ANNEX 4

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

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

INTRODUCTION

The meeting of the Working Group was held at the CSIRO Marine Laboratories, Battery Point, Hobart from 23–30 August. Dr R.C. Hennemuth (USA) was in the chair. A list of those attending is given in Appendix 1. Dr J.A. Gulland was appointed as rapporteur. A list of documents presented to the meeting is given in Appendix II.

REVIEW OF BASIC DATA

2. The Secretariat reported on the data on catches, effort, length and age composition etc. that had been received from the fishing countries. A summary of what data are now available is given in Appendix III in which the information presented by the Secretariat has been modified in the light of explanations and corrections given by the participants.

3. The group had pleasure in noting that there had been a considerable increase in the volume of data reported to the Commission or provided to the Working Group, especially relating to length and age composition. This had enabled the group to make significant advances on the preliminary analyses presented at the 1984 Commission meeting. However, the reporting of commercial catch and effort statistics was in all cases falling short of the requirements set out in the report of the Woods Hole data meeting and in the annex to the 1984 meeting of the *ad hoc* Working Group. In particular, data was received only from Poland giving an area breakdown smaller than the subareas of the STATLANT B forms. These forms were available from all countries only for 1982/83, and only from Poland and France for other years. In the annex to last year's report the group had noted that, failing complete reports, 'it was essential to have at least some years of fine detail CPUE for comparative purposes'. The absence of these detailed data continues to make it difficult to determine accurately the trends in abundance of several species. The group also noted that for the USSR the catch data for the 1983/84 season had not been received by the Commission at the time of the Working Group meeting.

4. The group noted that there had been some confusion about the statistics of catches of *N. rossii* at South Georgia, due to the change in reporting from calendar year to split

(July–June) year, and the omission of data for the split year 1969/70 from some tabulations (e.g. in the summary catch statistics, SC-CAMLR-IV/BG/7). This was clarified by noting that a comparison between calendar and split year catches allowed the catches in half-year periods to be deduced. This is set out below.

	Period	Original calendar year report (FAO/CAMLR)	Revised (split year report)	Deduced half-year catches	Deduced split-year catches
1969	I–VI	89100			
	VII–XII		Not	89,100	399,704
1970	I–VI	403,100	reported	310,604	
	VII–XII		101,558	92,496	101,558
1971	I–VI			9,062	
	VII–XII	11,800	2,738	2,738	2,738
1972	I–VI	NIL		NIL	
	VII–XII		NIL		

5. For many of the earlier years data have been received only for major areas (e.g. Atlantic) and not for sub-areas (e.g. South Georgia). For analyses it is important to allocate catches at least to sub-areas. Up to 1977 it seems reasonable to assume that all South Atlantic catches were taken from South Georgia (48.3). In the 1977/78 season some Polish catches were reported from other sub-areas. Assuming that the Soviet catches had the same distribution as Poland, the distribution in the 1977/8 and 1978/9 seasons were estimated as follows (for *Champsocephalus gunnari*).

Year	Fishing Nation	48.1 t	48.1 %	48.2 t	48.2 %	48.3 t	48.3 %	Total 48 t
1977/78	Poland	–		38446	94.9	2069	5.1	40515
	USSR	–		96906		5208		102114
1978/79	Poland	7411	62.5	4331	36.5	110	0.9	11852
	USSR	28319		16550		420		45289

The group suggested that the Commission's tabulation should be modified along these lines in order to reduce the amounts included under 'sub-area unknown'.

6. In general, there had been few problems with the species information. However, the group noted that in some recent years there had been significant quantities of unidentified species reported from some sub-areas. It urged the countries concerned to make every effort to reduce these uncertainties.

7. Problems were also met in respect of both age and length data. Examination of age-length keys reported by different countries showed some differences. For example,

recent keys for the 45–47 cm group for *N. rossii* at South Georgia reported by FRG and the USSR were as follows:

Age	3	4	5	6	7
FRG (1985)			23	61	7
USSR (1984)	87	276	188	19	

Differences for *C. gunnari* between USSR and Polish age frequencies were also noted.

8. Though these differences (of rather more than one year) still allowed some clear conclusions to be reached about certain matters, for example changes in mortality rates, it was clearly very important that they should be resolved. This would require direct interchange of experience between those actually engaged in reading scales or otoliths. In the first instance, this might be done by exchange of material, but it is likely that a small workshop-type meeting will be desirable. Since those concerned are unlikely to be attending other CCAMLR meetings, the workshop might be held in some conveniently located institute between Commission sessions.

9. In respect of length, the group noted that some difficulties had arisen because different length groupings, e.g. 3 cm and 5 cm, had been used when reporting data in respect of the same stock. It is preferable that data should be reported by 1-cm groups, since this ensures no loss of information, and should, if the original data is already in a computer, entail little additional work. If broader groupings are used, it is important that all countries report their data (if not in 1-cm groups) by the same groupings. The groupings used in present reports to the Commission are shown in Table 1. This shows that nearly all countries are now reporting by 1-cm groups. The Working Group therefore urged that the other countries should adopt the same system. It noted that Poland could use this system and that USSR would also try to find some solution to the problem. The Working Group also urged strongly that all measurements should be carried out according to the standards recommended by BIOMASS (i.e. total length to the cm below).

10. As noted later (paragraph 25), some problems have been met concerning the source of data (research/survey/commercial vessels) and mesh size. This should always be specified. Also, although samples from any source have value, for some purposes, e.g. VPA, it is important to know the size and age-composition of the commercial catches. Most of the Soviet data referred to survey rather than commercial catches; and the group therefore urged the Soviet delegation to make every effort in the future to collect samples from their commercial vessels.

NEW RESEARCH

11. The group heard presentations from FRG on the results of research vessel surveys in early 1985 (Documents 3 and 4), France, concerning assessments of the stocks around Kerguelen (Document 9), Argentina, concerning growth of *Champsocephalus* near Elephant Island (Document 11) and USSR on the reproduction of several species round South Georgia (Document 5). It also had available to it an English translation of the USSR document SC-CAMLR-III/INF.10 available in Russian at the 1984 meeting. It noted that in addition to information directly relevant to stock assessment, which has been used in the analyses in the following sections of this report, these documents also contained interesting biological results of a more general nature. These aspects were not discussed in detail during the working group meeting. The group noted that the basis of some of the statements made in the 1984 Soviet document, e.g. on natural mortality rates, or optimum fishing patterns, was not clear in the document. This made it difficult to compare and integrate these values with those from other sources. It hoped therefore that more detailed reports would be presented to the Commission at future meetings.

ASSESSMENTS

General

12. Information summarising the information on catches, density and biological characteristics of the major stocks, up-dating the similar information presented in the 1984 report, is given in Table 2. The group noted that the estimates of biomass were based on the assumption that the catches represented the total stock within the path of the trawl (between the wings). For fish living close to the bottom this assumption of full catchability seems satisfactory, but for fish that are sometimes well off the bottom (e.g. *C. gunnari*) this may lead to an under-estimate of the stock.

South Georgia

Notothenia rossii

13. An extensive series of length and age data from the beginning of the fishery in 1970 taken from research vessels which may not be fully representative of the commercial catches

were reported by the USSR. They enabled analyses of mortality rates, recruitment and yield-per-recruit to be made.

Mortality Rates

14. Given an array of age composition data for a series of years, there are a number of ways in which estimates of mortality can be obtained, each of which has some advantages and disadvantages. In the absence of CPUE data, or other annual indices of abundance, which might allow the changes in abundance of a single year-class to be followed through its life in the fishery, the most useful approach is to obtain estimates of mortality from data in a single year, using Heincke's or similar methods.

15. The basic equations are

$$S = \text{survival} = \frac{\text{Total numbers of fish age x + 1 and older}}{\text{Total numbers of fish age x and older}}$$

and Z = total mortality coefficient = $- \log_e S$.

Calculation could be made using x as any fully recruited age, but the most useful estimate will normally be for x = youngest fully recruited age.

16. Other estimates can be obtained from the same data, for example from the slope of the right hand limb of an age-frequency distribution, when plotted on a logarithmic scale – the so-called catch curve. These methods will give estimates which will have different values, but they will all have similar sources of potential error. First, the numbers at age will be affected by selection and recruitment, so that the methods should be applied only for fully recruited ages, and for ages for which there are no changes in selectivity. Second, trends in year-class strength are confounded with mortality rates. Strong year-classes among the younger fish, and especially, for Heincke's method a strong year-class aged x, will cause the mortality rate to be over-estimated. Conversely a declining trend in the year-class strength will tend to produce low estimates of mortality.

