the trawl fishery was almost entirely based on juvenile specimens with a few adults present in the catches. As longlining is highly size selective it is likely that the proportion of adults in the catches has increased substantially.

117. Biomass estimates were available from recent surveys of the FRG (1984/85), joint US/Polish (1986/87 and 1987/88) and UK/Polish (1988/89). They were 8 159 tonnes (1984/85), 1 208 tonnes (1986/87), 409 tonnes (1987/88) and 306 tonnes (1988/89). Estimates, however, are not directly comparable as the 1984/85 value included the Shag Rocks area which was omitted during the other surveys. As the surveys covered only the upper part of the bathymetric range of the species, biomass estimates, even that including Shag Rocks, are likely to be underestimates.

118. The species is a long living fish which may reach 25 to 30 years. *D. eleginoides* becomes mature at 8 to ten years. The slow growth rate and long life span implies that yield-per-recruit and sustainable yield as a proportion of unexploited biomass are very small.

119. Due to lack of relevant information from commercial catches and certain gaps in the knowledge of the biology of the species, the Working Group was unable to assess the state of

the stock. This presents problems as the catch has increased by a factor of 4 in the last two years (see paragraphs 8 and 9).

Management Advice

120. Even in the absence of information on the stock size it is possible to calculate the yield for different levels of the unexploited stock size (using, for example, the Gulland formula yield equals half the product of mortality and unexploited biomass). Natural mortality is estimated to be 0.06 (Kock, Duhamel and Hureau, 1985).

Biomass	Sustainable Yield
8 000 tonnes	240 tonnes
40 000 tonnes	1 200 tonnes

As the figure of 40 000 tonnes is some five times the stock estimate obtained by the FRG survey in 1984/85, this could be considered as a reasonable upper limit until further data become available.

Patagonotothen brevicauda guntheri in Subarea 48.3

121. Total catch was regulated by a TAC of 13 000 tonnes in 1988/89 (Conservation Measure 12/VII). This was intended to keep the catch at a level similar to that of the previous year. Total reported catch was 13 016 tonnes taken by the Soviet directed fishery in the area of Shag Rocks. Age composition data show that the catch was largely based on ages 2 to 4 as in previous years.

122. Catch and effort statistics were available from Soviet BMRT vessels from 1978/79 to 1988/89 and a biomass estimate of 81 000 tonnes was available from the Spanish survey in 1986/87.

123. There is much uncertainty about the rate of natural mortality for this species, however, it is unlikely to be higher than 0.7 (see Appendix 5). Yield-per-recruit calculations were carried out using two different values of natural mortality. For M = 0.48, $F_{0.1}$ was equal to 0.559, while for M = 0.63, $F_{0.1}$ was calculated at 0.783.

124. An assessment was presented at the meeting (WG-FSA-89/21) using the catch and effort data to calibrate the VPA. Natural mortality was assumed to be 0.9 in this assessment. Problems with the weight at age data used in the last three years resulted in overestimation of the biomass in these years. The assessment indicates a downward trend in stock size over the 11 year time series from 160 000 to about 100 000 tonnes. The biomass estimate for 1988/89 was 103 000 tonnes which indicated a decline in stock size over the time series from about 160 000 tonnes from 1978 to 1980. This effect may in part be due to the high value of natural mortality used in the assessment, which causes the estimates of biomass and recruitment in the early years to be inflated. This was shown to be the case in SC-CAMLR-VII/BG/18.

125. Assessments were also carried out using the biomass estimate from the trawl survey to calibrate the model. The partial recruitment pattern in the last year and assumed terminal fishing mortality were varied by trial and error, until the VPA biomass estimate in 1986/87 matched the trawl survey estimate of 81 000 tonnes. Two alternative runs of the model were completed with natural mortality values of 0.48 and 0.63 respectively. From these runs it is apparent that the projected biomass in 1989/90 is particularly sensitive to the value assumed for M.

126. It is possible to look at the effect on recruitment and projected biomass of varying natural mortality rates.

VPA Calibration Technique	Natural Mortality	Biomass 1989/90 (tonnes)	Proportion of biomass from 1 and 2 year old fish
Trawl survey 1986/87	0.48	130 000	27%
	0.63	90 000	50%
Catch and effort data	0.9	106 000	68%

As the rate of natural mortality is increased, the mean level of recruitment estimated in the VPA is increased. Therefore the projections depend more on the assumptions concerning recruitment for higher values of M. Given the paucity of independent information on the stock and the uncertainty over M, it is difficult to choose between the alternative interpretations of historical stock size.

Management Advice

127. Uncertainty in the value of natural mortality and the lack of any time series showing trends in biomass levels prevent accurate assessment of the current stock size. In the absence of reliable estimates of natural mortality to evaluate the alternative analyses and in the absence of information on current stock size, catch levels should not be based on VPA results, using $F_{0.1}$ calculations and assumptions about recruitment. The current status of this stock is unknown.

Subarea 48.2 (South Orkney Islands)

128. Catches in Subarea 48.2 were only substantial in the late 1970's when two very abundant year classes of *C. gunnari* were fished (Table 4). Most of these fish, in particular in 1977/78, were still juveniles. Since then catches of all species have been usually in the order of a few thousand tonnes except in 1982/83 – 1983/84 when 18 412 and 15 056 tonnes were taken.

Table 4: Catch by species in Subarea 48.2

	Champsocephalus gunnari	*Notothenia gibberifrons*	*Notothenia rossii*	Pisces nei	Total
1978	138 895	75	85	2 603	141 659
1979	21 439	2 598	237	3 250[1]	27 524
1980	5 231	1 398	1 722	6 217[2]	14 548
1981	1 861	196	72	3 274	5 403
1982	557	589		2 211	3 357
1983	5 948	1		12 463[3]	18 412
1984	4 499	9 160	714	1 583	15 956
1985	2 361	5 722	58	531	8 672
1986	2 682	341		100	3 123
1987	29	3		3	35
1988	1 336	4 469			5 805
1989	532	601		1	1 134

[1] Mainly Chaenocephalus aceratus
[2] Pseudochaenichthys georgianus and unidentified Nototheniids and Channichthyids
[3] Unknown species

129. The only species for which catch figures have been submitted were *C. gunnari* (532 tonnes) and *N. gibberifrons* (601 tonnes). Other species present in the catches have been *N. kempi*, *P. georgianus* and *N. rossii* (CCAMLR-VIII/MA/8) but catches of these species have not been specified in the STATLANT 08A and 08B forms.

130. No new data (length compositions, age length keys, biomass estimates) were available to the Working Group, therefore the Working Group was unable to carry out new assessments.

131. An assessment provided by Kock and Köster (SC-CAMLR-VIII/BG/18) based on a limited time series from 1977/78 to 1985/86 showed a substantial downward trend in the stock of *C. gunnari* since the onset of fishing. Stock size seems to be less than 10 000 tonnes at present. Biomass estimates from research vessel surveys in 1984/85 (FRG) and 1986/87 (Spain) were 3 669 and 1 179 tonnes respectively. From 1982/83 onwards the VPA suggest that recruitment was obviously low although there are some indications that recruitment values obtained from the VPA may be artefacts.

132. An assessment on the stock of *N. gibberifrons* during last year's meeting, using a rather poor database, did not indicate a severe impact of fishing on the stock since exploitation started in 1978/79, in particular if natural mortality is low.

133. To provide improved assessments of both stocks, *C. gunnari* and *N. gibberifrons*, length and age data from the catches since the mid 1980's are needed. An estimate of current stock biomass from a research vessel survey is also highly desirable.

Management Advice

134. Due to the lack of data the Working Group was unable to recommend a TAC for either species. In case, however, the recruitment failure in *C. gunnari* is real, the stock should be protected until evidence to the contrary is available.

Subarea 48.1 (Antarctic Peninsula)

135. Catch history in the Peninsula region has a similar history to that around the South Orkney Islands: large catches were obtained in the late 1970's when concentrations of *C. gunnari* (mostly juveniles) (1978/79), *N. rossii* (1979/80) and *Chaenodraco wilsoni* (1978/79 and 1979/80) were exploited. Catches have only been sporadic since then. Reported catches in 1988/89 were 140 tonnes of *C. gunnari* and 665 tonnes of *N. gibberifrons* (Table 5).

Table 5: Catch by species in Subarea 48.1

	Champsocephalus gunnari	*Notothenia gibberifrons*	*Notothenia rossii*	Pisces nei	Total
1979	35 930	3 280	470	12 516[1]	52 196
1980	1 087	765	18 763	5 536[1]	26 151
1981	1 700	50		4 266[2]	6 016
1982					
1983	2 604			16	2 620
1984					
1985					
1986					
1987	75	55		7	137
1988		1		1	2
1989	140	665		17	822

[1] Mainly Chaenodraco wilsoni
[2] Unknown species

136. No information on age and length in the catches was available to the Working Group. Due to the sporadic catches in recent years and the resulting significant gaps in the time series of length and age data, the Working Group was unable to provide any new assessments of the stocks.

137. Elephant Island is one of the most important fishing grounds in the Peninsula subarea. Biomass estimates obtained from research vessel surveys of the FRG in 1984/85, 1985/86 and 1987/88 in the area were in the order of 1 000 tonnes for *C. gunnari*. This and the low catches, if any, in the most recent years does indicate that stock size is obviously at a low level. Biomass of *N. gibberifrons* seems to be higher. It was estimated at 25 000 tonnes during an FRG research vessel survey in 1984/85.

138. Due to the sporadic nature of the fishery it would be extremely difficult to reconstruct the historical fishing pattern in *C. gunnari* by VPA analysis. One way to overcome this may be to combine age length data and biomass estimates of this species from Subareas 48.1 and 48.2 as has been done by Kock and Köster (SC-CAMLR-VIII/BG/18).

139. To improve assessment of the stock of *N. gibberifrons* age and length data from the recent catches are needed. A research vessel survey to provide a current biomass estimate is also desirable.

Management Advice

140. Due to the absence of data, the Working Group was unable to recommend a TAC.

Statistical Area 58

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

142. No results from mesh selectivity investigations are available for Statistical Area 58. Such results are necessary to formulate recommendations based on yield-per-recruit analyses of major stocks.

143. A summary of catches reported from Statistical Area 58 is given in Table 6. 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 these stocks, but some information is available from other subareas discussed at the Working Group's last meeting (SC-CAMLR-VII, paragraphs 69 and 70, pages 114 to 116).

Subarea 58.4

144. The reporting of catches of *P. antarcticum* in Subarea 58.4 is still not sufficiently detailed to establish where such catches are taken and whether these are from one or more stocks. Both fine-scale reporting and analysis of catch levels is required to establish the distribution of *P. antarcticum* stocks in Subarea 58.4 as a whole. Some reported catches in 1985 and 1986 indicate possible commencement of a fishery for the species but available data are insufficient to assess stocks. Catch levels since 1987 have, however, been low.

145. Review of available catch statistics for Divisions 58.4.1 and 58.4.2 indicate possible incorrect reporting of catches. For example, it is probable that fish reported as *C. gunnari* for 1980 and for 1985 to be present in the catch summaries (SC-CAMLR-VIII/BG/2, pages 47 to 48) 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.

Division 58.4.4 (Ob and Lena Banks)

146. Catches of *N. rossii*, *N. squamifrons*, and *D. eleginoides* are reported from the whole of Subarea 58.4 (see Table 6). Only *N. squamifrons* has been caught in significant amounts to date.

Notothenia squamifrons in Division 58.4.4

147. Catches, shown in Table 6, are variable and appear to be largest when less effort is required in the Kerguelen fin fishery or the krill fishery further to the South. It appears that the fish on these two seamounts should be assessed as separate stocks, but unfortunately the historical total catch data submitted to CCAMLR cannot be apportioned between them.

148. Some historical and recent data have been submitted by the USSR giving length frequencies, age/length keys and age compositions separately for Ob and Lena Banks. The USSR also reported in their Member's Activity Report the results of trawl surveys which gave biomass estimates of 21.25 ± 11.44 and 12.76 ± 4.34 thousand tonnes for Ob and Lena Banks respectively. The Working Group recommended that the basic survey data and details of the survey design be made available for consideration and analysis at the meeting of the Working Group in 1990.

149. The lack of separate catch data for each seamount precluded VPA assessments. There was insufficient information on which to assess current recruitment.

Management Advice

150. The Working Group drew attention to the increases in catches over the last two seasons. Lacking an assessment the Working Group is unable to give specific management advice. The submission of the recent survey data and historical catch data is recommended in order to carry out the necessary assessment at next year's meeting.

Table 6: Total catches by species and subarea in Statistical Area 58. Species are designated by abbreviations as follows: ANI (*Champsocephalus gunnari*), LIC (*Channichthys rhinoceratus*), TOP (*Dissostichus eleginoides*), NOR (*Notothenia rossii*), NOS (*Notothenia squamifrons*), ANS (*Pleuragramma antarcticum*), MZZ (Unknown), SRX (*Rajiformes spp.*).

