

**REPORT OF THE AD HOC WORKING GROUP  
ON FISH STOCK ASSESSMENT**

(Hobart, Australia, 19–23 October, 1987)

(SC-CAMLR-VI/3)

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## **INTRODUCTION**

The meeting of the Working Group was held at the CCAMLR Headquarters, Hobart Australia from 19–23 October, 1987. Dr K.-H. Kock was in the chair. A list of those attending is given in Appendix A. Dr J.A. Gulland was appointed rapporteur. A list of documents presented at the meeting is given in Appendix B. The agenda, as adopted by the Group, is given in Appendix C.

## **GENERAL MATTERS**

### **Basic Data**

2. There had continued to be improvements in the reporting of basic data to the Commission. However, some countries had failed to meet the deadlines for the reporting of 1986/87 STATLANT data (30 September), and had only submitted their data at the beginning of the meeting. This had made it impossible for the Secretariat to complete the basic data summaries (as contained in SC-CAMLR-VI/BG/5) in advance of the meeting. The Group stressed the importance of countries complying with the agreed deadlines for data submission (six weeks in advance of the meeting in the case of biological data).

### **Age Determination**

3. The Group noted with regret that the report of the Age Determination Workshop held in Moscow in 1986 was not yet available. The Chairman reported on the arrangements being made for the exchange of material used for age determination (SC-CAMLR-VI/BG/26). This exchange program should help to resolve the outstanding doubts and inconsistencies between countries about the interpretation of such material (otoliths, scales etc.).

## Early Life-History of Fishes

4. Information was presented concerning the Post-SIBEX Fish Data Evaluation Workshop held in Cambridge, UK in August 1987 (WG-FSA-87/14). The Group noted that an inventory of information and a bibliography on the early life-history of Antarctic fishes was being prepared by Drs Slosarczyk and Kellermann (SC-CAMLR-VI/BG/25). A key to the identification and a catalogue of fish larvae was being prepared by A.W. North and A. Kellermann (see WG-FSA-87/11). Printing this booklet (500 copies in one language) would cost some US\$6000–7000. This booklet would be useful in larval and pre-recruit surveys, which may be used for the estimation of adult stock size, or of the strength of year-classes in advance of their recruitment to the commercial fishery. Therefore the Group urged that the Commission help meet the costs of printing. This contribution might be shared with BIOMASS and the Alfred Wegener Institute of Polar and marine Research, Bremerhaven, FRG.

5. It was noted that in many of the cases examined by the Post-SIBEX Workshop, there was little or no correlation between the abundance of fish larvae and that of the adults, or with subsequent recruitment. Many plankton nets were highly selective in terms of the sizes and species of larvae caught. On the other hand, in the case of *C. gunnari* off S. Georgia and other chaenichthids in the Peninsula area, it appeared that mid-water trawls with small mesh liners were very efficient in catching late-stage larvae (over 50 mm in length). Surveys for these stages could be one way of obtaining the early estimates of recruitment which are likely to be of considerable importance if stocks of these species are to be managed by catch limits.

6. The Group believed that it would be valuable to give further and more detailed consideration (possibly at a small workshop) to the potential use of early life-history information in stock assessment.

## New Research

7. The results of various surveys carried out in recent years were reported. These included analyses for the South Georgia area by Polish scientists (WG-FSA-87/10); the results of the joint US/Polish survey in South Georgia in November–December 1986 (SC-CAMLR-VI/BG/12); and of the joint Soviet-Australian survey of Heard and McDonald, 1987 (SC-CAMLR-VI/BG/16). The results of simulation studies of the trends in future catches at South Georgia and Kerguelen were presented in WG-FSA-87/8 and 15. The implications of these studies, and of the other documents listed in Appendix B, for the

assessments and advice provided by the Working Group are discussed in the appropriate sections of this report.

#### Presentation of Data

8. The Secretariat had prepared two main working documents (SC-CAMLR-VI/BG/5 and WG-FSA-87/4) summarising the catch statistics until 1986, and certain routine analyses (yield-per-recruit and VPAs for some major stocks) respectively. These reports facilitated the Group's work and enabled it to concentrate on its proper scientific tasks. However, it was noted that because some data were reported after the required deadline, the statistical summary had to be revised manually during the meeting. Experience suggested that some modifications should be made to the procedures used for the VPA analyses:

- (a) an age-specific terminal F should be used, with the terminal F on the older fish being adjusted by the mean selectivity pattern of the previous years;
- (b) the print-out should make a clearer distinction between the results for the current and previous years, and the projection for the next year;
- (c) consideration should be given to using alternative terminal F, especially when the information available for setting the terminal F is scarce;
- (d) the print-out of input data should make clear which figures of catch-at-age are actual observations and which are interpolations from other years;
- (e) clearer specifications should be given of how interpolations were done;
- (f) the mean selectivity pattern should be used to calculate exploitable biomass as well as total biomass. This is likely to be particularly important when relating VPAs to estimates of biomass obtained from surveys.

## ASSESSMENTS

### General

9. As noted in the previous section, the Secretariat has made considerable progress in summarizing the basic catch data, in carrying out routine and pre-determined analyses (e.g. VPA), and in presenting the results in a form that can be easily used by the Group. This has greatly facilitated the work of the Group.

10. At the same time there is also much information that has been submitted to the Commission e.g. effort data, length and/or age data (other than those aspects included in VPA) and survey data, that remains in other forms e.g. extensive data sheets existing in a limited number of copies. It is not easy for a large group to use data in these forms in an effective way. The Group is aware that, partly because of time constraints, it was not possible to review these data as thoroughly as other data, and that therefore the stocks to which these data apply may have been assessed with less accuracy than might, under other circumstances, have been possible. This point, and the ways in which the presentation of data, and other aspects of the Group's work, might be more effective are discussed in a later section.

### *Notothernia rossii*

#### South Georgia Subarea (48.3)

11. The total reported catch in the 1986/87 season was only 216 tonnes, mostly taken by the Soviet union. This is approximately what would be expected since the fishermen comply with the resolutions and conservation measures approved by the Commission at its 1985 and 1986 meetings concerning the cessation of a directed fishery, and the avoidance of by-catch.

12. Information on biomass is available from surveys carried out in 1986/87, though not all the data from those surveys have been fully analysed and reported to the Commission. Each estimate for biomass is subject to considerable variance, and it is difficult to detect small changes in biomass. Thus while the observations are consistent with the recent restrictions having the expected effect, and beginning to allow the stock to rebuild, they are also consistent with there being no effect. It would be valuable to carry out some simulations or similar studies to determine how soon the effect of the restrictions could be detected, at different levels of survey effort.

13. The recent studies confirm that the stock abundance is now very much lower than in 1969, with the biomass being around 5% of the catches in that period. However, there are elements in the records of catches, age-composition etc. that are not wholly consistent. For example, it might have been expected that in 1970 there would have been some year-classes of juvenile fish in the inshore areas that would have entered the exploitable stock in the next few years, but there seems little sign of them in the age-composition of later years.

14. Bearing in mind that few natural populations remain exactly in equilibrium, there may have been other factors that exacerbated the impact of the heavy fishing in 1969/70. For example the fishery may have started at a time when the population was reaching the end of a period of unusually high abundance. These alternative hypotheses would not alter the immediate need to rebuild the stock, but could alter the expectations of the extent to which the stock could be rebuilt, and therefore decisions on when to re-open the fishery.

#### Other Atlantic Areas

15. No catches were reported from Subareas 48.1 or 48.2 in the 1985/86 or 1986/87 seasons, and there is no information on which to modify the conclusions in last year's report that the stock abundance was well below the levels at the times when fishing began.

#### Kerguelen Subarea (58.5)

16. Directed fishing on the spawning concentration has been prohibited since 1984, and since the 1985/86 season, catches have been limited to by-catch. Catches were 801 tonnes in 1985/86 and 482 tons in 1986/87. Both VPAs and catches per unit effort indicate a clear decline in abundance from 1980 to 1984. Since 1984 there seems to have been some recovery, though the catch statistics for the most recent seasons have not been fully analysed.

#### *Notothenia squamifrons*

17. The Group noted that extensive biological data from the Soviet fishery on the Ob and Lena Seamounts (Division 58.4.4) as requested last year by the Scientific Committee (SC-CAMLR-V, paragraph 4.41) had recently been received by the Secretariat. However, it had not been possible in the time available to process these data and to present them in a form

suitable for consideration by the Group. It was therefore not possible for the Group to make any assessment of these resources at this meeting.

*Champscephalus gunnari*

South Georgia Subarea (48.3)

18. Catches in 1986/87 were 71 247 tomes, the highest since 1983/84. The Soviet scientists reported that their fishing fleets had been advised to restrict their catches, and these catches could have been larger. It appears that this highly variable stock is at a peak. There were previous peak catches around 1977 and 1983.

19. Though trawl surveys have been made in the area in several recent years, the catches of this species in surveys are highly dependent on the rigging of the survey gear, so that it is difficult to use the available results to estimate recent trends in abundance. Though it should be possible to derive better indices from commercial catch and effort data, this has not been possible because no distinction was made between fishing targeted on krill and on fish before 1986. This distinction has been made in the most recent reports, and this may enable better indices to be provided in future.