17. With these reservations estimates have been made of mortality rates. The results of applying Heincke's method to the USSR and FRG data are shown in Figure 1. As noted elsewhere there are differences in interpretation in making age-determinations, with the FRG

interpretations tending to be older than the Soviet. Thus the age at full recruitment, used in producing the estimates, has been 6 for the Soviet data and 7 for the FRG data.

18. The alternative approach is illustrated in Figure 2, where the catch-curves corresponding to the USSR data in 1970 and 1984, and the FRG data for 1985, are given.

19. Both approaches show a very great increase in apparent mortality rate, since 1970. Despite differences in age-determination the Soviet and FRG data for 1984–1985 are consistent in showing high and approximately constant mortality rate from the age at full recruitment onwards for at least four or five years. At that point (about age 10) the data are too few to estimate age-specific mortality. In contrast, the 1970 data, which reflects conditions before fishing could have had a significant effect on mortality or length frequencies, should provide a measure of natural mortality. These data do not fit a constant mortality rate. Between ages 5 and 10, the numbers at age change little; between 10 and 12 there is a moderate decline, and then a very great decline between 12 and 13. Part of this may be explained by problems of age-determination, or by partial recruitment occurring over a wide range of ages (up to perhaps 9 or 10). However, the data are highly suggestive of a variable natural mortality, low over ages up to 10 or so, and then increasing. The Heincke estimates in Figure 1, which reflect the life-expectancy from 6 onwards are in 1970 and 1971 strongly influenced by the high mortalities after age 10, and therefore tend to over-estimate the mortality among the younger ages. However, under exploited conditions fish over age 10 are very scarce, and for the purposes of assessment it is the mortality rate among the younger ages that is important. A straight line representing an average natural mortality has been fitted by eye in Figure 2. This corresponds to a value of Z (= M) = 0.11. This is lower than other figures (e.g. 0.3 in the Soviet report at the 1984 meeting, SC-CAMLR-III/INF.10). For further calculations, e.g. of yield-per-recruit, values of 0.15 and 0.20 were used. While less subjective methods of fitting a line and obtaining an estimate of M. could be used, it is clear that whatever method is found to be appropriate will provide an estimate that will be lower than 0.3.

VPA and Recruitment Changes

20. In the report (p. 208) of its 1984 meeting, the Working Group had noted that the recruitment of *N. rossii* appeared to have decreased substantially. This was based on a rough comparison of the total contributions to the catches made by the year-classes present in 1970 (about 30–40,000 tons), and those caught in later years (about 5,000 tons). A more precise estimate can now be made, using the estimates of the numbers caught at each age in each year

(Table 3) and a Virtual Population Analysis. The type of analysis is indicated in Document 2 in Appendix II. With reservations concerning the representativeness of some input data (see paragraph 13), the VPA allows estimates to be made of the numbers in the stock at each age and of the fishing mortality on each age in each year. The results are given in Table 4. This shows the very high fishing mortality that occurred in the first years of the fishery, and also the large numbers that were present at each age at that time. The best quantitative estimates of the strengths of different year-classes can be obtained from the VPA tabulations. The numbers present at age 3 (or older ages, as indicated, for fish present in the stock in 1970), in millions, were as follows:

Year-class	Numbers	Y/c	Nos	Y/c	Nos
1958	6.5 (at 12)	1966	10.6 (at 4)	1974	6.5
1959	10.1 (at 11)	1967	5.6	1975	6.6
1960	15.6 (at 10)	1968	3.1	1976	4.6
1961	19.8 (at 9)	1969	3.4	1977	2.0
1962	21.6 (at 8)	1970	5.2	1978	0.7
1963	20.0 (at 7)	1971	6.1	1979	(0.3)
1964	20.3 (at 6)	1972	6.1	1980	(0.04)
1965	16.2 (at 5)	1973	6.8		

As indicated by the brackets, the estimates for the most recent years are sensitive to the values used for terminal F, and are therefore not very reliable. Even ignoring these last two very low values, the tabulation shows, not only that the average recruitment since 1970 is much smaller than that in the 1960s, but also that there has been a further decline in recruitment since 1976. There are some points that are not easily explained by a direct stock-recruitment relation, for example the moderately low year-classes of 1966–1969 for which the adult stock was still at its high, unexploited abundance. Nevertheless, the only prudent conclusion from the available data is that the recruitment is at a low value because of a low adult stock, and that the recruitment will remain at a very low level until the adult stock has been rebuilt.

21. Reports of rod and line fishing at the British Antarctic Survey base at Grytviken show declining catches from the time commercial fishing began. While too much weight should not be given to this evidence, it does confirm the changes in year-class strength estimated by other methods. It also illustrates the potential value of inshore surveys, e.g. with trammel nets, to monitor recruitment.

22. The Soviet delegation reported that Soviet scientists had carried out some surveys of juvenile fish. However, the information was not available at the time of the Working Group meeting, so it was not possible to use them to confirm or reject the conclusions about the trends in recruitment reached here. The Working Group urged that these data should be reported to the Commission as early as possible.

Yield-Per-Recruit

23. Calculations were made of yield-per-recruit, and biomass-per-recruit, using Soviet catch-at-age data, and values of M = 0.2 and M = 0.15. The detailed results are given in Document No. 13. The values of yields (gms/recruit) at age 2 may be summarised as follows:

	M = 0.15 Age at Recruitment					M = 0.20 Age at recruitment		
F	3	4	5	6	7	3	4	5
0.01	125	124	120	112	101	86	85	81
0.05	485	496	495	474	436	342	346	341
0.10	719	765	792	781	735	518	545	556
0.15	817	904	968	979	940	601	657	691
0.20	843	968	1070	1106	1081	633	716	775
0.40	748	948	1165	1291	1325	583	743	887
0.60	593	<u>850</u>	<u>1130</u>	1311	1383	487	<u>691</u>	<u>889</u>
0.80	500	770	1088	1302	1396	432	642	873

The average parameter values during recent years are approximately F = 0.6, with a mean age at first capture of 4 or 5. The corresponding values are underlined in the table above. This shows that purely in terms of yield-per-recruit there would be gains from conservation measures aimed at reducing fishing mortality, or increasing the size of first capture. The reductions in fishing mortality could be very substantial – down to 0.1 or less, i.e. less than one-sixth of the present value before there would be any significant fall in yield-per-recruit. Conservation measures, particularly reductions in fishing effort, could also have the more important effect of increasing spawning stock biomass.

Status of Stocks

24. The previous, 1984, report concluded that 'this stock is very severely affected by fishing'. All the further information discussed during the present meeting confirmed that conclusion. Not only was the stock depleted by the very large catches between 1969 and 1971, but the relatively small catches taken since then have been sufficient to cause further declines. Though the strengths of the year-classes currently in the fishery are not precisely known, they are certainly small, and small catches will be sufficient to prevent a recovery. The information on yield-per-recruit and current year-class strength, as well as on the effects of recent catches suggest that the current replacement yield is less than a thousand tons. In contrast, if the spawning stock could be rebuilt to provide recruitments of say 10 million fish (i.e. rather less than the recruitment in the 1960s), and the fishing mortality and age at first capture adjusted to provide a yield of around 1000 gm per recruit, this would correspond to a sustainable yield of around 10,000 tons.

Champsocephalus gunnari

25. Age and length data for this stock were available from a number of sources, including Polish commercial trawlers, FRG research vessels and Soviet survey vessels. There were considerable differences between these (see Figure 3). The FRG catches taken with a net with a small-meshed liner included large numbers of I-group fish around 15 cm, which were released by the larger mesh sizes used by the other vessels. The group noted that the reported Soviet survey catches included substantial catches of fish less than 30 cm, whereas because of a size limit of 30 cm, few fish of this size were taken in the commercial fishery. The survey data were therefore not fully representative of the commercial catches. This made it difficult to assemble reliable catch-at-age data for the fishery as a whole. The group therefore believed it was impracticable to attempt a VPA analysis at the present time.

26. It was possible to estimate total mortality rates, using the catch-curve method, for some recent data. This gave the following results:

1982/3	Polish data	Z = 1.1
1983/4	Polish data	Z = 2.2
1983	Soviet data	Z = 1.0
1984	Soviet data	Z = 0.6

27. These values are variable, and in the case of Poland possibly overestimates because of the presence of an apparently very strong recruiting year class (see paragraph 16). The difference between the Soviet and Polish figures may also reflect a systematic difference in fishing strategy. The values are all considerably greater than the value of natural mortality M = 0.35 used by the BIOMASS working group. This suggests a relatively high fishing mortality, probably in the range, taking an average over years of high and low fishing effort, of 0.5 – 1.0. This range is similar to the range of f = 0.8 to 0.9 in 1977/78 obtained by the BIOMASS Working Group. This estimate of the likely range of f also receives some confirmation, as already noted in last year's report, from the fact that catches have been high relative to the estimates of biomass from swept area methods.