Split	ANI			LIC	TOP				NOR			NOS			ANS		MZZ			SRX
Year	58	58.4	58.5	58.5	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	
1971	10231				XX				63636			24545					679			
1972	53857				XX				104588			52912					8195			
1973	6512				XX				20361			2368					3444			
1974	7392				XX				20906			19977					1759			
1975	47784				XX				10248			10198					575			
1976	10424				XX				6061			12200					548			
1977	10450				XX				97			308					11			
1978	72643		250	82	196	-	2	-	46155			31582		98	234		261			
1979	*101				3	-	-	-				1307					1218			
1980		*14	1631	8		56	138	-			1742		4370	11308				239		
1981			1122	2		16	40	-		217	7924		2926	6239				375	21	
1982			16083			83	121	-		237	9812		785	4038		50		364	7	
1983			25852			4	128	17			1829		95	1832		229		4	17	1
1984			7127			1	145	-		50	744		203	3794					**611	17
1985		*279	8253			8	6677	-		34	1707		27	7394		966		11	7	4
1986		*757	17137			8	459	-		-	801		61	2464		692				3
1987		*1099	2625			34	3144	-		2	482		930	1641		28		22		
1988		*1816	159			4	554	488		-	21		5302	41		66				
1989		*306	23628			35	1630	21			245		3660	1825		47		23	24	

* 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 58.5

Division 58.5.1 (Kerguelen)

Champsocephalus gunnari in Division 58.5.1

151. There are two separate stocks in Division 58.5.1, Skif Bank and the Kerguelen Shelf. No fishing occurred on Skif Bank in the 1989 season and no reassessment has been undertaken.

152. On the Kerguelen Shelf catches have been variable and closely reflect a three year cycle in recruitment over the last decade. Over this period, fishing has occurred on only one cohort at a time, with large catches taken as the fish reach three years of age. This occurred in 1983, 1986 and again in 1989.

153. Length and age data are available from both Skif Bank and the Kerguelen Shelf, along with CPUE data since 1981. Data were available from two surveys carried out by the USSR in 1987 and 1988. The data from the 1987 cruise were not used because the fish in the current cohort were at that time in the pelagic phase. The 1988 survey data were re-stratified to reduce bias arising from non-random sampling in the survey. A full description of reasons for re-stratifying and the results from the subsequent analyses are given in Appendix 8. The estimate of biomass for the current cohort last year, at age three, was 244 thousand tonnes (which can be compared with the estimate of 429 thousand tonnes obtained before re-stratifying).

154. The CPUE data since 1980, in terms of number of fish caught from each cohort per hour of fishing, are shown in Figure 4. These data indicate that it is unlikely that the current cohort is substantially stronger than its two predecessors, and if anything it may be slightly weaker. However, it is possible that some form of non-linear relationship between CPUE and biomass may be masking differences between the strengths of the various cohorts.

Catch Per Unit Effort for *C. gunnari*
on the Kerguelen Shelf

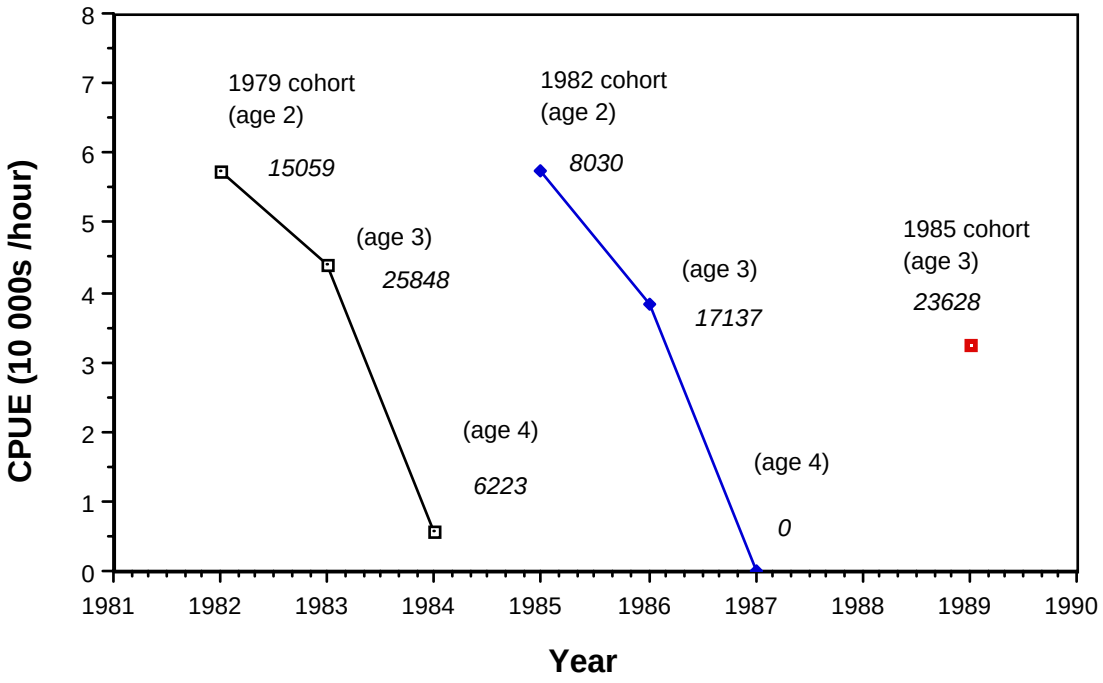


Figure 4: Yearly values of CPUE index for the *C. gunnari* Kerguelen Shelf stock in the northeast sector of Division 58.5.1 (Duhamel, 1987). Years are conventional notation for split-years. Cohorts and ages are labelled. Numbers in italics are catch (t).

155. The cohort analysis carried out at last year's meeting was updated as far as possible, and this is shown in Table 7. The analysis assumes that each cohort was extinguished by fishing by age five. The resultant cohort biomass estimates for the previous cohorts at age 2 (the same as the age of the most recent cohort at the time of the survey) cover the range 23 to 45 thousand tonnes.

Table 7: *C. gunnari*, Division 58.5.1 updated cohort analysis. Calculation utilising mean length at age and length weight relationship $W_t = 0.0088\ L_t^{3.4163}$ from Duhamel (1987) and WG-FSA-89/9.

Natural Mortality 0.35

Catches (Numbers of fish)

	Ages →			
Year	1	2	3	4
1981	3 624 733	0	0	0
1982	0	209 330 540	0	0
1983	0	0	197 917 300	0
1984	0	0	0	30 757 800
1985	0	99 665 427	0	0
1986	0	0	122 514 360	0
1987	0	0	0	0
1988	0	1 182 608	0	0
1989	0	0	169 942 929	0

Fishing Mortality

	Ages →			
Year	1	2	3	4
1981	0.005	-	-	-
1982	-	0.49	-	-
1983	-	-	1.86	-
1984	-	-	-	NA
1985	-	0.52	-	-
1986	-	-	NA	-
1987	-	-	-	-
1988	-	-	-	-
1989	-	-	?	-

Stock Abundance (Numbers of fish)

	Ages →			
Years	1	2	3	4
1981	920 856 596	-	-	-
1982	-	645 873 868	-	-
1983	-	-	279 415 631	-
1984	-	-	-	30 757 800
1985	-	292 582 215	-	-
1986	-	-	122 514 360	-
1987	-	-	-	-
1988	-	-	-	-
1989	-	-	NA	-

Table 7 continued

Stock Biomass 1000's tonnes

	Ages →			
Years	1	2	3	4
1981	-	-	-	-
1982	-	45 238	-	-
1983	-	-	35 709	-
1984	-	-	-	6 223
1985	-	23 251	-	-
1986	-	-	1 7137	-
1987	-	-	-	-
1988	-	?	-	-
1989	-	-	?	-

156. It is therefore difficult to reconcile the biomass estimate in 1988 with the lack of apparent difference in CPUE between the recent cohort and its predecessors, which were estimated to have much lower biomasses. The range of possible explanations includes, upward bias in the survey estimate, non-linearity in the CPUE, or downward bias in the cohort analysis. The survey estimate could still be biased upward because of failure to fully account for non-random sampling in the stratification, or because of underestimation of the area swept by the surveys, possibly due to herding effects by the trawl doors and warps.

157. Conversely, the cohort estimates would be biased downwards if the exhaustion of the cohorts was due to high rates of natural mortality after age four rather than by fishing. It was suggested that this could be caused by spawning stress, which could result in the disappearance of older fish that escaped the fishery but died after spawning. The existing data are unable to show which of the explanations is the more likely.

158. A further survey is recommended for 1990 to assess the strength of the incoming cohort. This should be carefully designed to take into account the information now available on the distribution of the stock over the shelf area. Further re-analysis of the 1988 survey, with fine scale stratification using density concentration information is recommended (see Appendix 8). Studies on the spawning grounds are recommended to help determine whether this species is subject to high post-spawning mortality. Age/length keys and length frequency data from catches prior to 1980 are required for a full stock assessment.

Management Advice

159. Because the stock in the last decade has consisted of only one cohort every three years it should be managed with caution until further information can be collected which could determine whether high post-spawning or similar natural mortality might explain the exhaustion of the cohorts. It would be prudent to assume, on the basis of the CPUE data, that the current cohort in the fishery is of comparable strength to the preceding strong cohorts of 1979 and 1982. Thus, the biomass of the 1985 cohort during the 1989 season could have been of the order of 23 to 45 thousand tonnes, and thus substantially affected by the catch of 23 thousand tonnes. A low level of fishing mortality should help to resolve the question whether high natural mortality is the cause of cohort exhaustion. If substantial survival proves possible in fish of the current age, it will have the desirable effect of increasing the number of year classes in the fishery and could lead to cohorts recruiting to the fishery more frequently than the current three year interval. Accordingly, the catch level in 1990 could be no higher than occurred on the preceding cohorts at age four, that is, in the range of 0 to 6 000 tonnes.

Dissostichus eleginoides in Division 58.5.1

160. The fishery is trawl based, occurring on a concentration in a relatively small area on the west coast in water 300–600 m deep. Large catches began in 1985 when this concentration was discovered. In 1986 and 1988, effort in this fishery was low because of the diversion of effort to fishing for *C. gunnari*. In years when the fishery was significant, the catch has declined from 6 677 tonnes to 1 630 tonnes/year.

161. The biomass of *D. eleginoides* was estimated from the USSR 1988 survey (WG-FSA-88/22 Rev. 1) to be, after re-stratification, 27 200 tonnes in the total area around Kerguelen Island. Of this, 19 000 tonnes was estimated to be in the western sector.

162. CPUE data are available since 1984/85 (see Table 8).

Table 8: CPUE data from the fishery for *D. eleginoides* on the Kerguelen shelf (Division 58.5.1)

	1984/85	1985/86	1986/87	1987/88	1988/89	
CPUE	2.50	1.41	1.79	0.78	1.64	(tonnes/hour)

163. No estimates of fishing mortality for this species are available.

164. No data are available concerning trends in recruitment for this species.

165. A lack of information on various stock parameters makes it very difficult to assess the state of this stock, in particular length-frequency and age/length data are needed.

Management Advice

166. *D. eleginoides* is a long-lived species with probable low productivity. An assessment of the stock is urgently required to estimate the level of catch to stabilise the stock. Adding the cumulative catch to the survey estimate gives a rough estimate for the unexploited biomass of 38 000 tonnes. Applying the Gulland rule (see paragraph 120) to this estimate gives a TAC of 1 100 tonnes.

Notothenia rossii in Division 58.5.1

167. 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. 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.

168. No new data derived from catches have become available since 1988 because of the prohibition of directed fishing on this stock. A biomass estimate of 13.8 thousand tonnes was obtained from re-stratifying the USSR survey (WG-FSA-88/22, Rev. 1).

169. A program to study pre-recruits in coastal waters has been conducted since 1982. This program will assist in stock assessment and has been useful in detecting changes in the abundance of the juvenile portion of the stock. Regular experimental fishing with trammel nets has been used to detect variation in abundance of this part of the stock, based on catches of age classes 2 and 3. A gradual increase in abundance has been observed from 1984 to 1988 with an average growth rate in year class strength of 36.3% (WG-FSA-89/9). An increase in recruitment to the mature shelf stock could be detectable in a few years.

Management Advice

170. Conservation measures (no directed fishery) will be continued into the beginning of the 1990's for the adult stock. Trends in the abundance of juvenile part of the stock need to continue to be monitored. Biomass surveys will be required to establish that the stock has made a substantial recovery prior to any resumption of exploitation.

Notothenia squamifrons in Division 58.5.1

171. It is not possible to separate catches taken in Subarea 58.5 from those in Subarea 58.4 prior to the declaration of the EEZ around Kerguelen by France in 1978. Since 1980 there has been a steady decline in catches, but with a small increase in 1984 and 1985. This is probably the result of redirection of fishing effort in relation to a low level abundance of *C. gunnari*, the main target species of the Kerguelen fishery. The catch in 1988/89 was substantially larger than in 1987/88 (see below) but comparable with 1986/87. Small catches of *N. squamifrons* were taken from Kerguelen-Heard Bank during 1988/89.

172. Comprehensive length frequency data are available from the commercial fisheries. Other available data include indices of abundance from catch and effort data (WG-FSA-89/9) and survey estimates of stock biomass in 1987 and 1988 (WG-FSA-88/22 Rev. 1). Results from VPA analyses of data after 1980 (see SC-CAMLR-VII, paragraph 101, page 131) and Soviet stock assessments of various stock parameters (age, growth and mortality) for the years 1969–1972 and 1980–1986 (WG-FSA-89/16 and 17) are also available.

173. A lack of both length frequency and length-at-age data in the CCAMLR database precluded sensible VPA's, particularly for the period when the stock was most heavily depleted (1971-1978).