20. Because of the large natural fluctuations in abundance it is not easy to use the level of abundance as a simple indicator of the effect of exploitation. It is now clear that abundance was high at the beginning of the 1986/87 season, but the available information is inadequate to estimate the current (October 1987) abundance with any precision. Survey estimates of the biomass during the 1986/87 season were some 80 000 tomes (from the Polish survey), and 150 000 tomes (from the Spanish survey). Bearing in mind that many fish could be mid-water and missed by the bottom trawl, and that the Polish survey covered only part of the area, the Group believed that the true figure was nearer to 150 000 tomes.

21. The impact of fishing is better indicated by the mortality rates. These appear now to be high, with only one or two age-groups contributing to the fishery. In contrast, when fishing started in 1976, all ages from 3 to 10 appeared in significant quantities in the catch. This is adding to the year-to-year variability in the stock (and hence in the catches). The number of year-classes in the spawning stock has also been reduced.

#### Peninsula Subarea (48.1)

22. A very small catch, 76 tonnes, was reported in 1986/87; this is the first reported catch since 1983. Surveys in the Elephant Island area gave estimates of 934 tonnes (FRG in 1985), about 1 000 (FRG in 1986) and 1 962 tonnes (Spain in 1987). The stock abundance is clearly low.

#### South Orkney Subarea (48.2)

23. Reported catches were only 29 tonnes in 1986/87, compared with a few thousand tonnes in previous years. An estimate of biomass of 1 179 tonnes was obtained from the Spanish survey in 1987. This is similar but rather lower than the estimate from the 1985 German survey (3 669 tonnes). Although commercial catches could be strongly affected by changes in the distribution and availability of the fish, well-designed surveys should be less affected by these factors.

24. Current abundance is clearly low, and it appears from the length and age data that the present stock is composed largely of the survivors of a relatively strong year-class (or year-classes) that recruited to the fishery in 1982.

25. There are considerable doubts about the inter-relations of the *C. gunnari* stocks found in different parts of the Atlantic, and it was felt that it would be useful, in order to get a better understanding of the dynamics of the fisheries, to run a VPA for the whole Atlantic sector combined. Analysis of infestation patterns with parasitic copepods, and discriminant analysis based on morphological and meristic characters carried out in Poland, GDR and FRG indicate that the population is separate from other populations in the Peninsula and South Georgia areas. Large fluctuations in length compositions without any apparent trend may, however, indicate immigration from or emigration to other areas at irregular intervals.

#### Kerguelen Subarea (58.5)

26. Catches in 1986/87 were only 2 625 tonnes. As in other areas, the stock is dependent on the recruitment of the occasional good year-class. The 1982 cohort, which provided the good catches in the 1985 and 1986 seasons on the main shelf is now passing out of the fishery, and the catch rates in numbers of this cohort have fallen from 5.76 in 1984/85 and 3.81 in 1985/86 to only 0.4–0.5 in the 1986/87 (the exact figures are not available, pending

full analysis of the log-books). The major part of the 1986/87 catches was taken on the Skiff Bank, largely from the 1984 cohort.

27. The 1985 cohort, which is currently protected by the 25 cm size limit, should enter the fishery soon, and may be of reasonable strength. The abundance of this cohort will be evaluated by a joint Soviet/French survey during the 1987/88 season prior to exploitation.

#### McDonald and Heard Islands

28. A joint Soviet–Australian survey was made in this area, and the results reported in SC-CAMLR-VI/BG/16. Most of the catches were of *C. gunnari*. The fish were taken in two small areas of relatively high density of 40 and 60 nm<sup>2</sup>. The estimated abundances in these areas were around 16 580 and 2 079 tomes respectively.

29. It was suggested that these figures, and corresponding estimates of potential yield should be treated with caution because of the non-random distribution of trawl hauls (see Figure 1), and also because of the likelihood that there is considerable natural variation in the stock. There are also uncertainties about the relationship of these fish to those around Kerguelen.

30. This region lies in the same statistical subarea as Kerguelen. It is important for the future work that the catch statistics and other information from any commercial fishery should be kept separate from those relating to Kerguelen.

#### *Notothenia gibberifrons*

##### South Georgia Subarea (48.3)

31. Catches in 1986/87 were 2 842 tonnes. This continues a picture apparent in previous years of relatively stable catches, in contrast to high fluctuations in other species.

32. VPA calculations were carried out, but because recruitment appears to occur over a wide range of ages (not being complete until ages 10–12), the results are highly dependent on the assumptions made about the recruitment patterns. In particular, the assumption of constant mortality with age can lead to a serious under-estimate of the abundance of the younger fish in the most recent years. It is clear that abundance decreased in the first few

years of exploitation, as might be expected with a long-lived fish, but the trends since 1981 are less clear, although they indicate a relatively stable biomass.

33. The age-composition and length composition data showed a decrease in the proportion of larger fish when exploitation began, indicating an increase in total mortality and a relatively high fishing rate, but in the most recent years the mean size has increased.

34. Biomass estimates are available from the 1984/85 German survey, and the 1986/87 US/Polish survey, which gave 15 762 and 13 394 tonnes respectively. These agree well, and given the variance in both figures, the difference cannot be taken as evidence of any decrease. An estimate of 11 356 tonnes for part of the area is also available from data of Polish commercial vessels.

#### Peninsula Subarea (48.1)

35. Catches in 1986/87 were only 56 tonnes, after several years of zero catch. The German survey in 1985 gave a biomass estimate of 25 000 tonnes around Elephant Island. It appears that this stock remains lightly exploited because it is only taken as a by-catch in the *C. gunnari* fishery and there is insignificant *C. gunnari* fishing to support the fleets.

#### South Orkney Subarea (48.2)

36. Catches in 1986/87 were only 2 tonnes, compared with several thousand tonnes in 1983/84 and 1984/85. The 1984/85 German survey gave a biomass estimate of 12 000 tonnes.

#### Other Species

37. An analysis of information collected by observers on board Polish commercial trawlers fishing around South Georgia (WG-FSA-87/10) enabled the trends in abundance of several species to be followed in the period 1976/77-1986/87. It appears that there has been some increase recently in the abundance of *Chaenocephalus aceratus*. Trends in the biomass density index of *Pseudochaenichthys georgianus* and *Notothenia rossii* are not clear (Figure 2). It is difficult to determine the role of fishing in these changes. In the interpretation of the trends in some seasons, the influence of targeted fishing for *C. gunnari* should also be

considered. When this species is abundant, fishing effort on other species is reduced, which might result in low biomass density estimates derived from 'swept-area' methods.

## MANAGEMENT ADVICE

### General Observations

38. Management involves a sequence of decisions, proceeding from the very general statements of principles, as set out in the Convention, to matters of specific measures, such as setting a TAC (total allowable catch) for a particular species in a particular area for a particular year. This sequence can be arranged in a number of ways; an example is illustrated below.

### Possible Decisions

- General Policies – Reactive management : act only when problems arise, and something is clearly needed.
  - Anticipatory management: act before problems arise.
  - Experimental management: set measures that will enable more to be learnt about the system.
  - Other.
  
- Specific Policies – Ensure that fishing mortality is not more than  $F_{0.1}$  (see below).
  - Ensure that spawning stock biomass does not fall below some specified level.
  - Ensure that fishing mortality does exceed replacement level.
  
- Strategies – Set the TAC (for current, and all future years until corrected) equal to 90% of the estimated MSY.
  - Set a sequence of TACs, to be modified from year to year according to predetermined rules.
  - Set a limit on fishing effort in terms of numbers and sizes of vessels.
  - Other.
  
- Tactics – Set 1988 TAC.
  - Other (according to strategy adopted)

39. The strategy that might be adopted could be more or less complex, according to the situation being faced. For example, for a severely depleted stock, the strategy might be merely to hold catches at the minimum possible level (preferably zero) until research has shown clearly that recovery has occurred. In the case of a hitherto unexploited stock, the first step may be to conduct a survey to estimate the stock biomass and distribution, along with the age-structure and age-weight relationship. From these data an appropriate target level of fishing mortality could be estimated. An appropriate fraction of the stock's area could then be opened to fishing, the size of the area being chosen to keep the level of fishing mortality around or below the target level.

40. There is bound to be considerable recycling within this hierarchy, with policies or strategies being modified in the light of, for example, changing knowledge of the resource. At the same time, the stages need to be distinguished, and decisions at one stage clearly determined (if only temporarily) before moving on to the next. Often the arguments that arise, especially over tactics (e.g. the level of next year's TAC) have proved difficult or impossible to resolve because there has been no prior decision on the policy or strategy to be followed.

41. The decisions at each stage have to be taken by the Commission, but these decisions will be easier if there is appropriate scientific advice.

42. Up to the present, the Commission has made few clear decisions on the policies or strategies it wishes to adopt. At the same time, it is clear (e.g. from Conservation Measure 7/V regarding catch limits for fishing round South Georgia in 1987/88) that it will require advice on tactical measures at its 1987 session.

43. The Working Group therefore found it necessary to make some working hypotheses about policies and strategies that the Commission might decide upon, particularly regarding a target level of  $F$ .