Yield-Per-Recruit

28. Using the value of M = 0.35, and the USSR weight at age data, calculations were made of the yield-per-recruit. The results are given in Document No. 14 and are summarised below (as yield in grams per recruit at age 2).

Fishing Mortality	Age at First Capture		
	2	3	4
0.01	8	7	6
0.05	31	30	28
0.10	50	49	46
0.15	61	62	59
0.20	68	70	68
0.40	74	82	84
0.60	73	83	88
0.80	71	83	89

29. This shows that for the high levels of fishing mortality probably occurring now, the optimum age at first capture would be around 4. Also, there would be little or no loss in yield-per-recruit from a substantial reduction in fishing mortality. Such a reduction would also provide an increase in the spawning stock biomass.

30. While it appears that this stock is heavily fished, there is no indication that recruitment has, up to the present, been affected. Though the information on year-class strength is not as good as for Kerguelen, it does suggest that, as in the case at Kerguelen, recruitment is variable. This variability is in part the cause of the high variability in annual catches, and this effect is increased by the degree to which recent catches are dominated by a single year-class. This, as noted last year, makes the fishery vulnerable to falls in recruitment, a possibility which has to be recognised if the high level of mortality continues.

Other Species

31. The Working Group was not able to examine in detail the information concerning the other species. Estimates of total mortality Z, were made for *N. gibberifrons*, *C. aceratus* and *P. georgianus*, using the formula

$$Z = \frac{K(L_\infty - \bar{1})}{\bar{1} - 1_c}$$

where $\bar{1}$ is mean length in the catch above the size of recruitment 1_C, and K and L_∞ are the von Bertalanffy coefficients. The results using data from Poland and FRG are given in Figures 4 and 5.

32. In interpreting these figures it has to be noted that the method is not very precise, and often tends to give under-estimates of the true mortality. However, the method should, at the

minimum, be useful in indicating trends in mortality. It should also be noted that the method, like catch-curves, produces an estimate which relates to the average mortality over some period prior to the time of observation. This lag has to be taken into account when attempting to relate mortality estimates to the catches, which are shown in the upper part of Figures 4 and 5.

33. For *N. gibberifrons* Figure 4 shows a clear upward trend, from about 0.1 in 1975/76, to 0.3 or more after 1981. This seems almost certainly due to the increased catches: catches were negligible before 1975. The data suggest the current values of F and M are around 0.2 and 0.1 respectively. In absolute terms these may, because of problems with the method, be too low, but it does seem probable that fishing mortality (as an average over some years) is well in excess of natural mortality. This high rate of fishing may be detrimental to the stock in the long run. It was noted that this species is taken as a by-catch.

34. For the other two species there is no clear trend. Except for 1977/78, when 13,000 tons of *P. georgianus* were taken (which may be reflected in the higher estimates of mortality in 1980/81 and 1981/82), reported catches of both species have been small. Some catch of these species may be part of reported catches of unidentified species.

KERGUELEN

35. Detailed information on the fishery around Kerguelen, with particular reference to *N. rossii*, *N. squamifrons* and *C. gunnari*, was presented by G. Duhamel (Document 9). Since 1979 detailed log-book data had been collected by the fishing vessels, and reported to the French authorities. This has allowed a detailed description of the location of the main fishing trends to be compiled, and catch-per-unit-effort data to be calculated by small areas.

N. rossii

36. The decline noted in the previous report has continued, as reflected by the CPUE in the peak season (in the winter, in the waters off the south-east coast – see Figure 2 of Document 9), and by the adjusted CPUE. The mean age and mean lengths have not changed much since 1980, so it is possible that, as in the South Georgia area, recruitment has been affected by the decline in the adult stock. In any case, it is clear that this stock is heavily exploited, and that even the relatively low catches (an annual average of around 5,000 tons since 1980) have been greater than the depleted stock can withstand.

N. squamifrons

37. This species is mainly found to the south and south-east of the island. The CPUE for these regions shows a fairly regular cycle with peak catch rates in the summer. The data since the 1979/80 season show no clear trend; the 1979/80 value was higher, but the values for the following four seasons have been all about equal.

38. Recent catches have been considerably smaller than the peak catches of 26,500 and 51,000 tons taken in the 1970/71 and 1971/72 seasons. However, there is no evidence to determine whether there has been a decline in stock size, or whether the decrease in catch is due more to a decrease in fishing effort on a species which is less attractive commercially than *N. rossii*.

C. gunnari

39. This relatively short-lived species is caught over much of the shelf, except the north west, including the Skiff Bank. The greatest catches are taken to the east of the island. Length and age analysis show that there are large variations in year-class strength. A good cohort was born in 1979, and supported good catches in the 1981/82 and 1982/83 seasons, but has now become scarce. Information from the 1984/85 season suggests that the 1982 cohort is also good. The relatively high total mortality suggests that fishing mortality may now be significant, but there is no evidence that this is affecting recruitment in any way. There is also at present no explicit analysis of the present situation of the fishery on the curves of yield-per-recruit as a function of mortality or size at first capture.

MANAGEMENT MEASURES

General Considerations: Mesh Regulation

40. In other areas regulations on the minimum size of mesh have proved acceptable methods for increasing the effective size (and age) of first capture. In the Convention area, comparisons of catches by research vessels using small meshes with those of the commercial fleets have shown, as noted above, that for *C. gunnari* the commercial nets do release the smallest size-class of fish (ca. 15 cm). For the other species a comparison of the data sets shows no such difference, with very small fish being absent even from the small-mesh

catches. This suggests that the small fish are absent from the commercial fishing grounds and that all sizes of fish offshore can be retained in the mesh sizes now in use.

41. The earlier analyses did suggest, on the basis of yield-per-recruit analyses, that if the age (and size) at first capture of at least *N. rossii* and *C. gunnari* was increased, then the yield-per-recruit and stock would improve. Because the selective action of a trawl is not exact, and selection occurs over a range of sizes, there cannot be a unique match of mesh size to size of first capture. However, it is usual to choose the mesh size whose 50% selection point (i.e. the length at which 50% of the fish will pass through the meshes) is equal to the desired length at first capture. This mesh size is in turn determined by the relation

50% selection point = selection factor x mesh size.

42. There were no direct observations on selectivity for Antarctic fish available at the meeting. It was therefore not possible to make good estimates of the appropriate mesh size. However, the selection factor (SF) must be closely related to the shape of the fish, and for fish free of spikes and projections the SF is close to the ratio of total length to maximum girth. It was therefore suggested that a first approximation to the SF could, in the absence of direct experiments at sea, be obtained from the physical examination of the fish, and measurements of girth and length. This might give acceptable values for some species, but it was pointed out that other species e.g. some ice fishes spread their gill covers and fins when caught, thus making it difficult to get through the meshes, and reducing the SF below the value that might otherwise be expected.

43. With this reservation, the group felt that some observations on girth and total length could be useful, but it also emphasised strongly the need for direct field observations on selectivity e.g. through the use of small-meshed covers, and urged countries to take advantage of any opportunity to carry out selectivity experiments.

44. The group noted that it is important, when introducing mesh regulations, to have a clear understanding of what is meant by a mesh of a given size. This question has been the subject of lengthy discussions in other Commissions, especially in the north Atlantic, and the experience of those bodies should be drawn upon in establishing CCAMLR rules. In this connection, the Working Party noted that the formulation used by the French authorities in respect of Kerguelen provided a useful starting point. This was as follows

Mesh size

'1. A mesh is of a minimum size when, diagonally stretched along the length of the net, a flat gauge, 2 mm thick and of the appropriate width, will pass easily through the mesh when the net is wet.

2. The mesh size in a net is of the acceptable size when at least 60% of the measurements on a series of 20 consecutive meshes reach the standard set out in paragraph 1. The measurements should be made at least 10 meshes away from the end of the cod-end, parallel to the longitudinal axis of the trawl.'

Closed Areas

45. Protection of any desired group of fish-juveniles, spawners etc. can also be achieved by closing areas for all or part of the year where these fish are abundant. The group therefore reviewed information on such distributions.

46. *Notothenia rossii* is known to spawn during May and June at South Georgia. No information is available on precise spawning locations. Differing opinions were discussed by the Working Group. According to some the spawning grounds are located within the 12-mile limit. Other opinions indicate that spawning occurs in a water depth of 120–350 m, which would suggest that spawning sites could be almost anywhere on the shelf. The same species at Kerguelen spawns in water at about 300 m deep on the shelf break and the same situation may apply at South Georgia. The group recommended that some sampling by research vessels be made to clarify this situation. Juveniles are demersal and inhabit the coastal kelp beds until four or five years old.