174. Fishing mortality affects age classes 5+, with the age of maturity being 9 years. The wide range of values for natural mortality (Duhamel, 1987; WG-FSA-89/17) obtained to date and the uncertainty concerning the longterm trajectory of the stock make it extremely difficult to assess fishing mortality.

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

176. Both CPUE and catch level data indicate that the stock remains at a low level. Catches in 1986/87 and 1988/89 have been less than the catch limits for these two seasons. CPUE index values of abundance south and southeast of the Island confirm that there has been a decreasing trend in the stock biomass. However, in 1988/89 this downward trend was not evident (WG-FSA-89/9, Figure 7). When taking into account the annual areal distribution of the stock this apparent recovery of the stock is small. It would appear therefore that the enforced restriction of fishing in 1987/88 is unlikely to have any longterm affect on this already heavily exploited stock.

177. Data are required on the following:

- recruitment;

- mesh selectivity to improve management advice based on yield-per-recruit calculations;

- additional surveys of stock biomass should be undertaken in order to improve currently available knowledge of stock abundance. In particular, surveys should be undertaken prior to any future exploitation of unexploited stocks in Division 58.5.1 (see paragraph 171).

178. In order to improve assessments of the stock, including trends in exploitation, it is critically important that the following data be submitted to CCAMLR:

- length frequency and age/length data for the *N. squamifrons* fishery in Division 58.5.1 from 1972 to the present. Such data should be provided for individual years as far as possible.

- catch data prior to the declaration of an EEZ around Kerguelen by France (3 February 1978) should be separated for Division 58.5.1 (as done in WG-FSA-89/16 and 17) and re-submitted.

- consolidate the catch data for Subarea 58.5. In particular care should be taken to ensure consistency between the data submitted to CCAMLR and data available to or held by individual members.

- all length data reported should only be total length to avoid possible confusion in the future.

Management Advice

179. A lack of information on recruitment patterns makes it difficult to provide objective predictions of future trends in the stock. However, given observed exploitation trends and the present status of the stock, protection of the *N. squamifrons* stock in Division 58.5.1 will be facilitated by closure of the directed fishery for this species. Similarly, recovery of this already depleted stock will be facilitated.

180. Since only about 15% of the current total stock biomass is comprised of adults and that fishing on other species in this area will continue, the setting of acceptable by-catch levels appears necessary. As the current quota levels have not been attained, it is recommended that future by-catch levels should be substantially lower than present quotas.

Division 58.5.2 (Heard Island)

181. 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 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.

182. Additional data on all exploited stocks of Channichthyids in Statistical Area 58 as a whole are still required urgently for assessment purposes. Such data should be submitted to and considered at the next meeting of the Working Group.

GENERAL ADVICE TO COMMISSION

183. In addition to the recommendations made to the Commission based on assessment of individual stocks, a number of other matters were raised by the Commission at its last meeting (CCAMLR-VII, paragraphs 114 to 116). These are covered in this section.

184. The possible catch, biomass and spawning stock biomass trajectories for the *C. gunnari* stocks are dealt with elsewhere in the report. The problem of by-catch of depleted species in the directed fishery for *C. gunnari* is different for the two main areas, Subareas 48.3 and Division 58.5.1.

185. In Subarea 48.3 a rough idea of the extent of the problem can be noted from the reported catches of *N. gibberifrons* and *N. rossii* from the USSR operations in October and November 1988. The catch of *C. gunnari* was 21 359 tonnes and the by-catch of *N. gibberifrons* was 838 tonnes and that of *N. rossii*, 152 tonnes.

186. Ideally, data on a haul by haul basis are needed to assess this problem but were not available. In their absence the simple pro rating of the catch figures above are the only guide the Working Group could give (i.e. if the catch doubled, a reasonable expectation would be for the by-catch also to double).

187. In Division 58.5.1 there appears to be no by-catch problem as the fishery operates on different species in different areas.

188. Two papers (SC-CAMLR-VIII/BG/42 and 47) available to the Working Group dealt with the implications of the operation of a complete ban on fishing for *C. gunnari* or a very low value for fishing mortality followed by a higher level. The papers had focussed on *C. gunnari* in Subarea 48.3. In general terms both papers indicated that there were benefits from a closure of the fishery or the operation of a low fishing mortality. Both papers were based on the assumption that the stock level was around that presented in WG-FSA-89/27. In this situation, a low fishing mortality results in decreased variability in catch and stock levels with little sacrifice in expected yield. A closure of the fishery would substantially decrease the probability that the stock would fall below any specified critical level.

189. No analysis of this type had been done for the *C. gunnari* stock in Division 58.5.1, however, the stock status is addressed in paragraphs 151 to 159.

Notothenia gibberifrons and *Notothenia rossii*

190. Four questions were asked by the Commission concerning these stocks. The Working Group's responses are given below.

> '(a) Is the abundance resulting from F_{max} a satisfactory measure of the GNAI population level for these species or should another measure be used?'

191. In the case of these two species a decline in stock size has been associated with a decline in recruitment. This means that the operation of a high constant fishing mortality is

likely to lead to stock depletion. The calculation of F_{max} is dependent on a particular equilibrium assumption of constant recruitment and hence is violated when recruitment declines. The priority for these stocks should be to facilitate recovery to a level where recruitment improves.

> '(b) What factors, other than directed or incidental catching, might be impeding their recovery?'

192. In addition to the decline in recruitment referred to above, juvenile *N. rossii* may be experiencing increased predation from fur seals. Information on this topic is qualitative not quantitative and the Working Group did not feel it could comment further, but recommended that advice be sought from SCAR. The central problem is that recruitment is lower than in earlier years. This low recruitment is associated with low spawning stock sizes and in the absence of other information is the most likely cause.

> '(c) What might be the effect, in terms of the total catches of these species, of the changes of fishing gear suggested for the *C. gunnari* fishery in SC-CAMLR-VII, paragraph 3.17?'

193. The use of a semi pelagic or midwater trawl for *C. gunnari* would reduce the by-catch of these two species. However, this would be at the expense of targeting on the younger age groups of *C. gunnari*. WG-FSA-89/27 suggests that around seven times more fish at age 1 and 1.7 times fish at age 2 were likely to be distributed above the bottom, in the water column. Assuming the mesh size currently in use, the age group 2 especially, may still be taken in midwater trawls.

194. An additional point made was that major shifts in the mode of operation of the fishery would present problems of stock estimates using CPUE based methods as the time series of catch and effort would be limited.

> '(d) What will be the likely results of keeping catch levels as high as four times the TAC calculated for F_{max} on the capability of the exploited part of the stock of *N. gibberifrons* to recover in 20 to 30 years?'

195. The stock is likely to be driven to extinction if such catch levels are retained for several years.

Mesh Size Regulations

196. Specific recommendations on mesh size are discussed in the report (paragraphs 29 to 40) and summarised in paragraph 36.

197. The Working Group wished to add that mesh regulations, even if they permitted the escape of young fish, were insufficient to ensure management of the stocks for sustainable yield. They would only be successful when operated with other management measures involving the control of fishing effort. It was noted that for certain stocks elsewhere in the world, high mortality of fish passing through nets had been observed.

Area/Season Closures to Protect Young Fish and Spawning Grounds/Aggregations

198. The current closed season is from 1 April to 20 November. SC-CAMLR-VIII/BG/16 examined the reproductive behaviour of *C. gunnari* and other Antarctic fish and suggested that the closed season should be extended to operate from 1 March to the end of the Commission meeting.

199. The Working Group agreed that a closed season was desirable and that the proposed extension was reasonable. However, an operational date which would not end until after the Commission's Meeting and would not tie the measure to the timing of the Commission's meeting, is required.

200. The Working Group noted that if mesh regulation were introduced to protect immature fish, the need for a closed season would be reduced.

Area Closures

201. The Working Group had no additional information on which to base particular recommendations to protect spawning grounds and aggregations.

Stock Levels where Recruitment may be Impaired

202. In two stocks, *N. rossii* and *N. gibberifrons* recruitment declines have been detected. In other stocks where declines in recruitment has not been detected a useful working definition would be the lowest spawning stock biomass estimated for the stock. Hence, if the current spawning stock was the lowest observed, the management should aim to ensure that future stock levels do not drop below this level.

General Conservation Policy

203. There are a number of significant uncertainties associated with the assessment of all stocks considered. For this reason, the Working Group considered that TAC's should be set for one year only, that management should ensure that target fishing mortality levels would not involve the reduction of spawning stock to levels where recruitment might be impaired.

204. Certain stocks have been depleted to very low levels and the potential by-catch from fisheries directed at less depleted species could endanger their recovery. In this context, the large level of the krill fishery, around 200 000 tonnes in Subarea 48.3, means that even a very small by-catch of larval or young fish in krill catches could be sufficient to endanger recovery of depleted species. This problem is potentially very serious and data on this aspect are limited, however, some data are published. The Working Group recommended that sampling on board krill vessels should be instituted to assess the level of abundance of fish larvae and young fish in the vicinity of krill concentrations. Methods for such sampling were developed during the BIOMASS program.

205. The Working Group draws the attention of the Scientific Committee to the stocks that it was not able to assess because of the lack of data. It recommends that the Scientific Committee considers ways to encourage the collection and submission of the required data.

206. Biomass surveys are central to many of the assessments carried out by the Working Group. The high sensitivity of the biomass estimates from the USSR survey conducted on the Kerguelen Shelf shows that it is crucial in interpreting survey results to have full details of the conduct of the surveys. The Working Group recommends that full details of the survey design and the haul by haul data should be made available when the results of surveys are submitted.

FUTURE WORK

Data Requirements

207. A summary of requests for data made by the Working Group in this and previous reports is attached as Appendix 9.

208. The provision of a datasheet for recording details of longline fisheries was specifically addressed by the Working Group. The requirement for detailed recording of this fishery, especially directed at *D. eleginoides* was identified in paragraphs 8 to 12.

209. The Secretariat was asked to prepare draft reporting sheets for the longline fishery. The Working Group recommended that reporting of these data be considered of high priority and should be implemented for the current fishing season.

210. Current methods for the analysis of biomass survey data use strata defined as areas of seabed within certain depth ranges and certain statistical areas. The currently used strata were obtained for a purpose slightly different from that of the Fish Stock Working Group. It was suggested that the procedure of defining strata should be reassessed in the light of the Working Group's requirements. These should include CCAMLR finescale reporting areas and 50 m depth contours down to 500 m where possible.

211. In reference to paragraph 3.6 concerning predation of *N. rossii* by Antarctic fur seals, it was suggested that if the feeding habits of *Arctocephalus gazella* were monitored, details of species and ages of fish prey consumed would be of interest to the Working Group. The Working Group recommended that the SCAR Group of Specialists on Seals be requested to provide advice on the most effective ways of obtaining quantitative information to address this problem.

212. The Working Group noted that there were some instances where catch data currently available in the CCAMLR database were inconsistent with those available to or held by individual Members (e.g. paragraph 66(ii)). It was therefore recommended that Members should make every effort to ensure adequate validation of and consistency in data submitted to the Secretariat and to other organisations.

Data Analyses Required and Software to be Developed Prior to the Next Meeting

213. Expansion of the Secretariat's assessment programs to include several VPA tuning methods is required. In particular, the Laurec-Shepherd and the Rivard (WG-FSA-89/22) models are required by the Working Group, and should be available alongside the traditional VPA and SVPA programs.

214. A more complete description of the Secretariat's databases is also required, and should be provided for the Working Group in 1990.

215. Some difficulty was encountered in using the Secretariat's Macintosh Microcomputers since most delegates are more familiar with IBM compatible computers. The Secretariat was requested to provide access to IBM machines at future meetings.

New Trends in Assessment Work

216. Discussion of new trends is assessment methodologies is restricted because of the short time available to delegates at the meeting. Investigation of new methodologies would be best served by discussions centred around working papers submitted to the Working Group.

217. The Working Group currently has no methodologies available for assessing the impact of closed areas and similar management strategies. It is not clear whether the appropriate data are available for the CCAMLR stocks, but such methods are available from, for instance, FAO sources.

Organisation of the Next Meeting

218. Because of the high number of assessments needing to be performed at the meeting there was a shortage of time available to the Working Group. Consequently, extending the next meeting by one day was recommended.

219. The Working Group requested that certain preliminary analyses be made by the Secretariat before the Working Group meeting. For this to be facilitated the Working Group emphasised that the deadline of 30 September for the submission of data must be adhered to.

This will allow the available data and analyses to be presented to the Working Group on the first day of its meeting.

220. The Working Group requested that the Secretariat in consultation with Members should prepare a glossary of terms used by the Working Group in its reports for the benefit of the Commission and other interested parties. This glossary should be included as an appendix in the next report of the Working Group.