44. In a similar situation, a number of other Commission or regulatory bodies have found it convenient to adopt as the target what has been called  $F_{0.1}$ . This is the value of fishing mortality at which the marginal yield per recruit (i.e. the increase in yield per recruit resulting from a small increase in fishing mortality) is 10% of that when fishing starts. This value of  $F$  has a number of advantages:

- it is easily calculated from values of growth, natural mortality and age at recruitment, which are available for most stocks;

- it is likely to make economic sense, being around the level at which the value of any increase in catch arising from increased fishing is likely to be significantly less than the increase in costs;
- as compared with higher  $F_s$  that might be adopted as target, it will give rise to a higher spawning biomass, and lead to catches and population sizes that vary less from year to year.

$F_{0.1}$  may also turn out to be close to alternative, but less easily calculable, target  $F_s$ . For example, though  $F_{0.1}$  will always be less than  $F_{MAX}$ , the value of  $F$  that gives the maximum yield per recruit, it may, when the effect of reduced spawning stock on recruitment is taken into account, be close to  $F_{MSY}$ , the value of  $F$  that gives the maximum sustainable yield.

45. The Working Group recognised that the Commission may wish to adopt other target  $F_s$  - perhaps smaller if it places emphasis on stability or large spawning stock, or larger, if it places emphasis on high short-term catches. The point to be stressed is that the absence of clear decisions on target  $F_s$  or other policies has raised problems for the Group in providing advice on TACs, or other tactical measures.

46. It was also assumed, for the purposes of providing tactical advice, especially in the light of Conservation Measure 7/V, that the strategy would be one in which the controls would be expressed as catch limits. This may be a less reasonable assumption. Experience elsewhere indicates that management by catch limits requires a highly sophisticated management apparatus. Unless the stock is long-lived, and recruitment reasonably constant, the setting of sufficiently accurate TACs will usually require extensive research to give up-to-date estimates of current stock abundance, and of the strength of the incoming recruitment. Enforcement of the regulations may also raise questions, and cause uncertainties in the reported catch statistics.

47. Before a definitive decision is taken on the strategy to be adopted, it would seem desirable to make a careful examination of such questions as the current ability of the Scientific Committee to provide accurate estimates of the TAC required to meet specified targets; the research required to improve this accuracy; and the ability of countries to enforce catch limits, and to assure other countries of this ability.

## Simulations

48. An increasingly valuable approach for providing scientific advice in taking these management decisions is simulation. This allows the scientists to advise the Commission on the consequences of each of a set of alternative decisions, and also of the degree to which these consequences (and especially the relative performance of different decisions) are sensitive to uncertainties e.g. in the current biomass, or the strength of incoming recruitment.

49. Examples of simulations are contained in documents WG-FSA-87/8 and 15, and later in this report in relation to the management of a *Champscephalus gunnari* stock. Simulations enable answers to be provided to many of the questions that those making decisions might ask - for example, how would the series of annual catches of *C. gunnari* differ under various levels of fishing mortality? Potentially a very wide range of questions can be examined. However, the questions and the inputs fed into the simulation need to be carefully determined. For example it is interesting to see how the relative performance of different TACs is affected by uncertainties about the current biomass. However, to answer this question in a meaningful way requires the specification of the management strategy for future years. After the initial year of management, would the TAC be maintained at the same level, or would it be adjusted in the light of improved knowledge of current biomass? If so, how quickly would the revised estimates be available, and how accurate would they be?

50. Productive use of the simulation approach is therefore complex, requiring repeated iterations between the user and the computer. Running simulations is not an operation that is efficiently done in a large working group. This is confirmed by the experience during the present meeting.

51. The Working Group believed that it would be extremely useful to examine further the use of simulation models in the provision of scientific advice. Some points that might be considered include (a) examination of the general ways in which simulation models might be of use to the Commission; (b) the identification of the sort of questions that might most usefully be addressed by simulation; (c) simulation to answer some representative questions; (d) determination of the requirements (data inputs, more specific framing of questions, computer hardware and software) for more effective use of simulation. Recognizing that this approach should be valuable in answering other questions of interest to the Commission (e.g. the impact of developing krill fisheries on associated or dependent species under various assumptions about the food requirements) the Group believed that this activity might well be one that should be sponsored by the Scientific Committee, as well as by the Fish Stock Assessment Working Group.

*Notothernia rossii*

South Georgia Subarea (48.3)

52. The immediate objective for this stock should be to rebuild the spawning stock as quickly as possible. Preferably no catches should be taken at all, but it was recognized that this would be impracticable if commercial fishing for the other species continues. The measures already taken by the Commission have clearly resulted in a decrease in the reported catch. The available data are not adequate to prove that they are also having the desired effect of rebuilding the stock.

53. It would be desirable to have better information on the incidence of by-catch and its variation in space and time. This could lead to modification in the management measures that would further reduce the by-catch. Some of this information should be available on data forms, but there has not been time to examine these in detail. For the present, the Working Group sees no reason to modify the measures already in force.

Other Atlantic Areas

54. In the absence of new information, the Group has no new advice to make about these stocks.

Kerguelen Subarea (58.5)

55. The immediate objective should be to rebuild the spawning stock. The measures currently in force appear to be having this effect, and should be continued.

*Champscephalus gunnari*

South Georgia Subarea (48.3)

(a) Protection of Small Fish

56. At present, the fishery starts catching the fish when they are relatively young, at 2–3 years old (the onset of sexual maturity). If the fish were afforded protection until they were 3 or 4 years old, there would be some benefits in terms of increased yield per recruit (Y/R) and a greater spawning stock biomass per recruit (SSB/R). This is shown in the following table, for different values of fishing mortality.

Fishing Mortality	Fished From Age 2		Fished From Age 3		Fished From Age 4	
	Y/R	SSB/R	Y/R	SSB/R	Y/R	SSB/R
0.2	.096	.335	.099	.409	.096	.488
0.4	.105	.158	.116	.236	.118	.326
0.6	.103	.089	.118	.162	.124	.251
0.8	.100	.056	.118	.125	.126	.211
1.0	.098	.038	.118	.103	.127	.186

57. The benefits are particularly marked in terms of spawning stock biomass and at higher levels of fishing mortality. For example if  $F = 0.8$  (and in peak years the fishing mortality has been well in excess of this value), changing the age at first capture from 2 to 4 would increase the yield per recruit by 25%, and the spawning stock biomass per recruit by four-fold.

58. Traditionally an increased age at first capture has been achieved by the use of a larger mesh size. This technique would be useful for *C. gunnari*, but the relation between mesh size of the codend netting used by the commercial trawlers and age at first capture is not clear. Dr Slosarczyk reported that the Polish scientists have made further selectivity studies. Due to limited ship time available for fishing with 80 mm meshes, these studies were not completed and will be continued in the 1987/88 season.

59. Further studies under commercial conditions and the full reporting of experiments that have already been carried out are needed. In the meantime the Group was not in a position to advise on the consequences of changing from the present 80 mm mesh.

## (b) Control of the Amount of Fishing

60. At present the fishery is characterized by the presence of only a limited number of age-groups, a high year-to-year variability in catches, and a relatively low spawner biomass. Reducing the level of fishing would tend to reverse these undesirable features. As noted earlier, the Group believed that, in many circumstances, setting a target  $F$  equal to  $F_{0.1}$  would result in a level of fishing that would be consistent with objectives such as increasing stability, or increasing spawner biomass.

61. In the case of *C. gunnari*,  $F_{0.1}$  was estimated to correspond to an actual value of fishing mortality of  $F = 0.21$ . So that the Commission can contrast the consequences of fishing at various rates, including  $F_{0.1}$ , simulations were run to compare possible future catches and spawner biomass under different policies. Three values of  $F$  (0.21, 0.3 and 0.5) were used, and three assumptions made about the current biomass (75 000, 150 000 or 225 000 tonnes) centred about the current estimate (see paragraph 20). To make the projections, a pattern of future recruitment was obtained by drawing a random sequence of recruitments from the values observed in the past. The same sequence was used for all the runs at different values of  $F$  and current biomass. The simulations therefore illustrate the differences to be expected between policies, but are not predictions of the future. The chosen sequence implies good recruitment around years 3 and 12 and poor recruitment between, but it is unlikely that this precise sequence will occur. What will occur will be a sequence of good and bad years, though their timing is likely to be different from that of the simulation.

62. Some results of the simulation concerning catch and spawning stock biomass are shown in Figure 3, a,b,c. For spawning biomass the picture is clear. The curves for the three levels of  $F$  are well separated, the spawning biomass being lower and relatively more variable at higher values of  $F$ . For all levels of initial biomass, in the last year of simulation the spawning biomass at  $F = 0.5$  is only some 40% of that of  $F = 0.3$ . For  $F = 0.3$ , the spawning biomass is 75% of that at  $F = 0.21$ .

63. As regards catch, in the first year the higher the  $F$  the greater the catch. After the initial period, the differences in yield between the three levels of fishing mortality chosen are not large. The ranking is not the same in all years. In years of poor recruitment there are, at the higher levels of  $F$ , few survivors from earlier good recruitment to support the fishery. Thus, for example, the predicted catches in year 8 from the population simulated at  $F = 0.5$  are very much less than those from the simulated populations for  $F = 0.21$  or  $F = 0.3$ . (It may be noted here that no allowance was made for any influence of spawning stock biomass on

subsequent recruitment. If there were any such effect, the catches at lower  $F$ s would be expected to be relatively greater from perhaps year 6 onwards).

64. Figure 4 shows the estimated biomass at age at the beginning and end of the simulation period, and indicates that the level of fishing mortality affects the age structure of the population.