47. *Champsocephalus gunnari* spawns during April and May in the fjords and bays following aggregation and migration inshore in the preceding two months.

Management Needs

South Georgia

Notothenia rossii

48. This stock is severely depleted, and the only hope for significant catches in the future is to rebuild the spawning stock. There should certainly be no directed fishery, but since any incidental catches would cause further declines in the stock, measures should also be taken to keep incidental catches to the minimum.

Champsocephalus gunnari

49. The stock appears to be heavily fished, even though there is no indication that recruitment has been affected as yet. Gains in terms of yield-per-recruit would be expected from any measures that increased the age of recruitment (e.g. mesh size), or reduced the fishing mortality (e.g. limits on annual catches, or on the number of vessels operating). Measures of the latter type by increasing the number of year-classes contributing effectively to the fishery, would reduce the year-to-year variability, and the vulnerability of the fishery to declines in recruitment.

Notothenia gibberifrons

50. The present fishing mortality, though due only to by-catch, appears to be high. It would seem desirable to keep the amount of by-catch to as low a level as practicable.

Kerguelen

51. Since 1979 a number of controls have been progressively established by the French authorities. These are set out in the report of the 1984 meeting of the Scientific Committee (paragraph 7.22). These measures seemed to have prevented the occurrence of the serious decline that has occurred for the South Georgia stock of *N. rossii*. However, the present controls seem to have been applied too late to prevent some decline in the stock of *N. rossii* in recent years, and consideration should be given to some strengthening. It might also be useful to analyse age and length data for *C. gunnari* to determine mortality rates, and make

yield-per-recruit calculations. These could show whether, to improve the yield-per-recruit, it might be desirable to reduce the amount of fishing, or increase the size at first capture.

FURTHER ACTIVITIES

52. The group emphasised that the first priority in terms of actions which would facilitate future assessment studies was to improve the amount, detail, quality and timeliness of basic data. Significant improvements were achieved in the reports to the Commission in advance of the present meeting. However, in a number of aspects, particularly regarding the submissions of detailed catch and effort statistics, the present reports by some of the biggest fishing countries fell short of the basic standards set out in existing Commission reports.

53. The group also noted a number of research studies which would be of particular value. These included a clarification of the methods of age determining, and of the present differences in interpretation between countries; mesh selection studies; the monitoring of young (up to 4 years old) *Notothenia rossii* in the inshore waters of South Georgia; and a more precise identification of the spawning grounds of this and other species.

54. The group noted that much of the time during its meeting had been taken up with work of data compilation, and running routine analyses such as VPA. With the benefit of experience, it is clear that the duration of the meeting could be shortened, and more time spent in discussions of matters of substance arising from the analyses, if most of this work could be done in advance of the meeting. The group therefore suggested to the Scientific Committee that, when similar meetings are convened in the future, clear guidance should be given to the Secretariat, so that they can carry out the preliminary analyses. Consideration should also be given to possible modifications of the latest dates of submission of data to the Commission.

ADOPTION OF THE REPORT

55. The Working Group adopted its Report.

CLOSURE OF THE MEETING

56. The Chairman in closing the meeting, thanked the Rapporteur, Dr Gulland, and others of the group who had worked on specific tasks during the meeting. He also expressed the appreciation of the Working Group to the CSIRO Marine Laboratories for making their facilities available.

APPENDIX I

LIST OF PARTICIPANTS OF FISH STOCK ASSESSMENT WORKING GROUP

(23–28, 30 August, 1985)

ARGENTINA	Dr A. Tomo Dr E. Marschoff
AUSTRALIA	Dr R. Williams Dr K. Kerry Mr W. de la Mare Dr G. Kirkwood Mr P. Heyward
CHILE	Dr A. Mazzei
EEC	Dr G. Duhamel
FRANCE	Dr. J.-C. Hureau
FRG	Dr K.-H. Kock
GDR	Dr W. Ranke
JAPAN	Dr Y. Shimadzu Dr Y. Watanabe
NORWAY	Nr O.J. Østvedt
POLAND	Dr W. Slosarczyk
SOUTH AFRICA	Mr D. Miller
USSR	Dr R. Borodin Mr S. Komogortsev
UK	Dr J. Beddington Dr I. Everson
USA	Dr R. Hennemuth Dr W. Gabriel
IUCN SCAR/SCOR OBSERVER	Dr J. Cooke
INVITED EXPERT	Dr J. Gulland (UK)

SECRETARIAT	Dr D. Powell Mr F. Ralston Dr E. Sabourenkov

APPENDIX II

FISH STOCK ASSESSMENT WORKING GROUP 23–30 AUGUST, 1985

LIST OF DOCUMENTS

Fish WG/1985/Doc.1	Draft Agenda Fish Stock Assessment Working Group 23–30 August, 1985
Doc.2	Note on Available Data and Programs for Fish Stock Assessment (Submitted by the Secretariat)
Doc.3	Preliminary Results of Investigations of the Federal Republic of Germany on *Notothenia rossii marmorata* Fischer 1885 in January/February 1985 (Karl-Hermann Kock)
Doc.4	Estimates of Fish Stock Biomass around South Georgia in January/February 1985 (Karl-Hermann Kock)
Doc.5	Reproduction Parameters of *Notothenia rossii marmorata*, *Notothenia gibberifrons* and *Champsocephalus gunnari* of South Georgia Island (L.A. Lisovenko)
Doc.6	Summary of Biological and Catch Data
Doc.7	List of Documents
Doc.8	Fish Catch Reports from the Peninsula, South Georgia and Kerguelen Subareas, 1970/71–1983/84
Doc.9	Distribution and Abundance of Fish on the Kerguelen Islands Shelf (G. Duhamel)

Doc.10 USSR Catches, Split-Year 1969/70
(Submitted by the Secretariat)

Doc.11 Age and Length Growth of *Champsocephalus gunnari*, Lonnberg 1905 (Pisces, Chaenichthyidae, in the Area of Elephant Island, West Zone, Antarctica
(Aldo P. Tomo)

Doc.12 List of Participants

Doc.13 Yield Per Recruit Calculations – *N. rossii*, South Georgia

Doc.14 Yield Per Recruit Calculations – *C. gunnari*, South Georgia

APPENDIX III

Data Availability (Update of Document 6)

STATLANT CATCH REPORTS

COUNTRY	SPLIT YEAR	FORM 8A[1]	FORM 8B[2]
USSR	71–78	Area Only	No
	79	Area Only	Catch/Mo/Area Only
	80–82	Yes	No
	83	Yes	Yes (X MSS)
	84	No	No
POL	77–85	Yes	Yes (MSS is MIXED)
GDR	77	Area Only	Despatched but not received before meeting.
	78–81	Yes	Despatched but not received before meeting.
	82–83	No Fishing	No Fishing
	84	Yes	Yes
FRA	80–85	Yes	Yes (EFF Unit is Days Fished)
BGR	78–80	Yes	Yes (X MSS, GEAR)

[1] Species
Split year
Subarea

[2] Species
Month
Gear
Effort (EFF)
Main Species Sought (MSS)
X = Not by

SPECIES/AREA	LENGTH COMPOSITION	AGE COMPOSITION	AGE/LENGTH KEY	LIFE HISTORY PARAMETERS				CPUE
				WEIGHT AT AGE	MATURITY AT AGE	MORTALITY	PARTIAL RECRUIT.	RESEARCH VESSEL
Notothenia rossii /So. Georgia	USSR: 70–73 75 77–78 81–83 85 Exploratory Fishing Mesh=120mm.		USSR: 70–73 75 77–78 81–83 85 W	USSR: 70	USSR: 70			
	GDR: 77 78 80 81							
	FRG: 85 Research Vessel		FRG: 85 Research Vessel	FRG: 85				
	POL: 77–85 (X80,83) [Mesh=60–100mm] Commercial							POL: 77–84 (SC-CAMLR-III/BG/11)
/48.1 Peninsula Subarea	JPN: 85 GDR: 79 FRG: 85		75–76 & 77–78 Available in published papers					
/Kerguelen	FRA: 80–85 Shelf 80–85 Skiff B Commercial							
Champsocephalus gunnari /So. Georgia	USSR: 72–84 X82 Research Vessel		USSR: 72–84 X82 Research Vessel	USSR: 78 Res.Vess.	USSR: 78 Res.Vess.			