APPENDIX 1

AGENDA

Working Group on Fish Stock Assessment
(Hobart, Australia, 25 October to 2 November 1989)

1. Opening of the meeting

2. Adoption of the agenda

3. Review of material for the meeting
   - 3.1 Catch and effort statistics
   - 3.2 Size and age composition data
   - 3.3 Results of the CCAMLR Otoliths/Scales/Bones Exchange Scheme
   - 3.4 Other available biological information
   - 3.5 Mesh selection experiments
   - 3.6 Assessments prepared by Member Countries
   - 3.7 Other relevant documents

4. Organisation of assessment work

5. Questions raised and information needed by the Commission

6. Policy advice

7. Management strategy

8. Advice to the Commission
   - 8.1 Mesh size regulations
   - 8.2 Closed areas/closed seasons
   - 8.3 TACs
   - 8.4 Other approaches to control 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 and software to be developed prior to the next meeting
    - 9.3 New trends in assessment work
    - 9.4 Organisation of the next meeting

10. Any other business

11. Adoption of the report

12. Close of the meeting.

APPENDIX 2

LIST OF PARTICIPANTS

Working Group on Fish Stock Assessment
(Hobart, Australia, 25 October to 2 November 1989)

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APPENDIX 3

LIST OF DOCUMENTS

Working Group on Fish Stock Assessment
(Hobart, Australia, 25 October to 2 November 1989)

Meeting Documents:

WG-FSA-89/1	Draft Agenda
WG-FSA-89/2	Annotated Draft Agenda
WG-FSA-89/3	List of Documents
WG-FSA-89/4	List of Participants
WG-FSA-89/5	Analyses Carried Out During the 1988 Meeting of the Fish Stock Assessment Working Group Secretariat
WG-FSA-89/6	Report of the Joint UK/Polish Fish Stock Assessment Survey Around South Georgia, February 1989 G. B. Parkes and I. Everson (UK) J. Sosinski, Z. Cielniaszek and J. Szlakowski (Poland)
WG-FSA-89/7	Proposed Maturity Scale for Icefish (Channichthyidae) Z. Cielniaszek (Poland) and G. B. Parkes (UK)
WG-FSA-89/8 Rev. 1	The Status of the *Champsocephalus gunnari* Stock in the South Georgia Area M. Basson, J. R. Beddington (UK) and W. Slosarczyk (Poland)
WG-FSA-89/9	Supplementary Data on Exploited Fish Stocks in Division 58.5.1 (Kerguelen) G. Duhamel (France)
WG-FSA-89/10	Software for Fish Stock Assessment Secretariat
WG-FSA-89/11	Summary of Length Composition Data Submitted Prior to 1988 Secretariat
WG-FSA-89/12	Availability of Catch and Biological Data Secretariat

WG-FSA-89/13	A Comparison Between Age Determinations of the Antarctic Fish *Notothenia gibberifrons* Lönnberg Using Scales and Otoliths Roger Coggan et al. (UK and Poland)
WG-FSA-89/14	Selectivity of Trawls with Reference to Icefish *(Champsocephalus gunnari* L.) S.F. Efanov, G.E. Bidenko and V.A. Boronon (USSR)
WG-FSA-89/15	Hydrological Conditions and Peculiarities of Glassfish Distribution on the South Georgia Island Shelf in 1986-1987 V.N. Shnar and V.I. Shlibanov (USSR)
WG-FSA-89/16	Growth and Age-length Structure of Grey Notothenia (*Lepidonotothen squamifrons* gunther) (nototheniidae) Populations in Different areas of Indian Sector of Southern Ocean A.K. Zaitsev (USSR)
WG-FSA-89/17	Natural Mortality of Grey Notothenia, Habitating Different Areas of Indian Sector of Southern Ocean A.K. Zaitsev (USSR)
WG-FSA-89/18	Growth and Natural Mortality of Yellowfin Notothenia *Patagonotothen guntheri shagensis* from Shag Rocks Shelf V.I. Shlibanov (USSR)
WG-FSA-89/19	On Ageing Technique for Icefish (*champsocephalus gunnari* Lönnberg 1905) from South Georgia Island Shelf Zh.A. Frolkina (USSR)
WG-FSA-89/20	On Assessment of Bertalanffy Growth Equation Parameters and Instantaneous Natural Mortality Rate on South Georgia Icefish Zh.A. Frolkina and R.S. Dorovskikh (USSR)
WG-FSA-89/21	1989/90 Stock Status and TAC Assessment for*Patagonotothen guntheri* in South Georgia Subarea (48.3) V.I. Shlibanov (USSR)
WG-FSA-89/22	1989/90 Stock Status and TAC Assessment for *Champsocephalus gunnari* in South Georgia Subarea (48.3) J. Frolkina (USSR)
WG-FSA-89/22 Rev. 1	1989/90 Stock Status and TAC Assessment for *Champsocephalus gunnari* in South Georgia Subarea (48.3) J. Frolkina and P. Gasiukov (USSR)
WG-FSA-89/23	Longline Data Recording Sheet Secretariat

WG-FSA-89/24	Vacant
WG-FSA-89/25	Summary of Length Composition Data Applicable to 1987/88 (Secretariat) (This is a copy of document WG-FSA-88/25)
WG-FSA-89/26	Summary of Length Composition Data Applicable to 1988/89 Secretariat
WG-FSA-89/27	Correction for Under-representation of 1 and 2 Year Old *Champsocephalus gunnari* in Bottom Trawl Surveys J. Beddington and M. Basson (UK)

Other Documents:

SC-CAMLR-VIII/BG/2	Summary of Fisheries Data Secretariat
SC-CAMLR-VIII/BG/16	Reproduction in the Antarctic Icefish *Champsocephalus gunnari* and Its Implication for Fisheries Management in the Atlantic Sector of the Southern Ocean Delegation of Federal Republic of Germany
SC-CAMLR-VIII/BG/18	The State of Exploited Fish Stocks in the Atlantic Sector of the Southern Ocean Delegation of Federal Republic of Germany
SC-CAMLR-VIII/BG/20	Evaluation of the Results of Trawl Selectivity Experiments by Poland and Spain in 1978/79 and 1986/87 W. Slosarczyk (Poland), E. Balguerias (Spain), K. Shust (USSR) and S. Iglesias (Spain)
SC-CAMLR-VIII/BG/26	Preliminary Observations on the Suitability of Semipelagic Trawl Gear in the Fisheries of Icefish (*Champsocephalus gunnari* Lönnberg, 1905) Delegation of Spain (partially translated)
SC-CAMLR-VIII/BG/27	Some Data on the Distribution, Abundance and Biology of the *Patagonotothen brevicauda guntheri* (Norman 1937) at Shag Rocks Delegation of Spain (partially translated)
SC-CAMLR-VIII/BG/35	Status of the Stocks of Antarctic Demersal Fish in the Vicinity of South Georgia Island, January 1989 Delegation of USA

SC-CAMLR-VIII/BG/36	Distribution and Abundance of Larval Fishes Collected in the Western Bransfield Strait Region, 1986-87 Delegation of USA
SC-CAMLR-VIII/BG/42	Effects of Variable Recruitment on the Potential Yield of the *C. gunnari* Stock Around South Georgia Delegation of United Kingdom
SC-CAMLR-VIII/BG/45	Bibliography of Antarctic Fish Delegation of Federal Republic of Germany
SC-CAMLR-VIII/BG/46	CCAMLR Antarctic Fish Otolith/Scales/Bones Exchange System Convener of the Fish Stock Assessment Working Group
SC-CAMLR-VIII/BG/47	Effects of Different Harvesting Strategies on the Stock of Antarctic Icefish *Champsocephalus gunnari* Around South Georgia Delegation of Federal Republic of Germany

APPENDIX 4

MATURITY SCALES

ANTARCTIC ROCK CODS (NOTOTHENIIDAE)*

Code	Maturity Stage	Description
Females: stages in ovarian maturation		
1	Immature	Ovaries small and firm. No eggs visible to naked eye.
2	Maturing virgin	Ovaries about 1/4 length of body cavity, firm and full of eggs that are uniform in size.
3	Developing	Ovaries large and contain eggs of two sizes.
4	Gravid	Ovaries large. Large ova spill out when fish is handles or ovary is cut.
5	Spent	Ovaries flaccid and contain many small eggs with only a few large eggs.
Males: stages in testicular maturation		
1	Immature	Testes very small, translucent and lying close to vertebral column.
2	Developing	Testes small (about 1% body weight), white, and convoluted.
3	Developed	Testes large, white, and convoluted. No milt produced when pressure is applied to testes or testes are cut.
4	Ripe	Testes large and opalescent white. Drops of milt produced when pressure is applied to testes or testes are cut.
5	Spent	Testes dirty white in colour, much smaller and more flaccid than at stage 4.

* EVERSON, I. 1982. Fish. In: El-sayed, Z. (Ed). Biological Investigations of Marine Antarctic Systems and Stocks. Cambridge: BIOMASS. Volume II, p. 79-97. CCAMLR Format Specifications for Reporting Biological Data to the CCAMLR Secretariat.

ICEFISH (Channichthyidae)

Based on observations of three species: *Champsocephalus gunnari*, *Chaenocephalus aceratus* and *Pseudochaenichthys georgianus.*

Table 1. Males

Maturity stage	Description
1. Immature	Testis small, translucent, whitish, long, thin strips lying close to the vertebral column.
2. Developing or resting	Testis white, flat, easily visible to the naked eye, about 0.25 x length of the body cavity.
3. Developed	Testis large, white; no milt produced under external pressure.
4. Ripe	Testis large, opalescent white; drops of milt produced under external pressure.
5. Spent	Testis shrunk and flabby, dirty white in colour.

Table 2. Females

Maturity stage	Description
1. Immature	Ovaries small, firm, short and ovoid; no eggs visible to the naked eye.
2. Developing or resting	Ovaries more extended, firm, colour milky to yellowy-orange. Small eggs may be visible, giving ovaries a grainy appearance.
3. Developed	Ovaries large, starting to swell the body cavity, colour varies according to species: *C. gunnari* - greyish; *C. aceratus* - yellow; *P. georgianus* - orange. Full of large opaque eggs held in connective tissue.
4. Gravid	Ovary large, filling the body cavity; large ova spill out of ovary when cut open.
5. Spent	Ovary shrunk, flaccid and generally empty, possibly with a few large eggs.

APPENDIX 5

SOME COMMENTS ON THE ESTIMATION OF NATURAL MORTALITY FOR *C. GUNNARI, N. SQUAMIFRONS* AND *P.B. GUNTHERI* BASED ON SOVIET DATA

(P. Sparre, FAO, Rome)

ESTIMATION OF NATURAL MORTALITY

Natural mortality rates may be estimated by several alternative methods.

2. Some methods use age composition data representing the virgin stock, i.e. data from before fishing started. These methods assume the fish stock to be in an equilibrium state, i.e. that all parameters have remained constant for a period of time not less than the life span of the species in question. This assumption is not likely to be met in reality. The recruitment, especially, is known to fluctuate considerably between years. This problem, however, can be circumvented by using the average age composition for a range of years.

3. As the age composition should be representative for the population in the sea, each age composition should be weighted by the number caught per unit of effort before summation.

4. The methods using age compositions sampled from the virgin stock either assume Natural Mortality, M, to remain constant from age group to age group or to be variable. Only one method estimating variable M is considered:

Baranov's method: (Baranov, 1914)

$M (=Z) = \ln (N_{a+1}/N_a)$

N_a = average number caught per unit of effort belonging to age group a.

Heincke's method (1913) provides an estimate of the average M value:

$$M\ (=Z) = \ln \frac{N_a + N_{a+1} + N_{a+2} + \ldots}{N_{a+1} + N_{a+2} + \ldots}$$

where a is an age group fully recruited to the fishery.

The remaining methods assume M to remain constant from age group to age group.

The Beverton and Holt (1956) method based on age data:

$$M\ (=Z) = \frac{1}{\bar{t} - t^{\nabla}}$$

where t^{∇} is an age under full exploitation, and $\bar{t}$ is the average age of fish of age t^{∇} and older.

Robson and Chapman (1961) showed that:

$$M\ (=Z) = \ln\left(1 + \frac{1}{\bar{t} - t^{\nabla}}\right)$$

is a more efficient estimator than that of Beverton and Holt.

The Beverton and Holt (1956) method based on length data:

$$M\ (=Z) = K\ \frac{L_{\infty} - \bar{L}}{\bar{L} - L^{\nabla}}$$

where L^{∇} and K are von Bertalanffy growth parameters, L^{∇} is a length under full exploitation and $\bar{L}$ is the mean length of fish of length L^{∇} and longer.

The Alverson-Carnee method:

$$M\ (=Z) = \frac{3K}{e^{TK} - 1}$$

where K is the von Bertalanffy parameter and T is the age when $N_t \supseteq w_t$ takes it's maximum value. N_t is the number of survivors at age t and w_t is the corresponding body weight.

A seventh method is the age based catch curve analysis which is based on the regression analysis:

$$\ln (N_x) = A - M{:}X \quad , \quad x = a, a + 1, ...$$

where a is an age group under full exploitation and A is a parameter (the intercept) which is not used. This method, however, is not used in the present paper. The age based catch curve has a length based equivalent.

5. Two methods are based on more general ecological/physiological considerations. They do not use size composition data as input and are therefore indirect methods. The preceeding methods based on size composition data will all provide an estimate of M, the precision of which depends on the quality of the input data and the degree to which the underlying assumptions are met. The two following approaches involve a number of assumptions which are highly questionable for individual fish species, as they are based on assumptions pertaining to a 'hypothetical average fish species'. These two (second class) methods are:

Pauly's method: (Pauly, 1980)

$$\ln (M) = -0.0152 - 0.279 \ln (L_\infty) + 0.6543 \ln (K) + 0.463 \ln (T)$$

where L□ and K are von Bertalanffy parameters and T is the temperature of the ambient water. For polar fish species Pauly replaced T by the so-called 'Effective physiological temperature', T_e which he defined by a graph giving the relationship between T and T_e. Selected values read from the graph are:

T	-2	-1	0	1	2	3	4°C
T_e	24	17	11	8	6	4.5	3.5°C

The Rikhter and Efanov (1976) method:

$$M = \frac{1.521}{T_m^{0.72}} - 0.155$$

where T_m is the age when 50% of the population is mature.