65. In the absence of more clearly specified goals, the working Group could not conclude on the basis of this simulation, that one or other policy was better than the rest. However, the long-term interests (such as increasing spawning stock biomass) seem to point to the lower levels of  $F$  as being more desirable.

66. If  $F = 0.21$  (i.e.  $F_{0.1}$ ) were adopted as the target, then the corresponding catch limit for the 1987/88 season can be readily calculated as  $0.21 \times$  mean biomass in 1987/88. This biomass is not known, and for the present purposes (and for similar calculations in respect of other stocks) the biomass for the most recent period for which estimates are available is used.

67. The recent biomass is believed to be around 150 000 tonnes (paragraph 20). If the biomass in the 1987/88 season remains at this level (which is a different assumption from that used in the simulation), the catch quotas corresponding to any desired target  $F$  can be readily calculated. The values are:

$F_{0.1}$	(= 0.21)	31 500 tonnes
$F$	= 0.3	45 000 tonnes
$F$	= 0.5	75 000 tonnes

68. The current biomass is not well known, and even less is known about the abundance of incoming recruits. A catch of 31 500 tonnes in 1987/88 may therefore result in an  $F$  that is different from 0.21. If the Commission wishes to use catch limits as a reliable method of managing this stock, arrangements would have to be made for getting better estimates of current biomass, and of the recruitment strength (perhaps from surveys of 0-group fish with mid-water trawls).

#### Other Atlantic Sub-areas

69. The standing stock in these areas is very low, and cannot sustain significant fishing.

## Kerguelen Subarea (58.5)

70. The objectives of the measures in force are to increase the spawning stock biomass. Because only one age-group is present in the catches, the stocks are very sensitive to exploitation, and depend on the level of recruitment. Surveys of the incoming cohorts are planned for 1987/88. Simulations similar to those done for South Georgia could be made for Kerguelen, using estimates of current biomass. Regulations have been set on the size of fish and on the level of catches for the 1987/88 season. The level of catches is based on the mean index of abundance for the two preceding cohorts. These regulations should reduce the impact of fishing on future spawning biomass.

## *Notothenia gibberifrons*

### South Georgia Subarea (48.3)

71. Recent catches in the last four years have averaged around 2 500 tonnes, and the stock appears to be stable. Replacement yield is probably also at about the same level.

## FUTURE WORK

### Organisation of Working Group

72. It was noted that the Scientific Committee, at its 1987 session, would consider a proposal to establish the Ad Hoc Working Group on Fish Stock Assessment as a formal standing Working Group (SC-CAMLR-V, paragraph 9.5). To assist the Scientific Committee, the Group prepared draft terms of reference for the Committee's consideration (Appendix D).

73. There was discussion on ways to improve the efficiency of the Group and it was agreed that there would be advantages in structuring the meeting into two sequential phases: one in which analyses (including actual computation) would be carried out, and a second period during which the analyses would be reviewed and interpreted.

74. In developing this idea, the Group noted that the assessments could be conveniently divided into four parts:

- (a) Reduction of data and preliminary analyses (paragraph 75).
- (b) Review and refinement of preliminary analyses (paragraph 76).
- (c) Assessments and formulation of advice (paragraph 77)
- (d) Developmental work (paragraph 78).

75. Reduction of data and preliminary analyses should be carried out by the Data Manager before the Fish Stock Assessment Meeting commences according to agreed procedures and with advice from the Convener of the Working Group and the Chairman of the Scientific Committee. It was agreed that this system would be improved if a small steering group, including the Convener and Chairman, was formed to provide this advice.

76. Review and refinement of the preliminary analyses should be undertaken by the working Group in the first few days of the meeting. During this time, additional computations could be undertaken by participants assisted by the Secretariat. The objective would be to complete the necessary additional computations prior to the commencement of the second phase.

77. The second phase of the meeting would involve the actual assessment of the status of the stocks and the preparation of advice for the Scientific Committee.

78. The Working Group would identify priorities for the developmental work included in part (d) which could be undertaken by Members in the intersession period. This work would be reviewed by a sub-group of specialists. This sub-group could also meet during the first phase of the meeting.

79. Taking the above into consideration, it was therefore recommended that future meetings should be longer, and that next year the Group should meet for a period of seven working days.

80. In discussing the organisation of the work, the Group commented on the good job the Secretariat had done this year in preparing for the meeting. In spite of this preparation, however, it had been difficult to complete certain tasks set down for the present meeting. Furthermore, it was felt that the future workload was likely to increase with the analysis of additional data.

81. The Working Group noted that the Secretariat was submitting a proposal to the Commission this year for the purchase of computing equipment. The Working Group did not discuss the proposal in detail, but confirmed the requirement for efficient, timely support for its work and that appropriate computing, printing and graphics capabilities were essential in providing such support.

#### Fine-scale Data Formats

82. In accordance with the Commission's decision at its last meeting (CCAMLR-V, paragraph 66), the Secretariat had prepared and distributed forms for the submission of fine-scale catch and fishing effort and biological data for finfish stocks. The Working Group made the following suggestions for improving the form for catch and effort data:

- calendar months should be divided into three parts day 1 to day 10, day 11 to day 20 and the remaining days. It was recognised that the third period would vary depending on the number of days in the month but this could be allowed for in any computations;
- an explanation should be added to the instructions to the effect that searching time has not been requested as a measure of fishing effort for finfish;
- nominal mesh size should be specified, but where available, measured mesh size should also be included;
- to assist in completing the forms, the species list should be included on the back of the form together with species codes. (The species list should be amended to include the following categories: commercially important species; blank spaces for the listing of other species, families, and catches NEI.)
- instructions should be included to the effect that catches converted to fish meal should be reported by species if possible.

83. In the past, the codes for ship size groups specified for use on STATLANT fine-scale data forms have not been used by some countries in their national data reports. It was recommended that all Members of the Commission report the size of ships using the system described in the instructions for the STATLANT and fine-scale data forms.

84. It was suggested that some data errors might be eliminated at source if the Secretariat were to provide a data entry program to all Members. It was agreed that the form in which data were submitted be discussed further at the next meeting of the Group.

85. It was also suggested that the instructions for completing the forms should be expanded to include a map of the Convention Area and perhaps illustrations of commercially important species. These instructions should be distributed as a bound manual.

#### Statistical Bulletin

86. A draft Statistical Bulletin had been prepared by the Secretariat in response to the request made during the 1986 Meeting of the Scientific Committee (SC-CAMLR-V, paragraph 7.9). It was noted that the Statistical Bulletin was designed to serve several purposes. It was a means of providing data for analysis by Members, and a means of providing general information on the state of the fishery and current fishing and survey activities of Member countries.

87. The Group agreed that because of the different types of data and the different purposes for publishing catch/effort data as compared with biological data, these data should be published in separate volumes. It also agreed that the Group's comments on the contents and structure of the Bulletin should be limited to aspects affecting its use as a data source. Specific comments were:

- Tables 5 and 6 of SC-CAMLR-VI/6 should be combined in one table;
- a complete bound version should be issued each year rather than pages to be inserted in a loose bound volume;
- the taxonomic listing of species should be retained;
- the Bulletin of Biological Data should include input data to the VPA used in the Stock Assessment of the previous year, and age/length composition data by each country submitting data.

## Mesh Selectivity

88. It was noted that several experiments were conducted last season and that others were in the planning stage. In particular, attention was drawn to the Polish experiment (paragraph 20).

89. The Group noted that the USSR had completed an experiment, but the results were not yet available. Spain conducted extensive survey work last year, which was reported in its submission for membership of the Commission. The Group agreed that these two completed experiments could provide valuable data for assessments and asked that the members provide the relevant information and analyses as soon as possible.

90. Once again the Working Group emphasized the necessity for mesh selectivity experiments to be conducted using the same type of gear as that used in commercial fishing.

## Biomass Estimates of *Champscephalus gunnari*

91. Some differences in estimates of the biomass from surveys of *Champscephalus gunnari* have been attributed to the use of nets with different heights in the net openings, and to the depths at which the nets were trawled. This situation clearly points to the need to carry out experiments aimed at determining the distribution of fish in the water column in order to improve the interpretation of the trawl survey results. The possibility of using acoustic methods and pre-recruit surveys to provide further independent estimates of biomass was also suggested.

## Trawl Survey

92. Members of the Group commented on the reliability of trawl survey data and drew attention to the general need to provide for the adequate design of surveys being planned for future seasons. The value of co-ordinating surveys was also discussed and particular mention was made of the contribution this would make to knowledge of spatial distribution of stocks. In this context, the Working Group noted the decision of the last Scientific Committee Meeting (SC-CAMLR-V, paragraph 9.4), which established a group under the Convenership of Dr Sherman (USA) to co-ordinate plans for surveys in the 1987/88 season and the Commission's general support for this activity (CCAMLR-V, paragraph 58). The Group agreed that it should make a strong input into the work of Dr Sherman's group.

## Simulation Studies

93. It was agreed that further work on the development of simulation models and risk analysis methods should be undertaken for the investigation of the effects of particular management options.