SPECIES/AREA	LENGTH COMPOSITION	AGE COMPOSITION	AGE/LENGTH KEY	LIFE HISTORY PARAMETERS				CPUE
				WEIGHT AT AGE	MATURITY AT AGE	MORTALITY	PARTIAL RECRUIT.	RESEARCH VESSEL
	POL: 76–84 X80,83 Commercial Also Shag Rocks 77,79,81	POL: 75–79 81–82 84 Commercial	POL: 76–84 X80,83 Commercial Also Shag Rocks 77,79,81	POL: Sosinski Paper				POL: 77–84 (SC-CAMLR-III/BG/11) Research & Comm [85Commercial]
	FRG: 85 Research Vessel							
	GDR: 77 78 80							
/48.2 So. Orkney	FRG: 85							
/48.1 Peninsula Subarea	FRG: 85 Research Vessel							
	GDR: 79 80							
	JPN: 81,82,85							
/Kerguelen	FRA: 80–85 Shelf, Skiff B Commercial							
N. squamifrons /Kerguelen	FRA: 80–85 Shelf 81–82 Skiff B.							
Pseudochaenichthys georgianus /So. Georgia	POL: 77–79 81–82 84 Commercial						POL: 77–84 (SC-CAMLR-III/BG/11) Research & Comm	

SPECIES/AREA	LENGTH COMPOSITION	AGE COMPOSITION	AGE/LENGTH KEY	LIFE HISTORY PARAMETERS				CPUE
				WEIGHT AT AGE	MATURITY AT AGE	MORTALITY	PARTIAL RECRUIT.	RESEARCH VESSEL
	FRG: 85 Research Vessel							
	GDR: 77 78							
N. gibberifrons /So. Georgia	POL: 76–82 X80 Commercial Also Shag Rocks 77,79,81	POL: 76–82 X80	POL: 76–82 X80 Commercial Also Shag Rocks 77,79,81					POL: 77–84 (SC-CAMLR-III/BG/11) Research & Comm
	FRG: 85 Research Vessel							
				USSR: 71	USSR: 71			
	GDR: 77 78 80 81							
/48.2 So. Orkney	FRG: 85							
/48.1 Peninsula Subarea	JPN: 81,82,85 Research Vessel							
	GDR: 79 80							
	FRG: 85							
N. guentheri /48.1 Peninsula Subarea	FRG: 85 Research Vessel							
Chaenocephalus aceratus /So. Georgia	POL: 77–85 X80,83 Commercial							POL: 77–84 (SC-CAMLR-III/BG/11) Research & Com

SPECIES/AREA	LENGTH COMPOSITION	AGE COMPOSITION	AGE/LENGTH KEY	LIFE HISTORY PARAMETERS				CPUE
				WEIGHT AT AGE	MATURITY AT AGE	MORTALITY	PARTIAL RECRUIT.	RESEARCH VESSEL
	FRG: 85 Research Vessel							
	GDR: 77 78							
/48.2 So. Orkney /48.1 Kerguelen	FRG: 85							
Dissostichus eleginoides /So. Georgia								POL: 77–84 (SC-CAMLR-III/BG/11) Research & Comm
Other Species /48.1 Peninsula Subarea	JPN: 81,82,85 Not all species all years Research Vessel							

TABLE I: Length groups used for length frequency calculations

(measured length range is in brackets – in cm)

	N. rossii	*N. squam.*	*N. guentheri*	*N. gibberif.*	*Ps. georgianus*	*Ch. aceratus*	*Ch. gunnari*
Argentina							1cm (20–46)
Japan*	1cm (32–59)			1cm (5–44)	1cm (13–52)	1cm (9–55)	1cm (8–41)
France**	1cm (32–87)	1cm (16–53)					1cm (11–38)
Poland	2cm (30–86)			1cm (6–51)	2cm (14–62)	2cm (12–80)	1cm (12–68)
FRG	1cm (34–73)		1cm (9–21)	1cm (4–49)	1cm (5–58)	1cm (8–71)	1cm (3–58)
USSR	2cm (39–71) 3cm (30–84) 5cm (30–85) 6cm (33–81)						2cm (12–60) 4cm (16–56)

* In Japan 1cm length groups are also used for other species: *N. nudifrons*, *N. neglecta*, *N. kempi*, *N. eulepidotus*, *Ch. rastrospinosus*, *Ch. wilsoni*, *P. antarcticum*, *Cryodraco antarcticos* and T. sp.

** In France 1cm length groups are also used for *D. eleginoides* and *Ch. rhinoceratus*

TABLE 2: Summary of Basic Information

Area: SOUTH GEORGIA
Species: NOTOTHENIA ROSSII

	Total Catch (t)	Target Species	CPUE (t/h) Polish Commercial Vessels	CPUE (t/h) Research Vessels	Biomass (t) From Commercial Catches	Biomass (t) From Research Vessel Catches	Mean length, weight, age $\bar{l}$ (cm)	$\bar{w}$ (g)	$\bar{t}$	
70	399704*	N. rossii					68.1 [a]63.6 [a]63.4	3664 3190 3890	9.3	
71	101558*						[a]61.9 [a]60.0 – [a]65.1 [a]64.9	3042 3294 – 3805 3683	–	
72	2738*						[a]60.1 [a]56.4 –	3325 2362 –	–	
73	23**						[a]59.5	59.4 2984	2418	6.8
74	5***							–	–	–
75	10**						[a]54.9 –	2390 –	–	
76	10753*					35682	[b]55.9 56.5 [a]54.9	2408 2077 2250	6.5	

* Where Atlantic catches were not reported by subarea, these were assigned to South Georgia

** Zero catch was reported. These were estimated from USSR length frequency samples for inclusion in VPA

*** Zero catch was reported. Estimated inasmuch as minimum value was required to proceed with VPA

**** Polish catches only

[a] Soviet
[b] Polish
[c] Split year
[d] FRG

Area: SOUTH GEORGIA
Species: NOTOTHENIA ROSSII

	Total Catch (t)	Target Species	CPUE (t/h) Polish Commercial Vessels	CPUE (t/h) Research Vessels	Biomass (t) From Commercial Catches	Biomass (t) From Research Vessel Catches	Mean length, weight, age $\bar{l}$ (cm)	$\bar{w}$ (g)	$\bar{t}$	
77	8365*	C. gunnari in Polish vessels			37928	–	59.1 [a]55.2	2381 2480	–	
78	6311*	Opportunistic in Polish vessels	0.05		5606	9326	[c]54.8 53.5 [a]54.8 [a]54.0	2279 1796 2430 2344	–	Total catch 48: 5143
79	7955*	Opportunistic in Polish vessels	0.44		–	1421	[c]48.9 50.5	1658 1476	–	Total catch 48: 8662
80	24897	Opportunistic in Polish vessels	0.07		–	–	–	–	–	
81	1651	C. gunnari in Polish vessels	0.02		2327		[c]43.0 43.0 [a]51.4	1159 906 1890	5.3	
82	1100	C. gunnari in Polish vessels	0.15		34284		[c]47.8 47.8	1556 1249	–	

* Where Atlantic catches were not reported by subarea, these were assigned to South Georgia

** Zero catch was reported. These were estimated from USSR length frequency samples for inclusion in VPA

*** Zero catch was reported. Estimated inasmuch as minimum value was required to proceed with VPA

**** Polish catches only

[a] Soviet
[b] Polish
[c] Split year
[d] FRG

Area: SOUTH GEORGIA
Species: NOTOTHENIA ROSSII

			CPUE (t/h)		Biomass (t)		Mean length, weight, age		
	Total Catch (t)	Target Species	Polish Commercial Vessels	Research Vessels	From Commercial Catches	From Research Vessel Catches	$\bar{l}$ (cm)	$\bar{w}$ (g)	$\bar{t}$
83	866	–	–		–		[a]53.6	2255 –	–
84	351****	C. gunnari in Polish vessels	0.06		2600		[c]45.9 – [a]51.6	1390 – 1867	–
85						12781	[c]47.1 [d]49.9	1494	

* Where Atlantic catches were not reported by subarea, these were assigned to South Georgia

** Zero catch was reported. These were estimated from USSR length frequency samples for inclusion in VPA

*** Zero catch was reported. Estimated inasmuch as minimum value was required to proceed with VPA

**** Polish catches only

[a] Soviet
[b] Polish
[c] Split year
[d] FRG

Area: SOUTH GEORGIA
Species: NOTOTHENIA GIBBERIFRONS

	Total Catch (t)	Target Species	CPUE (t/h) Polish Commercial Vessels	CPUE (t/h) Research Vessels	Biomass (t) From Commercial Catches	Biomass (t) From Research Vessel Catches	Mean length, weight, age $\bar{l}$ (cm)	$\bar{w}$ (g)	$\bar{t}$	
70										
71										
72										
73										
74										
75										
76	4999*					40094	[c]41.2 (41.2)	952 (802)		
77	3727*	C. gunnari			22339	–	[c]36.9 37.0	602 576		
78	16707*	Opportunistic in Polish vessels	0.53		19989	20100	[c]37.2 34.0	612 443		Total catch 48: -18500t
79	7485*	Opportunistic in Polish vessels	0.47	E		E 5894	[a]31.7 (30)	465 (302)		Total catch 48: 9910t