6. The Pauly method or the Rikhter and Efanov method should be used only when no age composition data representing the virgin stock are available, as they are considered less precise.

7. If estimates of longevity are available (e.g. from age/length keys) estimates of M may be converted into longevity and compared to the alternative estimate. If we define the longevity of a species as the age at which only 1% of a cohort has survived in the case of no fishing, the longevity, T_e, becomes:

$$T_e = - \frac{\ln(0.01)}{M} = \frac{4.605}{M}$$

NATURAL MORTALITY OF *CHAMPSOCEPHALUS GUNNARI* IN SOUTH GEORGIA WATERS

8. Frolkina and Dorovskikh (WG-FSA-89/20) gave the following input data representing the virgin stock:

Age group	1	2	3	4	5	6	7	8
Mean age	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5
N_a	20	258	509	272	227	119	49	15
$M = \ln \frac{N_a}{N_{a+1}}$	-	-	.62	.19	.64	.89	1.19	

9. The data represents the period from 1965 to 1969. It is not known how the data of the individual years were obtained (e.g. which age/length keys were used) and how they were pooled (e.g. are they the straight sum or were they weighted by CPUE before summed?).

10. It appears from the table that the mortality rate varies from age group to age group (up to a factor of six) so the assumption of a constant parameter system appears to be violated. One can only speculate on the reasons for increasing trend from age 5 and onwards. Plausible explanations are:

(a) the fish migrate out of the fishing grounds or escape from the trawl when they grow larger;

(b) the fish die from spawning stress or old age progressively from age 5 and onwards; and

(c) ages have been underestimated due to difficulties in otolith readings.

11. Disregarding the variability between age groups the following estimates of M were obtained:

Heincke's method;

$$M = \ln \frac{509 + 271 + 227 + 119 + 49 + 15}{271 + 227 + 119 + 49 + 15} = 0.56/yr$$

The two first age groups were excluded as they are obviously not fully recruited to the fishery. Excluding also age group 3 gives an M of 0.51 per year.

The Beverton and Holt method based on age data:

$$\bar{t} = \frac{3.5x509+4.5x271+5.5x227+6.5x119+7.5x49+8.5x15}{509+271+227+119+49+15}$$

$$= 4.63 \text{ year}$$

$$t^{\nabla} = 3 \text{ year}$$

$$Z = \frac{1}{4.67 - 3} = 0.60 \text{ per year}$$

Robson and Chapman's method gives:

$$Z = \ln \left(1 + \frac{1}{\bar{t} - t^{\nabla}} \right) = 0.47 \text{ per year}$$

The Alverson-Carnee method gives:

$$M = \frac{3K}{e^{TK} - 1} = 0.34$$

with K = 0.12
and T = 6 years

where the value of T is based on the table:

		Body Weight	
age	N_a	w_ag	$N_a W_a$ kg
3.5	509	77.6	39
4.5	272	163.1	44
5.5	227	228	52
T			
6.5	119	416	50
7.5	49	572	28
8.5	15	740	11

where w_a and $N_a W_a$ are weights in grammes and Kgs respectively, and the body weights and K are those given in the paper by Frolkina and Dorovskikh.

12. Based on length frequency data (which were not given in their paper) Frolkina and Dorovskikh calculated M from Beverton and Holt's length based formula and found the value to be 0.51 per year.

13. Taking into account that M is expected to lie in the range between 1.5K and 2.5K (Beverton and Holt, 1959) or 0.18 – 0.30 all the above values appear on the high side. Pauly's formula gives 0.19/year (with $T_e = 6$) and Rikhter-Efanov gives 0.53/year with $T_m =$ 3 years.

14. Thus, only Pauly's formula gives a result which is in the expected range. It would therefore be of great interest to the Working Group if the basic data (length frequencies and age/length keys for each year) were made available to allow for a full discussion.

15. The table below lists the results of the six alternative methods applied together with the corresponding longevity.

	M	longevity $= \frac{4.605}{M}$
Heincke	0.56	8.2
Beverton & Holt, age	0.60	7.7
Robson & Chapman	0.47	9.8
Alverson & Carnee	0.34	13.5
Pauly	0.19	24.2
Rikhter-Efanov	0.53	8.7
Mean value	0.45	10.2

It is recommended that both the Heincke's estimate of 0.56, and the lowest value, namely 0.19 derived from Pauly's formula, be tested in further analyses.

NATURAL MORTALITY OF *N. SQUAMIFRONS* IN THE INDIAN OCEAN SECTOR

16. This species is believed to be long lived (a life span of more than ten years). Thus, a time series of at least five years is required to produce a data set not biased by fluctuations in recruitment.

17. Zaitsev presents results based on data from 1978 to 1979 for Ob and Lena Banks and for Kerguelen Islands 1969 to 1972 in a working paper (WG-FSA-89/17). This paper does not present any input data but merely lists the results. Thus it is not possible to discuss the results of this paper. It would be of great interest to the Working Group to see the basic data behind Zaitsev's results.

18. Based on the Rikhter-Efanov method and the Pauly method Zaitsev presents results for M in the range from 0.10 to 0.31. A value of M = 0.2 seems reasonable for this species. This implies that after twenty three years 1% of the stock would survive in the case of no fishery.

NATURAL MORTALITY OF *PATAGONOTOTHEN BREVICAUDA GUNTHERI* FROM SHAG ROCKS

19. Shlibanov presents age composition data for the second half of 1978 in working paper (WG-FSA-89/18). As the time period considered is short, the data are not useful for estimation of mortality rates based on age composition methods.

20. This leaves us with only the Pauly method and the Rikhter and Efanov methods. Using Pauly's formula with L_∞ = 23.31, K = 0.33 and T_e = 6 gives M = 0.45 per year. Rikhter and Efanov's method gives M = 0.48 with T_m = 3.2 years (WG-FSA-89/17).

21. Using T_m = 2.5 as suggested by Shlibanov gives M = 0.63. A value of 0.5 seems reasonable for this species. This implies that after nine years 1% of the stock would survive in the case of no fishery.

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APPENDIX 6

PROBLEMS IN TUNING THE VPA FOR ASSESSMENT OF *C. GUNNARI* STOCKS IN SUBAREA 48.3 USING DATA FROM A UK/POLISH TRAWL SURVEY

(Submitted by the USSR Delegation)

The major patterns of change in biomass (see WG-FSA-89/27 and WG-FSA-89/22 Rev. 1) are consistent over the fishing seasons (see WG-FSA-89/27, Figure 2). The formation of points on the diagram linking biomass and CPUE is identical in both cases. In the terminal year there is only one difference in the biomass values which is defined by various abundance estimates for age group 2 only.

2. In the calculation of abundance and fishing mortality for age group 2, the following problems arise:

(i) abundance and biomass data from the UK/Polish trawl survey in January–February 1989 were underestimated due to an approximate 25% decrease in the area covered. This in turn reflected a 25% drop in abundance for all age groups over the 1988/89 season;

(ii) abundance and biomass estimates from the trawl survey contain an uncertainty of 49.9% in the variation rate. This bias is augmented by the bias obtained when defining age composition and age/length keys from only 184 specimens; and

(iii) although the abundance estimate for *C. gunnari* given in WG-FSA-89/27 was made on 1 July 1988, this value needs to be defined for 1 June 1988. In the same way the estimated number of specimens subject to natural mortality declined between 1 July and 1 November 1988.

3. Points (i) and (ii) prove that the calculations used in WG-FSA-89/27 produce estimates approximately 50% less than actual values and that the uncertainty surrounding the variation rate (ii) calls into doubt their possible practical application.

APPENDIX 7

PROBLEMS IN THE USE OF USSR CATCH AND EFFORT DATA FOR VPA TUNING

(Submitted by the UK Delegation)

Serious concerns were expressed by a number of Members of the Working Group with the use of the gross catch and effort data for the assessment of *C. gunnari*, which may render the results of WG-FSA-89/22 Rev. 1 unreliable. They are inter alia:

(i) the size and type of vessel differred over the period. The standardisation of effort had been performed on the basis of total catch for a season. It is not possible to judge whether such a calibration is reasonable;

(ii) as the geographical variations in the catch and effort data were unavailable it is not possible to judge whether the pooling that was done distorts the changes in catch and effort;

(iii) the time series of catch and effort used spanned the period of both the regulated and unregulated fishery. This could bias the time series in the later years as fleets orientated themselves to the high density areas (see paragraph 88); and

(iv) changes in efficiency of the fleets are possible as bottom trawls were substituted with midwater trawls. The calibration of vessels of different capacities would mask any such effect.

APPENDIX 8

BIOMASS ESTIMATES FROM THE USSR SURVEY OF KERGUELEN SHELF (DIVISION 58.5.1) IN 1988

A trawl survey was conducted in 1988 over the Kerguelen Shelf by two vessels from the USSR (WG-FSA-88/22 Rev. 1). Preliminary analysis of the results at last year's meeting suggested that a very strong cohort was about to enter the fishery. However, the Working Group noted that the CPUE from the 1989 season (WG-FSA-89/9) was in fact slightly lower than that from the preceding strong cohorts of 1979 and 1982 at corresponding ages.

2. Examination of the haul locations from the survey showed inhomogeneity in the sampling intensity, with the greatest intensity occurring in the areas of high densities for *C. gunnari*. This will lead to a substantial overestimate of the stock unless the survey analysis can be properly stratified. The preliminary analysis of these data were stratified on the basis of depth range only. This led to an estimate of biomass for *C. gunnari* on the Kergulen Shelf of 429 thousand tonnes, as shown in Table 8.1.

3. The nature of the problem with the realised survey design can be seen by comparing the station chart (Figure 8.1) with the fish density profiles synthesized from various sources by Duhamel (1987), shown in Figure 8.2. It can be seen that the sector to the northeast is a major concentration area for *C. gunnari* and that this area has had by far the largest number of hauls. The commercial fishing grounds, which have the highest fish concentrations, occur between latitudes 48°10'S and 49°S, and longitudes 70°50'E to 71°E. This small region of 1 136 km^2 comprises about 2% of the total 100 – 200m depth stratum. However, nine out of 97 hauls in the stratum were taken in this region. In terms of swept area, these hauls represented 10.4% of the sampling effort. Thus sampling within this stratum is not at random with respect to the distribution of fish.

4. That is not the only problem which leads to the need for further stratification. The Southern shelf used to contain the high concentrations of *N. rossii*, rather than concentrations of *C. gunnari*. The Western shelf area is difficult to trawl because of rough ground, and it may also be less productive than the other sectors of the Kerguelen Shelf.

5. The Working Group concluded that the estimates should be calculated on a depth stratified basis over the five sectors bounded by the lines shown on Figure 8.1. Even finer

geographical stratification could be required in the northeast sector, to take into account the density distributions in Figure 8.2. However, with the equipment available during the meeting stratification on such a fine scale was not possible.

6. The results given in Table 8.1 show that re-stratification of the estimate has led to a substantial revision of the biomass estimate for *C. gunnari* from 429 thousand tonnes down to 244.1 thousand tonnes. The estimates for the major species are given in Table 8.2.

Table 8.1: Biomass (tonnes) of *C. gunnari* Kerguelen Shelf stock during the 1988 survey.

Depth Range (m)	WG-FSA-89/22 Rev. 1	WG-FSA-89/27
100 – 200	299 814	107 700
200 – 300	96 348	86 400
300 – 500	32 800	40 000
Total	428 962	234 100

Table 8.2: Total biomass and biomass by species obtained during the 1988 survey on the Kerguelen Shelf (restratified).