## Collaboration with Other Organisations

94. Since its establishment, CCAMLR has benefitted from several studies undertaken as part of the SCAR BIOMASS Program. Examples are the review on the biology and status of exploited Antarctic fish stocks (BIOMASS Scientific Series No. 6) and the forthcoming review on krill and its biology and fisheries compiled by D. Miller and I. Hampton. Studies undertaken during the two Post-SIBEX Fish Data Evaluation Workshops resulted in a key to and catalogue of early life stages of Antarctic fish, which was of direct benefit to pre-recruit surveys planned under CCAMLR auspices in the near future. During the Post-SIBEX Fish Data Evaluation Workshops it was proposed to SCAR via the SCAR Group of Specialists on Southern Ocean Ecology to establish a new Antarctic Fish Ecology Working Party. To co-ordinate and closely liaise work undertaken by this group and the CCAMLR Fish Stock Assessment Working Group, it was recommended that the Chairman of the CCAMLR Fish Stock Assessment Working Group should be invited to the meetings of the SCAR Fish Ecology Working Party to ensure that the work of both groups is complementary.

95. The Data Manager reported that work had been undertaken during the year in collaboration with FAO to improve the STATLANT data from the Southern oceans held in the FAO data bank.

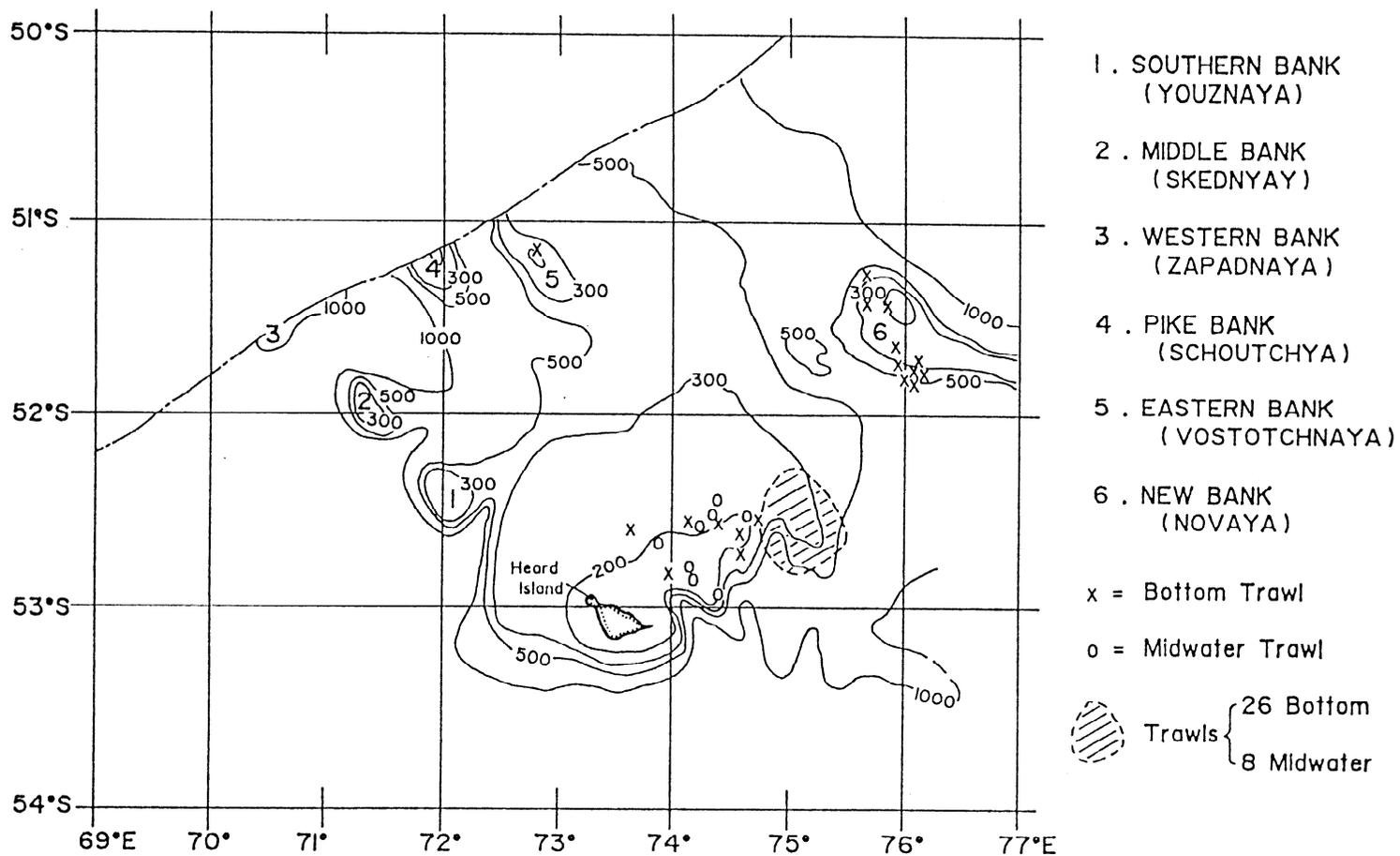


Figure 1: Distribution of research vessel survey trawls around Heard Island during the joint Soviet/Australian survey.

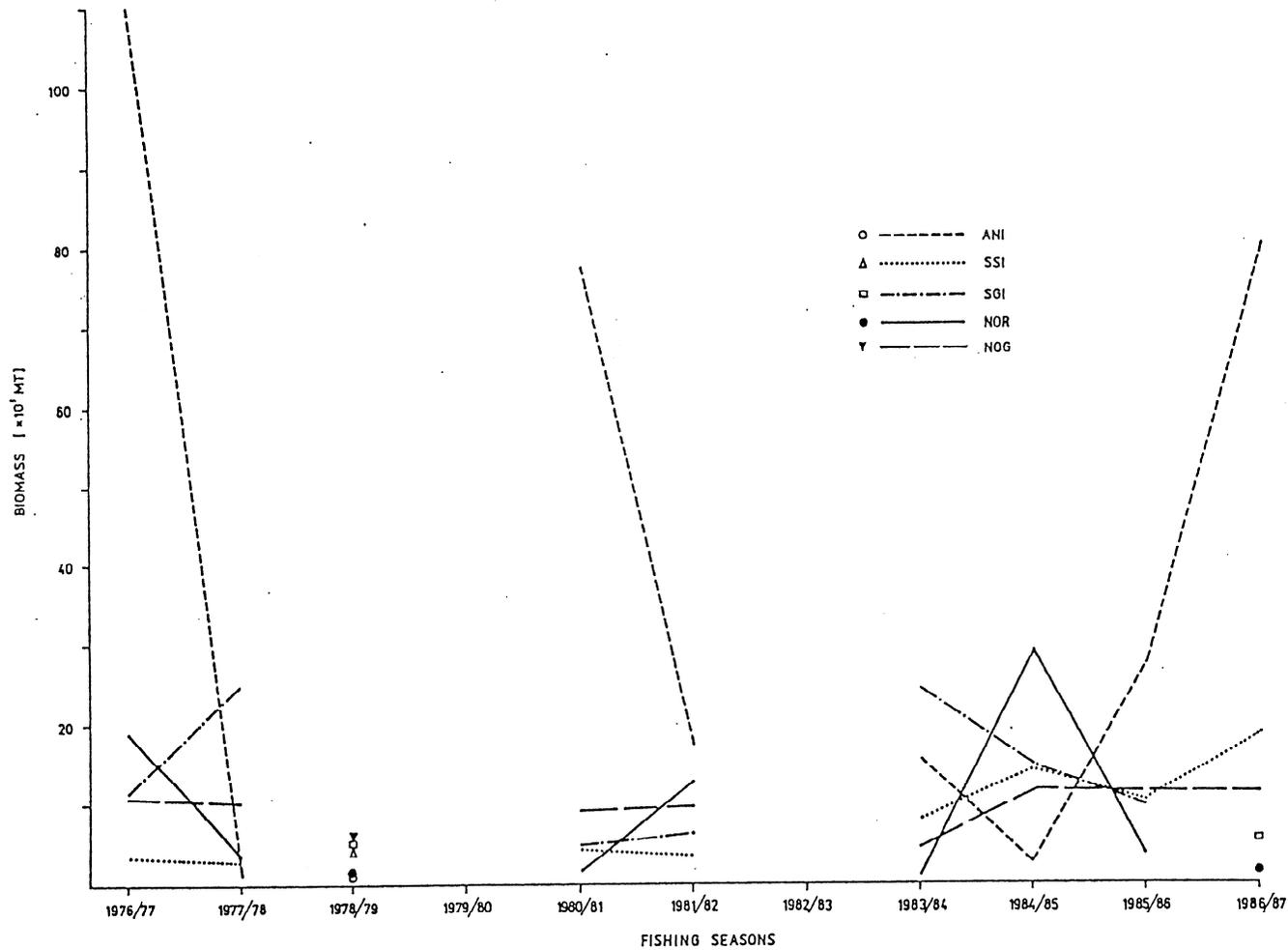


Figure 2: Changes in biomass of fish stocks around South Georgia, as estimated from catch rates of Polish trawlers. Symbols represent estimates based on catches by RV Professor Siedlecki.