* Where Atlantic catches were not specified by subarea, these were assigned to South Georgia
( ) Research vessel catches
[c] Split year

Area: SOUTH GEORGIA
Species: NOTOTHENIA GIBBERIFRONS

	Total Catch (t)	Target Species	CPUE (t/h) Polish Commercial Vessels	CPUE (t/h) Research Vessels	Biomass (t) From Commercial Catches	Biomass (t) From Research Vessel Catches	Mean length, weight, age $\bar{l}$ (cm)	$\bar{w}$ (g)	$\bar{t}$
80	8143	Opportunistic in Polish vessels	0.45		–	–			
81	7429	C. gunnari in Polish vessels	0.30		13693	–	[c]33.0	602	
82	2605	C. gunnari in Polish vessels	0.13		25801	–	[c]31.9 32.0	422 368	
83									
84	531**	C. gunnari in Polish vessels	0.10		17700				
85				E		E	30.3		

** Polish catches only
( ) Research vessel catches

c Split year

Area: SOUTH GEORGIA
Species: CHAMPSOCEPHALUS GUNNARI

	Total Catch (t)	Target Species	CPUE (t/h) Polish Commercial Vessels	CPUE (t/h) Research Vessels	Biomass (t) From Commercial Catches	Biomass (t) From Research Vessel Catches	Mean length, weight, age $\bar{l}$ (cm)	$\bar{w}$ (g)	$\bar{t}$	
71	10701*									
72	551*									
73	1830*									
74	254*									
75	746*									
76	12290*					141469	35–45			
77	93400*	C. gunnari in Polish vessels			226606	–	35–45			
78	7277**	Opportunistic in Polish vessels	0.11		2372	34713	25–32		$\simeq$ 3	Total catch 48: 154309 #
79	518**	Opportunistic in Polish vessels	0.02		–	1152	25–32		$\simeq$ 3	Total catch 48: 28317

* Where Atlantic catches were not specified by subareas these were assigned to South Georgia
** Soviet Catches form Area 48 were prorated based on the distribution of Polish catches by Atlantic subarea
# Probably mostly taken around South Orkney Islands

Area: SOUTH GEORGIA
Species: CHAMPSOCEPHALUS GUNNARI

	Total Catch (t)	Target Species	CPUE (t/h)		Biomass (t)		Mean length, weight, age			
			Polish Commercial Vessels	Research Vessels	From Commercial Catches	From Research Vessel Catches	$\bar{l}$ (cm)	$\bar{w}$ (g)	$\bar{t}$	
80	7592	Opportunistic in Polish vessels	0.05		–	–				
81	29322	C. gunnari in Polish vessels	0.62		88414	–	25–30		≃ 3	
82	46311	C. gunnari in Polish vessels	0.62		46192	–	25–30		≃ 3	
83	128184	–	–		–	–				
84	8098****	C. gunnari in Polish vessels	1.46		153000***	–				
85	[d]			E		15821	[d]21.3			15821

*** Bottom and pelagic trawl data combined
**** Polish catches data

[d] FRG

Area: SOUTH GEORGIA
Species: DISSOSTICHUS ELEGINOIDES

	Total Catch (t)	Target Species	CPUE (t/h)		Biomass (t)		Mean length, weight, age			
			Polish Commercial Vessels	Research Vessels	From Commercial Catches	From Research Vessel Catches	$\bar{l}$ (cm)	$\bar{w}$ (g)	$\bar{t}$	
70										
71										
72										
73										
74										
75										
76						13497	–	–		
77	441*	C. gunnari in Polish vessels			4676		63.3 49.1	2956 1280		South Georgia Shag Rocks
78	1925*	Opportunistic in Polish vessels	0.03		–	7322	–	–		
79	194*	Opportunistic in Polish vessels	0.01		–	646	–	–		

* Where Atlantic catches were not specified by subarea, these were assigned to South Georgia
** Polish catches only

Area: SOUTH GEORGIA
Species: DISSOSTICHUS ELEGINOIDES

	Total Catch (t)	Target Species	CPUE (t/h)		Biomass (t)		Mean length, weight, age			
			Polish Commercial Vessels	Research Vessels	From Commercial Catches	From Research Vessel Catches	$\bar{l}$ (cm)	$\bar{w}$ (g)	$\bar{t}$	
80	261	Opportunistic in Polish vessels	0.02		–	–	50.5 39.3	1404 616		South Georgia Shag Rocks
81	322	C. gunnari in Polish vessels	< 0.01		233	–	–	–		
82	354	C. gunnari in Polish vessels	–		–	–	–	–		
83	116		–		–	–	–	–	–	
84	3**	C. gunnari in Polish vessels	0.01		–	–	–	–		
85						8159				

* Where Atlantic catches were not specified by subarea, these were assigned to South Georgia
** Polish catches only

Area: SOUTH GEORGIA
Species: PSEUDOCHAENICHTHYS GEORGIANUS

	Total Catch (t)	Target Species	CPUE (t/h) Polish Commercial Vessels	CPUE (t/h) Research Vessels	Biomass (t) From Commercial Catches	Biomass (t) From Research Vessel Catches	Mean length, weight, age $\bar{l}$ (cm)	$\bar{w}$ (g)	$\bar{t}$
70									
71									
72									
73									
74									
75									
76						36401			
77	1608	C. gunnari in Polish vessels		–	23210	–	[c]47.8	1086	
78	13015	Opportunistic in Polish vessels	0.47	–	39703	31057	[c]49.3	1199	
79	1104	Opportunistic in Polish vessels	0.19	E –	–	E 4192	[c]40.9	637	

* Polish catches only

[c] Polish split year (e.g. 76/77)

Area: SOUTH GEORGIA
Species: PSEUDOCHAENICHTHYS GEORGIANUS

	Total Catch (t)	Target Species	CPUE (t/h) Polish Commercial Vessels	CPUE (t/h) Research Vessels	Biomass (t) From Commercial Catches	Biomass (t) From Research Vessel Catches	Mean length, weight, age $\bar{l}$ (cm)	$\bar{w}$ (g)	$\bar{t}$
80	665	Opportunistic in Polish vessels	0.04	–	–	–			
81	1584	C. gunnari in Polish vessels	0.11	–	8717	–	[c]44.7	875	
82	956	C. gunnari in Polish vessels	0.13	–	16940	–	[c]44.6	868	
83	–	–	–	–					
84	888*	C. gunnari in Polish vessels	0.16	–	70500	–	[c]47.3	1049	
85				E		8134	43.0		

* Polish catches only

[c] Split year

Area: 58.5
Species: N. ROSSII ROSSII

	Total Catch (t)	Target Species	CPUE (t/h) Commercial Vessels	Biomass (t) From Commercial Catches	Biomass (t) From Research Vessel Catches	Mean length, weight, age $\bar{l}$ (cm)	$\bar{w}$ (g)	$\bar{t}$
70	(20300)							
71	(149700)							
72	(37400)							
73	(2500)							
74	6150	C. gunnari N. rossii N. squamifrons						
75	6667	C. gunnari N. rossii N. squamifrons						
76	1859	C. gunnari N. rossii N. squamifrons						
77	6318	C. gunnari N. rossii N. squamifrons						
78	17239	C. gunnari N. rossii N. squamifrons						
79	No fishing							

Area: 58.5
Species: N. ROSSII ROSSII

	Total Catch (t)	Target Species	CPUE (t/h) Commercial Vessels	Biomass (t) From Commercial Catches	From Research Vessel Catches	Mean length, weight, age $\bar{l}$ (cm)	$\bar{w}$ (g)	$\bar{t}$	¢ Lcm	Wg	™ Lcm	Wg
80	1721	C. gunnari	8.35	–	–	55.3		≃ 7				
81	7991	C. gunnari N. rossii N. squamifrons	5.38	–	–	52.7		≃ 6.5	50.0	1615	54.7	2092
82	9881	C. gunnari N. rossii N. squamifrons	1.60	–	–	50.8		≃ 6	49.0	1524	51.3	1722
83	1881	C. gunnari N. rossii N. squamifrons	1.65	–	–	53.9		≃ 6.5	49.7	1588	54.7	2092
84	749	C. gunnari N. rossii N. squamifrons	0.38	–	–	(54.4)		≃ 7	51.1	1720	55.3	2162