	Fish biomass (tonnes)
Total	277 300
C. gunnari	234 100
N. rossii	13 800
N. squamifrons	2 200*
D. eleginoides	27 200

* probably underestimated in relation to migration

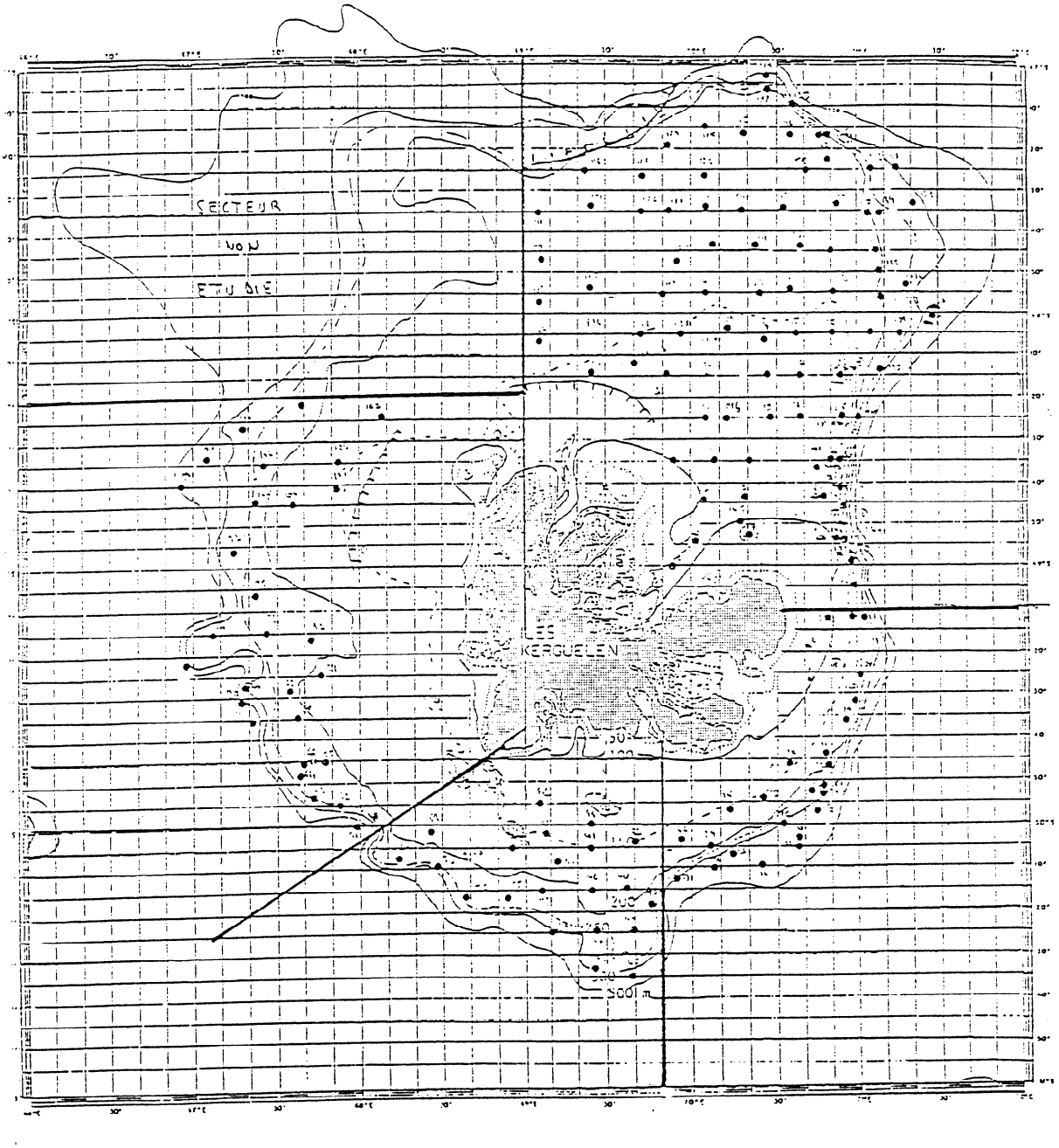

Figure 8.1

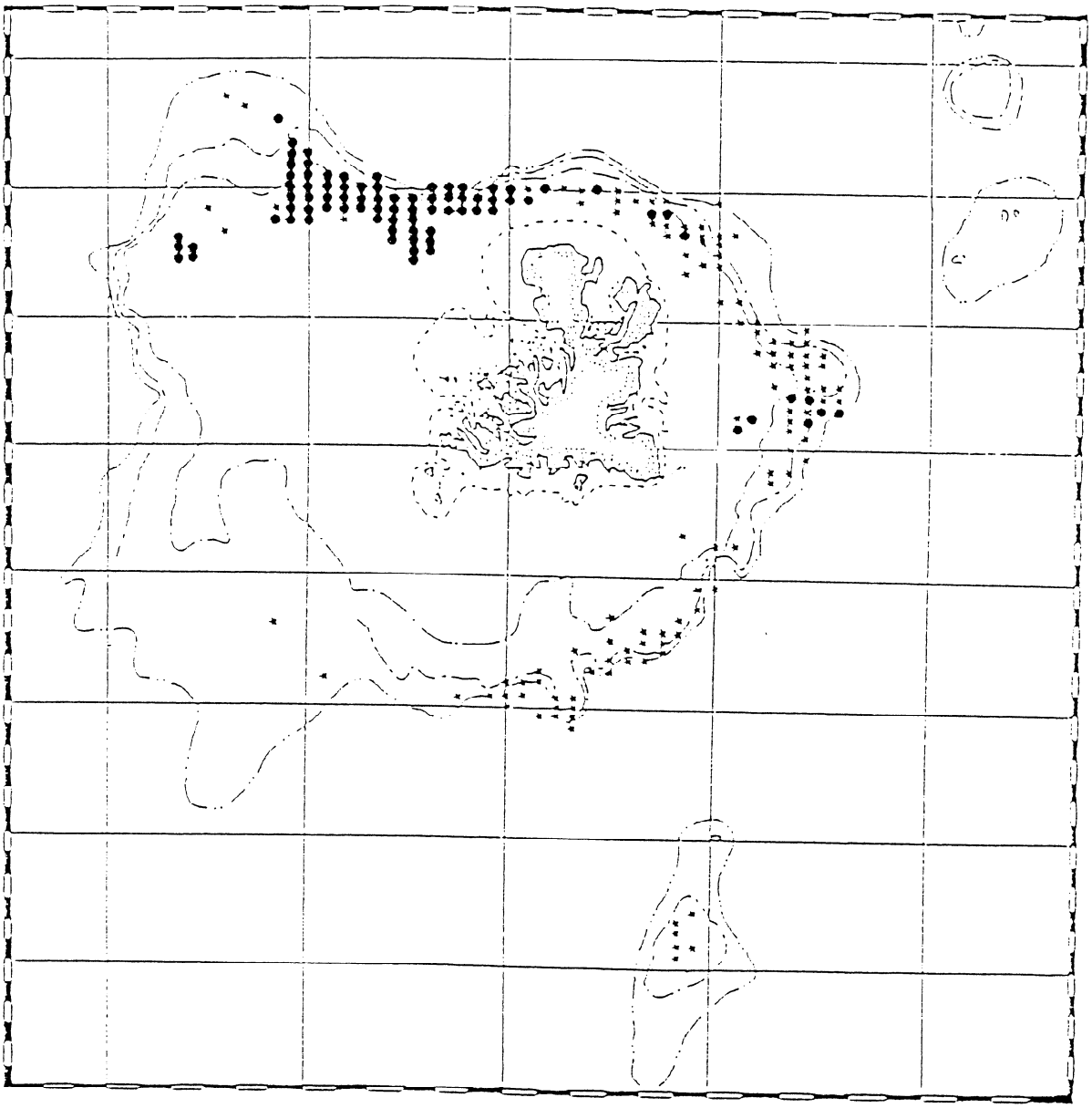

Figure 8.2

APPENDIX 9

DATA REQUIREMENTS

1. Catch and effort for longline fisheries on *D. eleginoides* in Subarea 48.3. (See this report, paragraph 10).

2. New length composition data from commercial fishery to improve assessment. (Generally).

3. USSR scientists asked to provide 1990 Meeting with data for a year by year analysis of growth and natural mortality in *C. gunnari* in Subarea 48.3. (See this report, paragraphs 46 and 47).

4. Biological information (length composition, age/length keys) should be collected from the incidental catch of *N. rossii* in Subarea 48.3. (See this report, paragraph 83; also SC-CAMLR-VII, Annex 6, paragraphs 11 and 22; SC-CAMLR-VI, Annex 5, paragraph 12; SC-CAMLR-V, Annex 4, paragraphs 22, 45 and 48; SC-CAMLR-IV, Annex 4, paragraph 26).

5. Information on length and age of *N. squamifrons* in Subarea 48.3 for past and current commercial catches as well as biomass estimates from research vessel surveys is urgently needed. (See this report, paragraph 113; also SC-CAMLR-V, Annex 4, paragraph 79).

6. Length and age data from the catches since the mid 1980's of *C. gunnari* and *C. gunnari* and *N. gibberifrons* in Subarea 48.2 are needed. An estimate of current stock biomass from a research vessel survey is also highly desirable. (See this report, paragraph 133; also SC-CAMLR-VII, Annex 6, paragraphs 61 and 64; SC-CAMLR-VI, Annex 5, paragraph 91).

7. Age and length data from recent and current catches of *N. gibberifrons* in Subarea 48.1 is needed. A biomass estimate from a research vessel survey is also needed. (See this report, paragraph 139).

8. Fine scale reporting of catches of *P. antarcticum* in Subarea 58.4 is required. (See this report, paragraph 144).

9. Catches of *C. wilsoni* are being reported as *C. gunnari* from Subarea 58.4 - more care needed in reporting species. (See this report, paragraph 45; also SC-CAMLR-V, Annex 4, paragraph 79).

10. Data from recent trawl surveys undertaken by the USSR have been used in analyses presented to the Working Group. It is recommended that the basic survey data and details of survey design be made available to the 1990 Meeting of the Working Group. (See this report, paragraph 148).

11. Historical catch data for *N. squamifrons* in Division 58.4.4 should be submitted. (See this report, paragraph 150; also SC-CAMLR-VII, Annex 6, paragraphs 80 and 81; SC-CAMLR-V, Annex 4, paragraph 79).

12. Age/length keys and length frequency data are required from catches of *C. gunnari* in Division 58.5.1 prior to 1980. (See this report, paragraph 158; also SC-CAMLR-IV Annex 4, paragraph 51).

13. The following data is required for *N. squamifrons* in Division 58.5.1 (see this report, paragraph 178):

    (a) length-frequency and age/length data for *N. squamifrons* taken from Division 58.5.1 are required from 1972 to the present;

    (b) catch data prior to 1978 should be separated from Division 58.5.1;

    (c) data held by Members should be checked for consistency with that held in CCAMLR data base; and

    (d) length data should be requested as total length.

14. Data on all exploited stocks of *Channichthyids* in Statistical Area 58 are required. (See this report, paragraph 182; also SC-CAMLR-VII, Annex 6, paragraph 73).

APPENDIX 10

1989 ASSESSMENTS SUMMARIES

1989 ASSESSMENT SUMMARY FOR *CHAENOCEPHALUS ACERATUS* IN SUBAREA 48.3 (SOUTH GEORGIA SUBAREA)

Split-Year Ending	Recommended TAC	Agreed TAC	Actual landings (tonnes)	Biomass[f] (tonnes)	Mean F
1977			293		na
1978			2 066		na
1979			464		na
1980			1 084		na
1981			1 272		na
1982			6 767		na
1983			0		na
1984			161		na
1985			1 042	11 542[a]	na
1986			504		na
1987			339	8 621[b]	na
1988			313	6 209[b]	na
1989	1 100[d]	[e]	1	5 770[c]	na
1990	0				

[a] from FRG research vessel survey

[b] from joint US/Polish research vessel surveys

[c] from joint UK/Polish research vessel survey

[d] applying $F_{0.1}$ = 0.15 (females) and 0.18 (males) to the mean of (b) (8 000 tonnes) (1988/89), (c) (6 000 tonnes) (1989/90)

[e] catches prohibited under Conservation Measure 11/VII

[f] using 'swept area' method

The Fishery:

Catches are usually relatively small and variable. This species is mostly taken incidentally by fisheries directed at other species.

Conservation Measures in Force:

General Conservation Measures for Subarea 48.3 apply.

This includes Conservation Measure 11/VII (fishing on *C. gunnari* and by-catch prohibited from 4 November 1988 to 20 November 1989).

Data and Assessments:

Length composition data mainly from research vessel catches are available for most years. Biomass estimates from a number of surveys are available, in particular, since 1984/85. No VPA calculations have been attempted.

Fishing Mortality:

No reliable information.

Recruitment:

No reliable information.

State of the Stock:

The biomass still seems well below the level prior to exploitation and in the first years of fishing.

Management Advice:

Given the rather even distribution of the species over the area and its co-occurrence with other species (e.g. *N. gibberifrons, P. georgianus*) it is unlikely that this catch could be taken without a substantial by-catch of these species. In view of these problems, its likely detrimental effects on other species with a low stock size and the apparent stock-recruitment relationship in *C. aceratus*, the Working Group recommended that no directed catches of these species be taken and by-catches be reduced to a minimum to allow the recovery of this stock.

Data Requirements:

Catch records from all fishing nations. Length and age compositions from commercial catches from most of the years.

1989 ASSESSMENT SUMMARY FOR *CHAMPSOCEPHALUS GUNNARI* IN SUBAREA 48.3 (SOUTH GEORGIA SUBAREA)

Split-Year Ending	Recommended TAC	Agreed TAC	Actual landings (tonnes)	Biomass (tonnes)	Mean F
1971	-	-	10 701		
1972	-	-	551		
1973	-	-	1 830		
1974	-	-	254		
1975	-	-	746		
1976	-	-	12 290		
1977	-	-	93 400		
1978	-	-	7 557		
1979	-	-	641		
1980	-	-	7 592		
1981	-	-	29 384		
1982	-	-	46 311		
1983	-	-	128 194		
1984	-	-	79 997		
1985	-	-	14 148		
1986	-	-	11 107		
1987	-	-	71 151		
1988	31 500	35 000	34 620		
1989	10 194[a]	[b]	21 359		
1990	[c]				

[a] at $F_{0.1} = 0.313$

[b] directed fishing on *C. gunnari* was prohibited from 4 November 1988 in accordance with CCAMLR Conservation Measure 11/VII. A TAC was not appropriate.

[c] see below, Management Advice.

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.

During the Seventh Meeting of the Commission, 24 October to 4 November 1988, the catch of *C. gunnari* reported under Conservation Measure 9/VI reached 10 121 tonnes with two periods still unreported. Following the Scientific Committee's advice of a TAC at $F_{0.1}$ of 10 194 tonnes, Conservation Measure 11/VII was adopted prohibiting fishing of this species after 4 November 1988 (CCAMLR-VII, paragraphs 92 to 97).