ANI = *Champscephalus gunnari*    NOR = *Notothenia rossii marmorata*  
 SSI = *Chaenocephalus aceratus*    NOG = *Notothenia gibberifrons*  
 SGI = *Pseudochaenichthys georgianus*

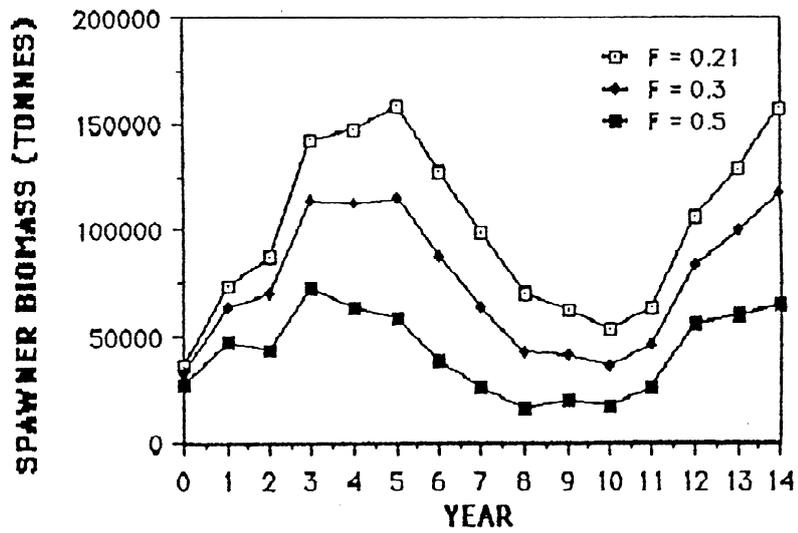
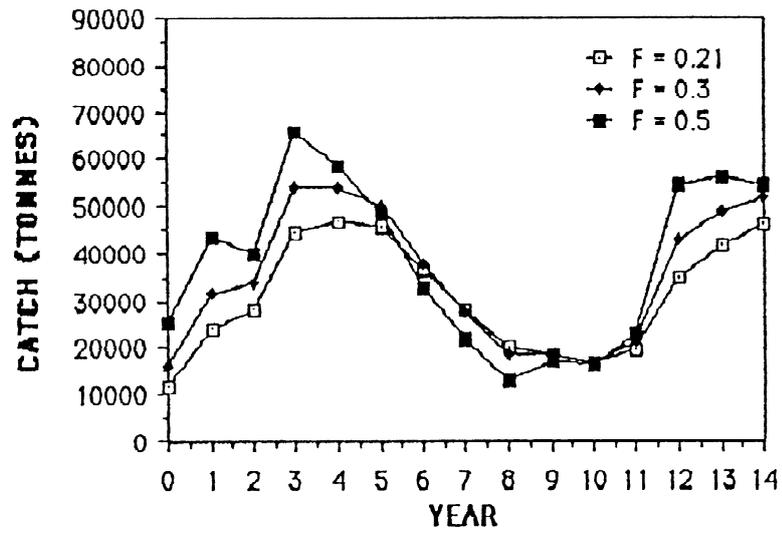


Figure 3a: Projected catches (top panel) and spawner biomass levels (bottom panel) for three different levels of fishing mortality ( $F = 0.21$ ,  $0.3$  and  $0.5$ ) and an initial biomass of 75 000 tonnes.

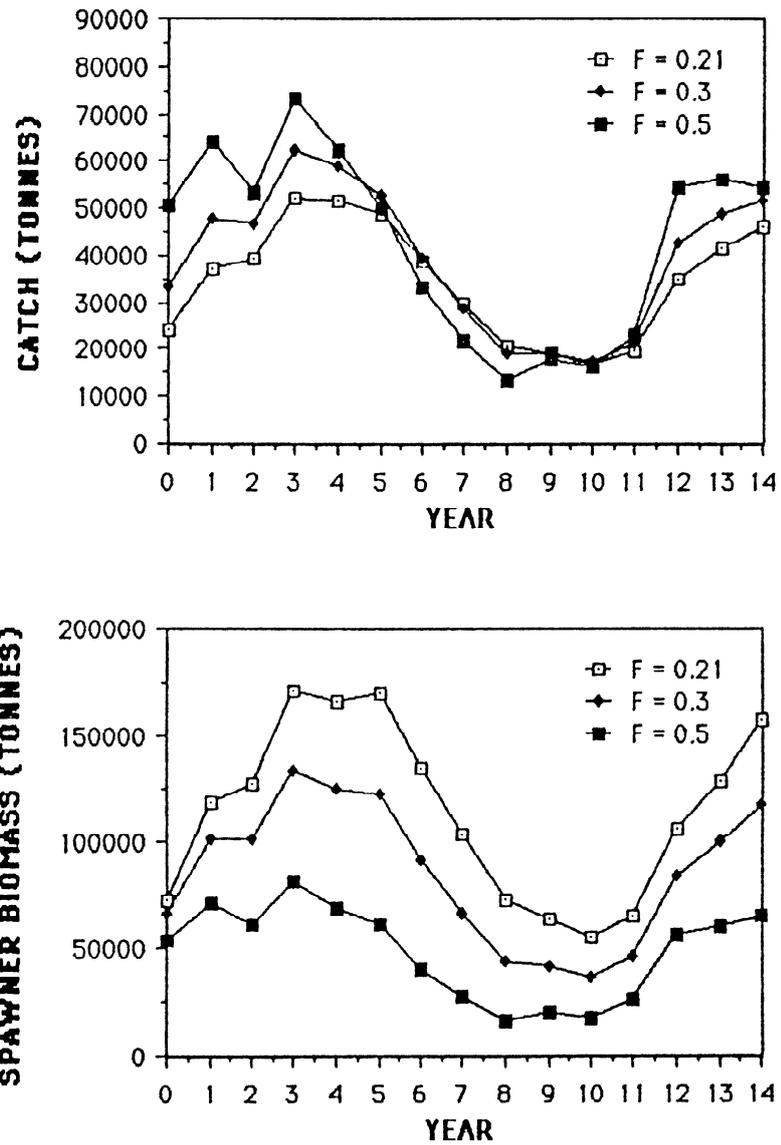


Figure 3b: Projected catches (top panel) and spawner biomass levels (bottom panel) for three different levels of fishing mortality ( $F = 0.21, 0.3$  and  $0.5$ ) and an initial biomass of 150 000 tonnes.

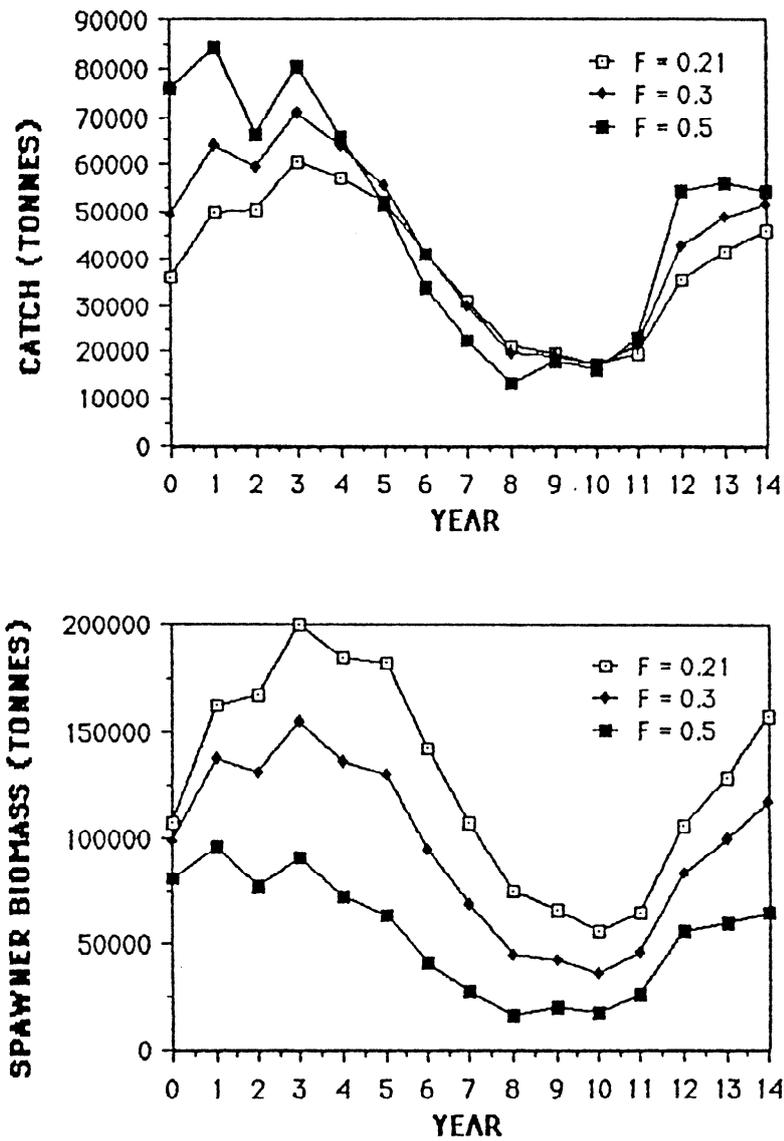


Figure 3c: Projected catches (top panel) and spawner biomass levels (bottom panel) for three different levels of fishing mortality ( $F = 0.21, 0.3$  and  $0.5$ ) and an initial biomass of 225 000 tonnes.