Area: 58.5
Species: C. GUNNARI

	Total Catch (t)	Target Species	CPUE (t/h) Commercial Vessels	Biomass (t) From Commercial Catches	From Research Vessel Catches	Mean length, weight, age $\bar{l}$ (cm)	$\bar{w}$ (g)	$\bar{t}$
70	(500)							
71	(49900)							
72	(15700)							
73	(7200)							
74	26714	C. gunnari N. rossii N. squamifrons	–	–	–			
75	30043	C. gunnari N. rossii N. squamifrons	–	–	–	24.1 (Skiff Bank) 32.3 (Others)		3 4
76	8841	C. gunnari N. rossii N. squamifrons	–	–	–			
77	26947	C. gunnari N. rossii N. squamifrons	–	–	–			
78	42668	C. gunnari N. rossii N. squamifrons	–	–	–	27.4 (Skiff Bank) 32.0 (Others)		3 4
79	No fishing							

Area: 58.5
Species: C. GUNNARI

	Total Catch (t)	Target Species	CPUE (t/h) Commercial Vessels	Biomass (t) From Commercial Catches	Biomass (t) From Research Vessel Catches	Mean length, weight, age $\bar{l}$ (cm)	$\bar{w}$ (g)	$\bar{t}$	
80*	1368	C. gunnari							
*	1169*	N. rossii	1.81 (Shelf S.W.)			26.4	96	3	
	1*	N. squamifrons	0.01 (Skiff Bank)			–		–	Non representative
81*	1052	C. gunnari							
*	61*	N. rossii	0.42 (Shelf N.E.)			35.3	246	5	
	992*	N. squamifrons	1.60 (Skiff Bank)			28.5	123	3	
82*	15990	C. gunnari							
*	6928*	N. rossii	4.01 (Shelf N.E.)			23.5	66	2	
	1025*	N. squamifrons	1.61 (Skiff Bank)			32.6	190	4	
83*	25927	C. gunnari							
*	21004*	N. rossii	6.63 (Shelf N.E.)			27.8	114	3	
	4*	N. squamifrons	0.03 (Skiff Bank)			(22.5)	57	2	
84*	(7139)	C. gunnari							
*	6155*	N. rossii	0.98 (Shelf N.E.)			32.6	190	4	
	898*	N. squamifrons	1.12 (Skiff Bank)			27.7	112	3	
85*	5456*		6.18 (Shelf N.E.)			24.8	79	2	
*	223		0.89 (Skiff Bank)			31.3	167	4	

* Nb. Tons analysed for CPUE and mean length

** A total amount of	1	Ton has been caught on the Skiff Bank during	1980
	992	“	1981
	1025	“	1982
	4	“	1983
	898	“	1984
	223	“	1985

TABLE 3: Numbers Caught at Each Age, *N. rossii*. Estimates based on length frequency, age length and mean weight data provided by U.S.S.R.

70	0.	0.	1233020.	5445839.	10686174.	14898992.	14487986.	16029261.	14487986.	11919194.	6678859.	5445839.	1335772.
71	0.	104133.	911162.	2134724.	2863653.	3071919.	2837620.	3202085.	3150019.	3097952.	2056624.	2134724.	494631.
72	0.	3346.	32625.	70269.	92856.	107077.	101222.	112933.	105404.	92856.	56885.	49356.	12548.
73	0.	26.	524.	1396.	1571.	1213.	977.	829.	707.	619.	401.	384.	87.
74	0.	4.	111.	362.	452.	312.	227.	149.	119.	105.	65.	65.	14.
75	0.	4.	222.	854.	1146.	736.	485.	234.	159.	146.	88.	92.	21.
76	0.	4436.	195186.	798490.	1184426.	891647.	621048.	283907.	168570.	124209.	70977.	70977.	13308.
77	0.	6804.	122464.	530679.	884465.	772206.	561295.	244929.	132670.	71438.	37420.	34018.	6804.
78	0.	15771.	199765.	465242.	586153.	509927.	391645.	215536.	126167.	65712.	31542.	18399.	2628.
79	0.	13999.	276483.	703456.	853946.	650959.	479470.	248484.	143491.	69996.	34998.	17499.	3500.
80	0.	34821.	951768.	2623167.	3064230.	2066034.	1462473.	696416.	394636.	174104.	92855.	34821.	5803.
81	0.	818.	69542.	204534.	232351.	138265.	93268.	40089.	22908.	7363.	4909.	1636.	0.
82	0.	0.	51799.	160053.	177513.	93704.	59365.	22116.	12222.	2328.	2328.	0.	0.
83	0.	0.	13441.	79111.	121355.	83720.	53765.	19202.	8449.	3456.	1536.	384.	0.

TABLE 4: V.P.A. for *N. rossii* (based on catch at age data, Table 3)

Notothenia rossii, South Georgia

	YEAR													
AGE	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
	FISHING MORTALITY													
2	0.000	0.027	0.001	0.000	0.000	0.000	0.001	0.001	0.003	0.006	0.042	0.003	0.000	0.300
3	0.278	0.387	0.011	0.000	0.000	0.000	0.032	0.021	0.034	0.068	0.748	0.111	0.218	0.400
4	0.812	1.109	0.046	0.001	0.000	0.000	0.171	0.114	0.103	0.161	1.615	0.348	0.398	0.600
5	1.247	1.584	0.116	0.001	0.000	0.000	0.347	0.290	0.178	0.278	2.296	0.585	0.579	0.600
6	1.560	1.977	0.199	0.002	0.000	0.000	0.427	0.401	0.271	0.306	2.497	0.701	0.498	0.600
7	1.499	2.030	0.297	0.002	0.000	0.001	0.561	0.526	0.365	0.440	2.919	0.989	0.760	0.600
8	1.590	2.593	0.400	0.003	0.000	0.001	0.529	0.451	0.394	0.417	2.947	0.923	0.676	0.600
9	1.540	2.584	0.715	0.004	0.001	0.001	0.661	0.507	0.444	0.498	3.343	1.349	0.834	0.600
10	1.700	2.837	0.605	0.008	0.001	0.001	0.808	0.664	0.510	0.475	2.619	1.026	0.446	0.600
11	1.261	2.674	0.466	0.004	0.001	0.001	0.762	0.614	0.708	0.566	3.023	0.600	1.169	0.600
12	2.203	3.282	0.525	0.005	0.001	0.002	1.141	1.093	0.711	1.182	2.312	0.572	0.000	0.600
13	0.000	2.236	0.213	0.001	0.000	0.000	0.353	0.291	0.210	0.278	2.312	0.000	0.000	0.000
MEAN F	1.485	2.236	0.213	0.001	0.000	0.000	0.353	0.291	0.210	0.278	2.312	0.572	0.521	0.600
REC AGE	4+	4+	4+	4+	4+	4+	4+	4+	4+	4+	4+	4+	4+	4+

Table 4, continued

AGE	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
								STOCK SIZE							
2	220.7	4259.7	6366.9	2868.9	441.4	441.4	7896.5	7989.9	5639.7	2424.6	928.9	355.8	44.1	0.0	0.0
3	5571.1	3114.8	3394.2	5256.2	6123.8	6123.8	6830.2	6518.2	6580.1	4605.6	1970.1	729.2	290.9	44.7	0.0
4	10664.1	3452.6	1732.4	2751.2	4438.1	5235.2	5586.5	5416.9	5227.0	5208.0	3521.3	763.7	534.3	191.6	24.5
5	16215.6	3876.7	932.8	1355.0	2267.1	3418.0	4428.2	3854.7	3956.7	3860.3	3630.3	573.3	441.6	293.8	86.1
6	20301.9	3815.4	651.4	680.0	1110.6	1888.9	2808.8	2561.8	2360.8	2711.6	2392.7	299.2	261.5	202.7	132.0
7	20094.8	3492.8	432.7	436.9	556.7	922.9	1581.7	1499.8	1404.5	1474.3	1635.0	161.3	121.5	130.2	91.1
8	21662.8	3674.0	375.6	263.3	357.5	461.2	756.4	739.2	725.3	798.3	777.1	72.3	49.1	46.5	58.5
9	19852.5	3617.2	225.0	206.2	215.3	297.4	380.3	365.1	385.6	400.4	430.7	33.4	23.5	20.5	20.9
10	15664.1	3483.4	223.4	90.1	168.0	177.1	244.0	160.7	180.0	202.6	199.3	12.5	7.1	8.4	9.2
11	10074.5	2342.7	167.1	99.9	73.2	136.8	145.1	89.0	67.8	88.5	103.1	11.9	3.7	3.7	3.8
12	6530.7	2336.6	132.3	85.8	81.5	60.1	113.0	55.5	39.4	27.3	41.2	4.1	0.0	0.9	1.7
13	0.0	590.5	71.8	64.1	69.9	67.1	49.0	29.6	15.2	15.9	6.9	0.0	0.0	0.0	0.4
TOT NOS	146852.7	38056.4	14705.4	14157.6	15903.1	19229.8	30819.7	29280.3	26582.3	21817.4	15636.5	3016.5	1777.3	942.9	428.1
WGHTUNAD	489899.0	108578.3	13324.8	13113.6	17786.4	24124.9	33419.7	30141.8	28932.8	29232.2	26417.7	3522.3	2518.6	1825.5	1140.5
SPWN NOS	135473.2	29648.0	5156.3	6378.4	9275.1	12156.1	15452.5	14199.0	13856.1	13767.5	11550.6	1801.6	1285.4	798.1	399.0
WGHTUNAD	478253.3	104861.4	10957.0	10401.7	14541.7	20326.1	28018.5	25012.1	24134.1	25326.6	23801.7	2950.9	2184.9	1671.2	1091.5