Conservation Measures in Force:

(1) Fishing, other than for scientific purposes, prohibited in waters within 12 n 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) System for reporting catches on the basis of 10-day period (Conservation Measure 9/VI).

(4) Prohibition of a directed fishery on *C. gunnari* from 4 November 1988 to 20 November 1989 (Conservation Measure 11/VII).

Data and Assessments:

Age and length data are available for the 1988/89 season. Estimates of biomass are available from research surveys (joint UK/Polish and USA). Soviet catch and effort data from STATLANT forms for 1988/89 are available.

Two VPA assessments were considered, one tuned to the UK/Polish survey estimate of biomass, the other tuned to effort data (see WG-FSA-89/27 and WG-FSA-89/22 Rev. 1).

Fishing Mortality:

The two assessments described give radically different absolute levels of fishing mortality. In the last years the mortality on age group 2 has been high.

Recruitment:

Although the two working papers give rather similar levels of abundance, the pattern of recruitment is substantially different. WG-FSA-89/27 indicates that recent recruitment is small compared to the average over previous years, while WG-FSA-89/22 Rev. 1 indicates that there is a substantial year class born in 1987, which is the highest in the last 7 years.

State of the Stock:

There is a large difference between the estimates of total abundance in the final year (1988/89) from the two analyses. The abundance of the stock still mainly depends on young fish, 1 to 3 year olds.

Management Advice:

The TAC's at different target F levels that have been derived from the two assessments are given in Table 2. They differ substantially.

Table 2: TAC levels (tonnes) for *C. gunnari*, Subarea 48.3, calculated from assessments presented in WG-FSA-89/27 and WG-FSA-89/12 Rev. 1 (M = 0.35).

	Assessment presented in WG-FSA-89/27	Assessment presented in WG-FSA-89/22 Rev. 1
$F_{0.1} = 0.313$	6 545	22 235
$F_{max} = 0.645$	11 961	40 273

In essence, if the trawl survey and the analysis based on it is correct, a TAC based on the CPUE tuned VPA will lead to a substantial depletion of the stock.

If the analysis based on the CPUE tuned VPA is correct and a TAC is set on the basis of the trawl survey results, the stock will increase substantially.

Analysis of mesh selectivity experiments now indicate that a mesh size of 110 mm would afford substantial protection to juvenile fish and permit the growth of any strong year class that might appear. If the Commission decides to adopt this, then a new TAC based on a different $F_{0.1}$ value would need to be calculated (see paragraph 89).

Data Requirements:

Because of the major discrepancy between the two analyses presented, a further survey is clearly desirable. Estimates of the strength of recruiting year classes are urgently required, which might best be obtained by a survey with both bottom and midwater trawls.

1989 ASSESSMENT SUMMARY FOR *PSEUDOCHAENICHTHYS GEORGIANUS* IN SUBAREA 48.3 (SOUTH GEORGIA SUBAREA)

Split-Year Ending	Recommended TAC	Agreed TAC	Actual landings (tonnes)	Biomass[(f)] (tonnes)	Mean F
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	5 520[(b)]	na
1988			401	9 461[(b)]	na
1989	1 800[(d)]	[(e)]	1	8 278[(c)]	na
1990	0				

[(a)] from FRG research vessel survey

[(b)] from joint US/Polish research vessel surveys

[(c)] from joint UK/Polish research vessel survey

[(d)] using $F_{0.1}$ = 0.3 on the mean of (a - c) (8 000 tonnes)

[(e)] catches prohibited under Conservation Measure 11/VII

[(f)] estimates using 'swept area' method

The Fishery:

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

Conservation Measures in Force:

General Conservation Measures for Subarea 48.3 apply.

Data and Assessments:

Estimates of biomass are available from a number of surveys. Length frequency data mostly from research vessel catches are available since 1975/76 and some age length keys from the first years of fishing. 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.

State of the Stock:

Although reported catches have been fairly light since 1977/78, stock biomass is still much less than before the fishery started in 1976/77.

Management Advice:

Catches of this species can only be taken with a substantial by-catch of other species. In view of this problem and its likely detrimental effects on other species with a low stock size (e.g. *N. gibberifrons, C. aceratus*) the Working Group recommended that no directed catch of these species be taken and by-catches to be reduced to a minimum to allow recovery of these stocks.

Data Requirements:

Catch reports from all fishing countries. Length frequency compositions and age/length keys from the commercial fishery for most years.

1989 ASSESSMENT SUMMARY FOR *NOTOTHENIA GIBBERIFRONS* IN SUBAREA 48.3 (SOUTH GEORGIA SUBAREA)

Split-Year Ending	Recommended TAC	Agreed TAC	Actual landings (tonnes)	Biomass (tonnes) [a]	Mean F [a]
1976			4 999		
1977			3 357		
1978			11 758		
1979			2 540		
1980			8 143		
1981			7 971		
1982			2 605		
1983			0		
1984			3 304		
1985			2 081		
1986			1 678		
1987			2 844		
1988			5 222		
1989		[b]	838		
1990	[c]				

[a] from VPA with M = 0.125

[b] total ban on fishing *N. gibberifrons* (Conservation Measure 11/VII)

[c] $F_{0.1}$ = 0.094, M = 0.125

The Fishery:

Moderate catches have been taken in most years with a peak of 11 000 tonnes in 1978. Catch in 1988/89 was mainly by-catch in the *C. gunnari* fishery.

Conservation Measures in Force:

General Conservation Measures for Subarea 48.3 apply.

This includes Conservation Measure 11/VII prohibiting commercial by-catches of *N. gibberifrons* in Subarea 48.3.

Data and Assessments:

Catch at age data was updated to 1987/88, but no commercial data was available for 1988/89 catches. The VPA was run up to 1987/88 and calibrated to the biomass estimates from trawl surveys. Half the catch in 1987/88 was added to the estimate to approximate the biomass at the beginning of the 1987/88 season.

Fishing Mortality:

Fishing mortality is high and has increased on younger age groups in the population. Terminal F was estimated at 0.9 on fully recruited age groups in 1987/88.

Recruitment:

From the VPA results, recruitment appears to have declined from 1976 to 1986, as stock size has decreased. Projections based on mean recruitment levels may overestimate the size of new recruiting age classes.

State of the Stock:

Biomass estimates from trawl surveys in recent years suggest that this stock has declined from about 14 000 tonnes in the period 1984 to 1986 to about 8 000 tonnes from 1987 to 1989. The stock appears to be at only 20% of the level of the mid 1970's (40 000 tonnes).

Management Advice:

Because of the current low stock size and the evidence for a stock recruitment relationship, the Working Group was unable to recommend a TAC at the level of $F_{0.1}$. Catches should be kept to a minimum to increase stock size. The Working Group recommended that there should be no directed fishery for *N. gibberifrons* and by-catch should be restricted to not more than 300 tonnes.

Data Requirements:

Length and age data are required from commercial catches.

1989 ASSESSMENT SUMMARY FOR *NOTOTHENIA ROSSII* IN SUBAREA 48.3 (SOUTH GEORGIA SUBAREA)

Split-Year Ending	Recommended TAC	Agreed TAC	Actual landings (tonnes)	Spawner Biomass (tonnes)	Biomass[e] (tonnes)	Mean F
1970			399 704			
1971			101 558			
1972			2 738			
1973			0			
1974			0			
1975			0			
1976			10 753		35 682[a]	
1977			7 945			
1978			2 192		9 325[a]	
1979			2 137			
1980			24 897			
1981			1 651			
1982			1 100			
1983			866			
1984			3 022			
1985			1 891		12 781[a]	
1986		[f]	70			
1987		[f]	216		11 471[b] 1 634[c]	
1988		[f]	197		1 699[c]	
1989		[f]	152		2 439[d]	

[a] from FRG research vessel survey

[b] from Spanish research vessel survey

[c] from US/Polish research vessel survey

[d] from UK/Polish research vessel survey

[e] estimates using 'swept area' method

[f] directed fishing prohibited under Conservation Measure 3/IV

The Fishery:

A very large directed fishery took place in the 1969/70 and 1970/71 seasons and smaller directed fisheries in 1975/76 and 1979/80. Otherwise catches have been taken as by-catch in fisheries based largely on other species.

Conservation Measures in Force:

General Conservation Measures apply. In addition,

(1) 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).

(2) Directed fishing on *C. gunnari* is prohibited in Subarea 48.3 from 4 November 1988 to 20 November 1989 and during this time *N. rossii* shall not be taken except for scientific purposes (Conservation Measure 11/VII).

Data and Assessments:

Length and age data are available for most seasons, and biomass estimates have been made from a number of research surveys, in particular since 1984/85. Problems with interpretation make the age data unsuitable from 1985 onwards, but VPA have been run up to that data.

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 1960s. 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. Conservation measures should remain in force.

Data 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. Albeit commercial catches are small, information on length frequency composition, age/length keys etc. should be submitted to CCAMLR.

1989 ASSESSMENT SUMMARY FOR *PATAGONOTOTHEN BREVICAUDA GUNTHERI* IN SUBAREA 48.3 (SOUTH GEORGIA SUBAREA)

Split-Year Ending	Recommended TAC	Agreed TAC	Actual landings (tonnes)	Biomass (tonnes)	Mean F
1979			15 011		
1980			7 381		
1981			36 758		
1982			31 351		
1983			5 029		
1984			10 586		
1985			11 923		
1986			16 002		
1987			8 810	81 000[a]	
1988			13 424		
1989	[b]	13 000[c]	13 016		
1990					

[a] from Spanish survey

[b] no TAC recommended

[c] based on recent years catches

The Fishery:

Total catch in 1988/89 was 13 016 tonnes taken by a Soviet directed fishery in the Shag Rocks area. Age compositions of catches were mainly age groups 2 to 4 as in previous years.

Conservation Measures in Force:

(1) The catch of *P.b. guntheri* in Subarea 48.3 was limited to 13 000 tonnes in the 1988/89 season (Conservation Measure 12/VII).

(2) The catch reporting system applies (Conservation Measure 9/VI).

Data and Assessments:

Catch at age data was available up to 1988/89 and was used in the VPA. Some CPUE data was available from the Soviet fleet and one estimate of biomass from a trawl survey was available for 1986/87 (81 000 tonnes). Assessments were made using two values of natural mortality, 0.48 and 0.63.

Fishing Mortality:

Fishing is directed at age classes 2 to 4 and appears to be only at moderate levels in recent years.

Recruitment:

The biomass estimated for 1989/90 from projections of the VPA results is very sensitive to the assumed value of recruitment. Use of near values may give over-optimistic results. A large proportion of the fishable biomass is made up of new recruits, e.g. for M = 0.63, ages 1 and 2 make up 50% of the projected biomass in 1989/90.

State of the Stock:

The current status of this stock is unknown. Uncertainty in the value of natural mortality and the lack of any time series showing discernable trends prevent an accurate assessment of the stock size at present.

Management Advice:

In the absence of reliable estimates of natural mortality to evaluate the alternative analyses and in the absence of information of current stock size, catch levels should not be based on VPA results using $F_{0.1}$ calculations and assumptions on recruitment.

Data Requirements:

Length and catch at age data should continue to be collected from commercial catches. Survey estimates of abundance over a time series are required for stock assessment. Natural mortality should be determined from unexploited populations if possible.

1989 ASSESSMENT SUMMARY FOR *NOTOTHENIA SQUAMIFRONS* IN SUBAREA 48.3 (SOUTH GEORGIA SUBAREA)

Split-Year Ending	Recommended TAC	Agreed TAC	Actual landings (tonnes)	Biomass[(d)] (tonnes)	Mean F
1972			35		
1973			765		
1974			0		
1975			1 900		
1976			500		
1977			2 937		
1978			2 327[(a)]		
1979			280[(a)]		
1980			272		
1981			544		
1982			812		
1983			0		
1984			0		
1985			1 289		
1986			41		
1987			190	13 950[(b)]	
1988			1 553	409[(b)]	
1989			927	131[(c)]	

[(a)] from subarea unknown, probably South Georgia

[(b)] from US/Polish research vessel survey

[(c)] from UK/Polish research vessel survey

[(d)] estimates using 'swept area' method

The Fishery:

Catches have been reported since 1971/72. Annual catches usually varied between several hundred and 2 to 3 000 tonnes.

Conservation Measures in Force:

General Conservation Measures for Subarea 48.3 apply.

Data and Assessments:

Fishing Mortality:

No reliable information.

Recruitment:

No reliable information.

State of the Stock:

No reliable information.

Management Advice:

As the status of the stock is unknown the Working Group was unable to recommend a TAC.

Data Requirements:

Length and age compositions from the commercial catches.

1989 ASSESSMENT SUMMARY FOR *DISSOSTICHUS ELEGINOIDES* IN SUBAREA 48.3 (SOUTH GEORGIA SUBAREA)

Split-Year Ending	Recommended TAC	Agreed TAC	Actual landings (tonnes)	Biomass[(d)] (tonnes)	Mean F
1976				13 497[(a)]	
1977			441		
1978			1 920	7 322[(a)]	
1979			194		
1980			255		
1981			239		
1982			324		
1983			116		
1984			109		
1985			285	8 159[(a)]	
1986			564		
1987			1 199	1 208[(b)]	
1988			1 809	674[(b)]	
1989			4 138	326[(c)]	

(a) from FRG research vessel surveys including Shag Rocks

(b) from joint US/Polish research vessel surveys excluding Shag Rocks

(c) from joint UK/Polish research vessel survey excluding Shag Rocks

(d) estimates using 'swept area' method

The Fishery:

Catch history is available since 1976/77. Annual catches until 1985/86 were mostly several hundred tonnes. Since 1985/86 catches gradually increased to 4 138 tonnes in 1988/89.