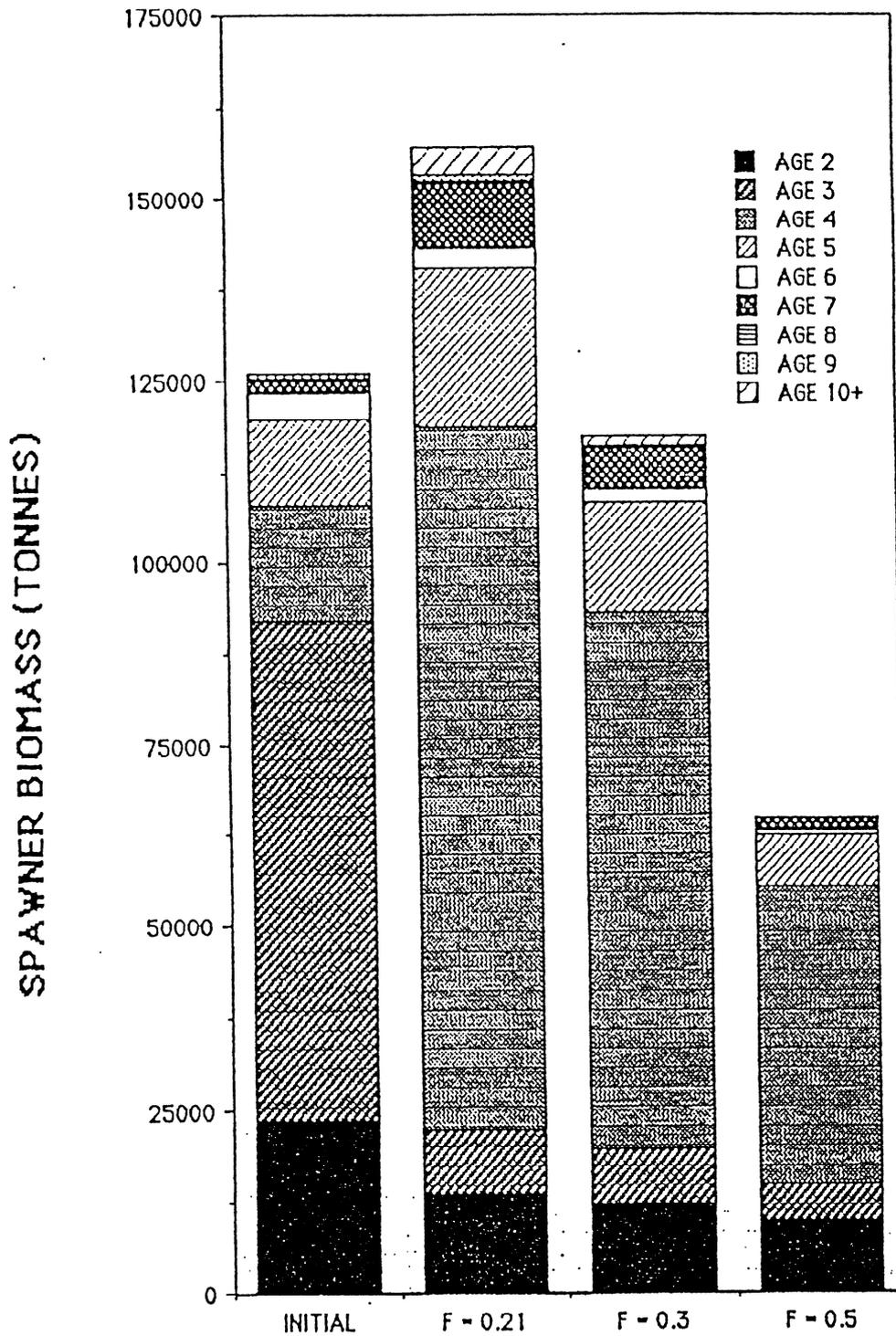


Figure 4: Projected spawner biomass for ages 2-9 and 10+ at the beginning (year 0) and end (year 14) of simulations involving three different levels of fishing mortality ( $F = 0.21$ ,  $0.3$  and  $0.5$ ). The first column gives the initial values (note that identical initial values were used in each simulation). The second column gives values at the end of the simulation with  $F = 0.21$ . The third column gives values at the end of the simulation with  $F = 0.3$ . The fourth column gives values at the end of the simulation with  $F = 0.5$ . The shading on the columns indicates the values for each age class.

**LIST OF PARTICIPANTS**

Ad Hoc Working Group on Fish Stock Assessment  
(Hobart, 19–23 October, 1987)

Dr K.-H. Kock (Convener, FRG)  
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## LIST OF DOCUMENTS

Ad Hoc Working Group on Fish Stock Assessment  
(Hobart, Australia, 19–23 October, 1987)

Meeting Documents:

WG-FSA-87/1	Draft Agenda
WG-FSA-87/2	List of Documents
WG-FSA-87/3	List of Participants
WG-FSA-87/4	Data and stock assessments for fish stocks in the Convention Area. (Secretariat)
WG-FSA-87/5	Key biological parameters of antarctic fish target speices in ccamlr areas 48.1, 48.2, 48.3, 58.4.2, 58.4.4. (K. Shust, A. Kozlov, V. Boronin, V. Shlibanov, V. Gerasimchuk and A. Zaitsev, USSR)
WG-FSA-87/6	Availability of catch, effort and biological data. (Secretariat)
WG-FSA-87/7	$F_{rep}$ – An example calculation for <i>Notothenia rossii</i> in Subarea 48.3. (Secretariat)
WG-FSA-87/8	Simulation of recovery rates fo fish stocks in the South Georgia Island area (Subarea 48.3). (R.C. Hennemuth and K.D. Bisack, USA)
WG-FSA-87/9	Re-analysis of some published data on <i>Notothenia rossii</i> from the South Georgia region of Antarctica. (USA).
WG-FSA-87/10	Analysis of changes in biomass of fish stocks in the South Georgia Area in 1976/77 – 1986/87. (M. Mucha and W. Slosarczyk, Poland).
WG-FSA-87/11	Identification key to the early life stages of Antarctic fishes. (A.W. North, UK)

- WG-FSA-87/12 Antarctic fish species which are currently exploited or have been harvested in the past on various fishing grounds or statistical areas and subareas.  
(Convener of the Ad Hoc Working Group on Fish Stock Assessment)
- WG-FSA-87/13 Figures showing the length composition of commercially important species taken from Subarea 48.3 during the 1986/87 fishing season.  
(Secretariat)
- WG-FSA-87/14 Report on Post SIBEX Fish Data Evaluation Workshop in Cambridge in October 1986 and August 1987.  
(Convener of the Ad Hoc Working Group on Fish Stock Assessment)
- WG-FSA-87/15 Simulation of Recovery Rates of Fish Stocks in the Kerguelen Island Area.  
(R.C. Hennemuth and K.D. Bisack (USA) and G. Duhamel, France)
- WG-FSA-87/16 Distribution of fish larvae at South Georgia: Horizontal, Vertical, and Temporal distribution and early life history relevant to monitoring year-class strength and recruitment.  
(A.W. North, UK)
- WG-FSA-87/17 Projected catches for *Champscephalus gunnari* from Subarea 48.3 under a variety of assumptions concerning recruitment, fishing mortality and initial biomass.  
(Secretariat)
- WG-FSA-87/18 Format specifications for summaries of fine-scale catch and fishing effort data submitted to the CCAMLR Secretariat.  
(Secretariat)
- WG-FSA-87/19 Format specifications for reporting fine-scale biological data to the CCAMLR Secretariat.  
(Secretariat)
- WG-FSA-87/20 Length composition data for *Patagonotothen brevicauda guntheri* taken from Subarea 48.3.  
(Secretariat)

## 2. Other Documents

- SC-CAMLR-VI/6 Draft outline of CCAMLR Statistical Bulletin.  
(Secretariat)

SC-CAMLR-VI/BG/5	Summary of fisheries data. (Secretariat)
SC-CAMLR-VI/BG/12 Rev. 1	Results of Fish Stock Assessment Survey, South Georgia region, November–December 1986. (W. Gabriel, USA)
SC-CAMLR-VI/BG/16	Brief report of the joint Soviet-Australian expedition of the USSR-FRV ‘Professor Mesyatsev’ to the Australian fishing zone around the territory of Heard and McDonald Islands, May–August 1987. (USSR)
SC-CAMLR-VI/BG/17	US Antarctic marine living resources program ecosystem monitoring survey 1986-87 Cruise results. Cruise No. SI 86-01 (1-111). (USA)
WG-CSD-87/12	Beyond MSY: a consideration of definitions of management objectives. (J.A. Gulland)
CCAMLR-VI/11	Proposal for purchase of computer equipment for data management and analysis. (Secretariat)
SC-CAMLR-VI/BG/23	A rationale for Conservation areas within Antarctic waters. (Australia)
SC-CAMLR-VI/BG/25	Inventory of existing information about early stages of Antarctic fish. (Observer for SCAR)
SC-CAMLR-VI/BG/26	CCAMLR Antarctic fish otoliths/scales/bones exchange system – Progress Report. (Convener of the Ad Hoc Fish Stock Assessment Working Group).