Up to 1987/88 the fishery was entirely trawl-based. Most of the catches of the 1988/89 season were taken by longlines.

Conservation Measures in Force:

Mesh size regulations.

Data and Assessments:

Length compositions from research vessel catches in 1975/76, 1977/78 and 1984/85. Biomass estimates for 1975/76, 1977/78, 1984/85, 1986/87 – 1988/89.

Fishing Mortality:

No information.

Recruitment:

No information.

State of the Stock:

The Working Group was unable to assess the current state of the stock.

Management Advice:

In the absence of information on stock size the Working Group was only able to calculate the yield for different levels of unexploited stock size based on natural mortality estimates of 0.06.

Biomass	Sustainable Yield
8 000 tonnes	240 tonnes
40 000 tonnes	1 200 tonnes

As the figure of 40 000 tonnes is some five times the stock estimate obtained by the FRG survey in 1984/85, this could be considered as a reasonable upper limit until further data become available.

Data Requirements:

Length and age compositions from the commercial fishery (past and current). Biomass estimates from research vessel surveys.

1989 ASSESSMENT SUMMARY FOR *NOTOTHENIA SQUAMIFRONS* IN DIVISION 58.4.4 (OB AND LENA BANKS)

Split-Year Ending	Recommended TAC	Agreed TAC	Actual landings (tonnes)	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
1989			3 660		

The Fishery:

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:

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

All other Conservation Measures are applicable in this division as outlined in Division 58.5.2.

Data and Assessments:

Length frequencies, age compositions and age length keys have been submitted by the USSR separately for Ob and Lena Banks.

The USSR Member's Activities Report gives biomass estimates for Ob and Lena Banks of 21.25 ± 11.44 thousand tonnes and 12.76 ± 4.34 thousand tonnes

respectively. The Working Group recommends that the new survey data be made available for consideration and further analysis by the Working Group for Fish Stock Assessment in 1990.

Recruitment:

There was no information from which to assess current recruitment.

State of the Stock:

The lack of catch data separated for each bank has precluded assessment.

Management Advice:

The Working Group drew attention to the observation that catches have increased over the last two seasons.

In the absence of an assessment, the Working Group was unable to give specific management advice. It recommends the submission of the recent survey data and historical catch data separately for each bank.

Data Requirements:

1989 ASSESSMENT SUMMARY FOR *CHAMPSOCEPHALUS GUNNARI* IN DIVISION 58.5.1 (KERGUELEN SHELF AND SKIF BANK)

Split-Year Ending	TAC	Skif Bank			Kerguelen Shelf			
		Actual Landings (tonnes)	Cohort (Yr)	Mean F	Actual Landings (tonnes) [c]	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	1976		
1979					0			
1980		1			1 630	1976		
1981		992	1978		130	1979		
1982		1 024	1978		15 059	1979		
1983		4			25 848	1979		
1984		904	1981		6 223	1979		
1985	x	223	1981		8 030	1982		
1986	x	0			17 137	1982		
1987	16 000[a]	2 625	1984		0			
1988	12 500[b]	2			157	1985		
1989					23 628	1985		

[a] refers period 1 October 1986 to 31 December 1987 for Division 58.5.1

[b] refers to period 1 January 1988 to 31 December 1988 for Division 58.5.1

[c] landings prior to 1989 are for the whole of Subarea 58.5

The Fishery:

There are two separate stocks in Division 58.5.1 (Kerguelen Shelf and Skif Bank). Catches are variable and reflect fairly closely a three year cycle in recruitment. Over the last decade fishing has occurred on only one cohort at a time with large catches taken as the fish reach 3 years of age. This occurred in 1983, 1986 and again in 1989.

No fishing occurred on the Skif Bank stock in the 1989 season and so no reassessment was undertaken.

Conservation Measures in Force:

(1) 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).

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

(3) TAC's set from 1985 onwards under the joint French-Soviet agreement.

(4) Conservation Measures as for *N. rossii* in Division 58.5.1.

Data and Assessments:

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

CPUE data since 1981.

Survey estimates of biomass for Kerguelen Shelf* stocks in 1987 and 1988 (WG-FSA-88/22 Rev. 1) was partially reanalysed, but because of non randomness in sampling distribution, it was decided not to use the abundance estimate (see Appendix 1).

Fishing Mortality:

The cohort analysis from the 1988 Meeting was updated as far as possible (see Appendix 2).

Recruitment:

Based on the CPUE data (Figure 1), the strength of the incoming cohort seems to be comparable in strength with the two preceding strong cohorts, although it may be slightly weaker.

* fish at age 1 in pelagic phase therefore bottom trawl survey not useful.

State of the Stock:

In light of the unsatsifactory biomass estimates there is little recourse but to assume, on the basis of the CPUE data, that the current cohort in the fishery is of comparable strength to the preceding strong cohorts of 1979 and 1982. Thus the biomass of the 1985 cohort during 1988/89 could have been in the range of 23 000 to 45 000 tonnes. Therefore the catch of 23 000 tonnes in the 1989 season may have had a severe impact on the current cohort.

Management Advice:

In previous assessments it was pointed out that 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 or 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.

Given that substantial depletion of the current strong cohort could have occurred in 1989, it would be prudent for any fishing in 1990 to be in the range of previous catches from the preceding cohorts at 4 years of age, i.e. 0 to 6 000 tonnes. A survey is required to assess the strength of the 1988 cohort.

Data Requirements:

New and properly designed survey .

Careful reanalysis of 1988 survey.

Stratified as suggested in Appendix 1.

Studies of post spawning mortality.

1989 ASSESSMENT SUMMARY FOR *DISSOSTICHUS ELEGINOIDES* IN SUBAREA 58.5.1 (KERGUELEN SHELF AND SKIF BANK)

Split-Year Ending	Recommended TAC	Agreed TAC	Actual landings (tonnes) [(a)]	Biomass (tonnes)	Mean F
1978			2		
1979			0		
1980			138		
1981			40		
1982			121		
1983			128		
1984			145		
1985			6 677		
1986			459		
1987			3 144		
1988			554		
1989			1 630	27 200	

[(a)] landings prior to 1989 are for the whole of Subarea 58.5

The Fishery:

The fishery is confined to a concentration in a relatively small area on the west coast in water 300 to 600 m deep. Large catches began in 1985 when this area was discovered. In 1986 and 1988 effort in this fishery was low because of concentration on *C. gunnari*. In years of significant fishery, the catch has declined from 6 677 tonnes to 1 630 tonnes per year and CPUE has declined from 2.50 t/h to 1.64 t/h.

Conservation Measures in Force:

None.

Data and Assessments:

Biomass estimate 1988/89 (from Soviet/French survey):

for total area	27 200 tonnes
for western zone	19 000 tonnes

CPUE:	1984/85	1985/86	1986/87	1987/88	1988/89	
	2.50	1.41	1.79	0.78	1.64	(t/hour)

Fishing Mortality:

No estimates available.

Recruitment:

No data.

State of the Stock:

As CPUE has declined by approximately 30% in three years, and this is a long-lived species with probably low productivity (as in the case with most other nototheniids), this rate of fishing may be too high.

Management Advice:

Assessment urgently required.

Data Requirements:

Age/length keys.
Length.

1989 ASSESSMENT SUMMARY FOR *NOTOTHENIA ROSSII* IN DIVISION 58.5.1 (KERGUELEN)

Split-Year Ending	Recommended TAC	Agreed TAC	Actual landings (tonnes) (b)	Biomass (tonnes)	Mean F
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		
1981			7 924		
1982			9 812		
1983			1 829		
1984			744		
1985		0(a)	1 707		
1986		0(a)	801		
1987		0(a)	482		
1988		0(a)	21		
1989		0(a)	245		

(a) avoidance of direct fisheries (CCAMLR Resolution 3/IV) and by-catch only allowed (Franco-Soviet Fishery Contract)

(b) landings prior to 1979 are for the whole of Subarea 58.5

The Fishery:

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. 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:

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

(2) 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).

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

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

(5) 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).

(6) 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).

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

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

Data and Assessments:

No new data are available since the 1988 Scientific Committee Meeting in relation to the prohibition of a directed fishery on the adult stock. A provisional biomass estimate was available from the USSR survey.

Fishing Mortality:

Recruitment:

A program to study pre-recruits in coastal waters to assess the stock and detect any changes in the abundance of the juvenile portion of the stock has been established recently (1982). Regular experimental fishing with trammel nets would allow

detection of variations in abundance of this part of the stock (based on catches of age classes 2 and 3 fishes). A gradual increase in abundance with an average growth rate of 36.3% has been observed from 1984 to 1988 (WG-FSA-89/9). Considering the deferred impact to the adult part of the stock an expected increase in recruitment would be detectable in four years for the shelf stock.

State of the Stock:

Management Advice:

Conservation measures (no directed fishery) will be continued into the beginning of 1990 for the adult stocks. Trends in the abundance of the juvenile part of the stock need to be continually monitored. An evaluation survey will need to be conducted prior to any new exploitation.

Data Requirements:

1989 ASSESSMENT SUMMARY FOR *NOTOTHENIA SQUAMIFRONS* IN DIVISION 58.5.1 (KERGUELEN)

Split-Year Ending	Recommended TAC	Agreed TAC	Actual landings (tonnes) [b]	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		
1981			6 239		
1982			4 038		
1983			1 832		
1984			3 792		
1985			7 394		
1986			2 464		
1987		[c]5 000	1 641		
1988		[c]2 000	41[d]		
1989		[c]2 000+	1 825		

[a] includes catches from Division 58.4.4 and possibly Subarea 58.6

[b] landings prior to 1989 are for the whole of Subarea 58.5

[c] TAC set by fishing season and **not** by split-year

[d] see (5) under Conservation Measures in Force

The Fishery:

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 redirection of fishing effort in relation to a low level abundance of *C. gunnari*, the main target species of the Kerguelen fishery. The catch in 1988/89 was substantially larger than in 1987/88 (see below) but comparable with 1986/87.

Conservation Measures in Force:

(1) 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).

(2) 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).

(3) Catch limits have been set since 1987 under the joint French/Soviet agreement (SC-CAMLR-VII, paragraph 83, page 120).

(4) Conservation Measures as for *N. rossii* in Division 58.5.1.

(5) During 1987/88 no directed fishing on *N. squamifrons* was undertaken between December 1987 and September 1988.

Data and Assessments:

Comprehensive length frequency distribution data are available from the commercial fisheries. Other available data include indices of abundance from catch and effort data (WG-FSA-89/9) and survey estimates of stock biomass in 1987 and 1988 (WG-FSA-88/22 Rev. 1). Results from VPA analyses of data post 1980 (see SC-CAMLR-VII, Annex 5, paragraph 101) and Soviet assessments of various stock parameters (e.g. growth/mortality) for the years 1969 to 1972 and 1980 to 1986 (WG-FSA-89/16 and 17) are also available.

A lack of both length frequency and length at age data in the CCAMLR database precludes sensible VPA's, particularly during the period when the stock was most heavily exploited (1971 to 1978).

Fishing Mortality:

Fishing mortality affects age classes 5+ with the age of maturity being 9 years. The wide range of values for natural mortality (Duhamel, 1987; WG-FSA-89/17) obtained to date and uncertainty concerning the long-term trajectory of the stock make it extremely difficult to assess fishing mortality.

Recruitment:

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

State of the Stock:

Both CPUE and catch level data indicate that the stock remains at a lower level. Catches in 1986/87 and 1988/89 have been less than the catch limits for these two seasons (see Table 6). The value of the CPUE index value of abundance south and southeast of the island confirm that there has been a decreasing trend in the stock biomass, however in 1988/89 this downward trend was not evident (WG-FSA-89/9, Figure 7). However, taking into account the annual areal distribution of the stock, this apparent recovery of the stock is small. It would appear therefore that the enforced reduction of fishing in 1987/88 is unlikely to have any longterm effect on this already heavily exploited stock.

Management Advice:

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

Since only about 15% of the current total stock biomass is comprised of adults and that fishing on other species in the area will continue, the setting of acceptable by-catch levels appears necessary. As the current quota levels have not been attained, it is recommended that future by-catch levels should be substantially lower than present quotas.

Data Requirements:

Data are required on the following:

- recruitment patterns;

- mesh selectivity to improve management advice based on yield-per-recruit calculations; and

- additional surveys of stock biomass should be undertaken in order to improve currently available knowledge of stock abundance. In particular, surveys should be undertaken prior to any future exploitation of unexploited stocks in Division 58.5.1 (see paragraph 171).

In order to improve assessments of the stock and exploitation trends, it is critically important that the following data be submitted to CCAMLR:

- Length frequency and age length data for the *N. squamifrons* fishery in Division 58.5.1 from 1972 to the present. Such data should, as far as possible, be provided for individual years.

- Catch data prior to the declaration of an EEZ around Kerguelen by France (3 February 1978), should be reported for Division 58.5.1 (as done in WG-FSA-89/10 and 17) and re-submitted.

- consolidated catch data for Subarea 58.5. In particular, care should be taken to ensure consistency between the data submitted to CCAMLR and data available to or held by individual members.

- to avoid possible confusion in the future, all length data should be reported as total length only.