**AGENDA FOR THE MEETING**

Ad Hoc Working Group on Fish Stock Assessment  
(Hobart, 19–23 October, 1987)

1. Opening of meeting.
2. Adoption of Agenda.
3. Review of Data and Presentation of Documents:
  - Review of data submitted to CCAMLR prior to 30 September, 1987 and also in previous years.
  - Presentation of documents.
  - Report of the Fish Age Determination Workshop, July, 1986.
  - Present status of the otolith/scale/bones exchange scheme established under the auspices of CCAMLR. (Report of the Chairman of the Ad Hoc Working Group.)
  - Results of Post-SIBEX Fish Data Evaluation Workshop, Cambridge, August, 1987, that are of direct relevance to the Ad Hoc Working Group.
4. Trends in abundance of exploited Antarctic fish stocks derived from VPA and CPUE analyses and also from surveys of early life history stages and by trawling.
5. Review of values of estimated parameters. (This is to obtain agreement on the input data values, particularly M and Z, for subsequent analyses, e.g. yield per recruit.)
6. Trends in Recruitment
  - Year to year variability
  - Stock recruitment relationships
7. Assessment
  - Yield per recruit analysis
  - Production models

8. Consideration of Management Actions
  - Mesh size limitations
  - Target fishing mortalities
  - Estimation of minimum spawning stock biomass
  - Total allowable catches
  
9. Future Work
  - Organisation of Working Group
  - Data requirements
  - Data analyses required prior to future meetings
  - Future research
  - Collaboration with other organisations
  
10. Any Other Business
  
11. Adoption of Report.

**SUGGESTED TERMS OF REFERENCE FOR THE  
WORKING GROUP ON FISH STOCK ASSESSMENT**

- (a) Apply and develop methodologies for fish stock assessment, including:
  - (i) procedures for monitoring fish stock abundance and population structure
  - (ii) protocols for the collection and analysis of fishery-related data including the relevant operations of the CCAMLR data base
  - (iii) analytical procedures for the estimation and projection of fish stock population trajectories;
- (b) review and conduct assessments of the status and potential yield of fish stocks in the Convention area;
- (c) evaluate the potential impact on fish stocks of possible management actions.

**BIOMASS ESTIMATES AROUND SOUTH GEORGIA  
OBTAINED BY THE ‘ANTARTIDA 8611’ SPANISH SURVEY**

[from ‘Informe de Resultados Antártida 8611 Pescas Científicas’  
(Report of Results Antartida 8611 Scientific Fisheries) MAPA, SGPM, IEO.]

Method

Biomass

The target species biomass calculation by archipelago and by depth stratum was done by the swept area method (Saville 1978), which is obtained by multiplying the distance travelled by the gear (from the moment it is tense until it is turned around) by the horizontal opening. The horizontal opening was estimated by means of the following equation (De La Cueva Sanz, 1974):

$$JK = (((CD-AB)*AE+AB)*JO)/(JO+GJ+EG)$$

JK = Fishing gear’s horizontal opening

CD = Distance between the cables at 1 meter from the snatch blocks

AB = Distance between the snatch blocks

AE = Length of the paid out rope

JO = Size of the net

GJ = Length of the sweep wires

EG = Length of the bridles

The lengths of sweep wires and bridles were kept constant at values of 50 m and 15 m respectively throughout the survey.

Using to our advantage the accuracy in location afforded by the satellite tracking system GPS, the distance travelled was calculated according to the following formula:

$$\text{distance} = \cos^{-1} (\sin(\text{LATi}) * \sin(\text{LATf}) + \cos(\text{LATi}) * \cos(\text{LATf}) * \cos(\text{LONf} - \text{LONi})) * 60$$

whereas:

LATi and LONi: initial latitude and longitude

LATf and LONf: final latitude and longitude

In the final calculation of the mean swept area, all values that had been found to be clearly erroneous were excluded.

Within each archipelago the mean catch by haul and its corresponding standard deviations as well as variation coefficients were established for the various depth strata being studied.

The mean density by stratum was calculated extrapolating the mean catch by haul, expressed in tonnes, over an area of one square nautical mile.

The stratified mean for the whole area and its variance were obtained by applying the following formulae (Saville, 1978):

$$\bar{x}_{st} = \frac{\sum \bar{x}_n * \text{area}(n)}{\text{total area}} ; \text{var } \bar{x}_{st} = \frac{\sum \text{var } \bar{x}_n * \left[ \frac{\text{area}(n)}{\text{total area}} \right]^2}{\text{total area}}$$

The biomass estimates by stratum and for the total area were done by inferring the corresponding mean densities for the total surface of every area.

## RESULTS OBTAINED AND COMMENTS

### Swept Area

Mean values estimated for the distance travelled and the horizontal opening of the fishing gear are shown in Table VI.

For the travelled distance, a mean value of 2.221 nautical miles was obtained with a moderate variation coefficient of 24.09%, which indicated the accuracy of the estimate.

However, we can observe that considerable variability occurs in the opening of the fishing gear with a standard deviation greater than the mean.

Calculations of this parameter have always conflicted. Various tests carried out in test channels, have established an approximate ratio of 1/3 between the mean opening of the fishing gear and the length of the floats line.

Pauly (1983) obtained different values for this ratio in South western Asian waters. These varied between 0.4 and 0.6 and it was believed that the best answer would be the intermediate value equal to 0.5.

Estimates of 0.254, 0.30 and 0.56 were obtained for shellfish, cephalopod and cramp ray trawling gears respectively, at Surveys carried out by the Canary Islands Oceanographic Center of the Spanish Institute of Oceanography (Delgado and Santana, 1985; López Abellán, pers. com.).

The ratio of 0.37 observed in the fishing gear used during the ‘ANTARTIDA 8611’ survey falls within the range considered to be acceptable. The position close to the lower end can be accounted for as corresponding to a semi midwater gear, which has a greater structural tendency to a vertical opening, rather than to a horizontal one.

Table IV: Mean, standard deviation and variation coefficient obtained in the calculation of distance travelled (DR), horizontal opening of the fishing gear (AB) and swept area (AR), during the ‘ANTARTIDA 8611’ survey.

	DR (nm)	AB (nm)	AR (nm <sup>2</sup> )
No OF OBSERVATIONS	298	282	-
MEAN	2.221	0.007	0.016
STANDARD DEVIATION	47.21	252.00	0.020
VARIATION COEFF. (%)	24.09	128.57	125.00

Table XX: Mean catch per haul (X), mean biomass catchable by trawl (BME), standard deviation (SD), variation coefficient (CV) and mean density (DM) of some species captured around South Georgia during the 'ANTARTIDA 8611' survey. Limits of reliability (LC) = 95%.

SPECIES		<i>N. rossii</i>	<i>N. gibberifrons</i>	<i>D. eleginoides</i>
0-150 m	NUMBER OF HAULS	18	18	18
	X (kg/0.016 nm <sup>2</sup> )	0.19	1.67	0.003
	SD	0.14	1.00	0.003
	Cv (%)	73.68	58.88	100.00
	DM (t/nm <sup>2</sup> )	0.01	0.10	0.00019
	BME (t)	25	250	0.47
150-250 m	NUMBER OF HAULS	51	51	51
	X (kg/0.016 nm <sup>2</sup> )	4.35	6.61	0.17
	SD	2.83	1.04	0.09
	Cv (%)	65.06	15.73	52.94
	DM (t/run <sup>2</sup> )	0.27	0.41	0.01
	BME (t)	1 425	2163	53
250-500 m	NUMBER OF HAULS	29	29	29
	X (kg/0.016 nm <sup>2</sup> )	51.86	4.36	3.53
	SD	49.58	1.42	2.04
	Cv (%)	95.60	32.57	57.79
	DM (t/nm <sup>2</sup> )	3.24	0.28	0.22
	BME (t)	10 021	866	680
TOTAL	NUMBER OF HAULS	98	98	98
	X (kg/0.016 nm <sup>2</sup> )	16.91	4.83	1.09
	SD	14.17	0.69	0.58
	Cv (%)	83.80	14.29	53.21
	LC	166.59	28.40	105.78
	DM (t/nm <sup>2</sup> )	1.06	0.30	0.07
	BME (t)	11 471	3 252	733

SPECIES		<i>Ch. gunnari</i>	<i>Ch. aceratus</i>	<i>Ps. georgianus</i>
0-150 m	NUMBER OF HAULS	18	18	18
	X (kg/0.016 nm <sup>2</sup> )	21.72	0.92	0.79
	SD	17.44	0.34	0.34
	Cv (%)	80.29	36.96	43.04
	DM (t/nm <sup>2</sup> )	1.36	0.06	0.05
	BME (t)	3 405	150	125
150-250 m	NUMBER OF HAULS	51	51	51
	X (kg/0.016 nm <sup>2</sup> )	436.48	5.85	3.76
	SD	220.20	1.08	1.20
	Cv (%)	50.45	18.46	31.91
	DM (t/nm <sup>2</sup> )	27.28	0.37	0.24
	BME (t)	143 929	1 952	1 266
250-500 m	NUMBER OF HAULS	29	29	29
	X (kg/0.016 nm <sup>2</sup> )	20.42	2.88	3.22
	SD	7.30	0.97	1.54
	CV (%)	35.75	33.68	47.83
	DM (t/nm <sup>2</sup> )	1.28	0.18	0.20
	BME (t)	3 959	557	619
TOTAL	NUMBER OF HAULS	98	98	98
	X (kg/0.016 nm <sup>2</sup> )	222.61	3.87	2.92
	SD	106.94	0.66	0.74
	Cv (%)	48.04	15.50	25.34
	LC (%)	95.50	30.82	50.38
	DM (t/nm <sup>2</sup> )	13.91	0.24	0.18
	BME (t)	151 293	2 659	2 010