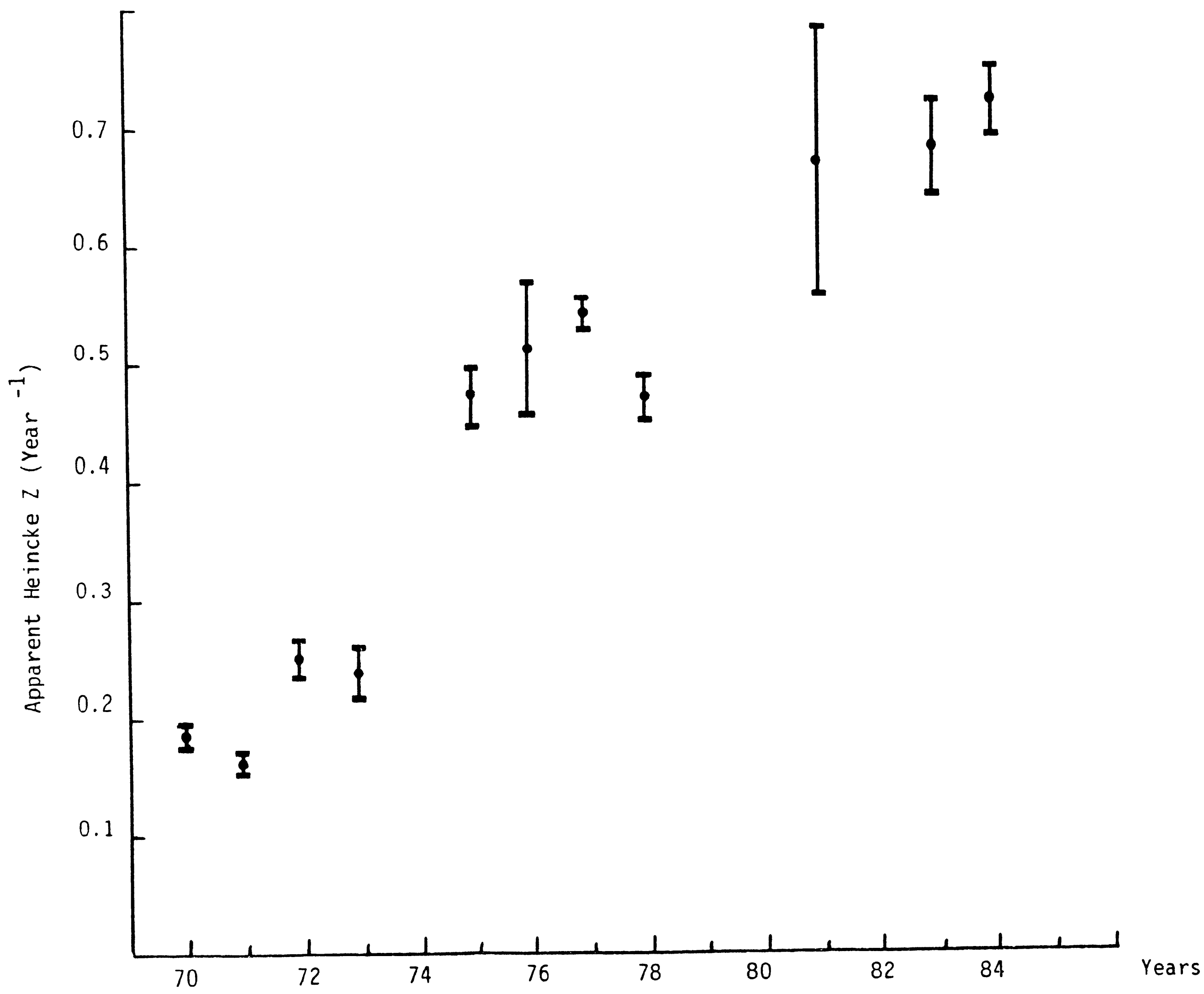

Figure 1: Estimates of total mortality in *N. rossii* for subdivision 48.3 using Heincke method
Error bars - ± Standard error
Age at full recruitment = 6 years

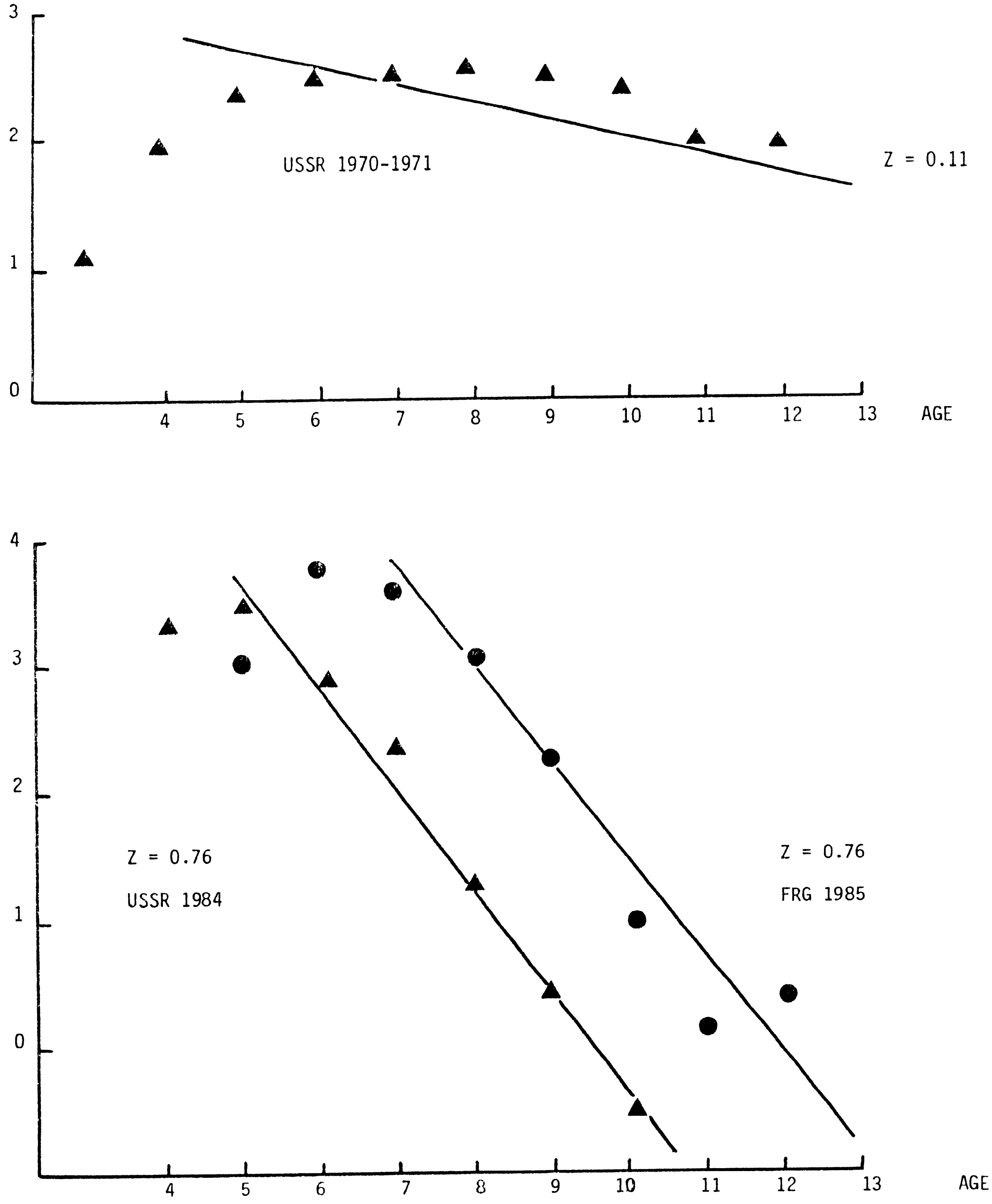

Figure 2: Catch Curves for *N. rossii* for S. Georgia, based on 1970–1971 USSR data, 1984 USSR data and 1985 FRG data.

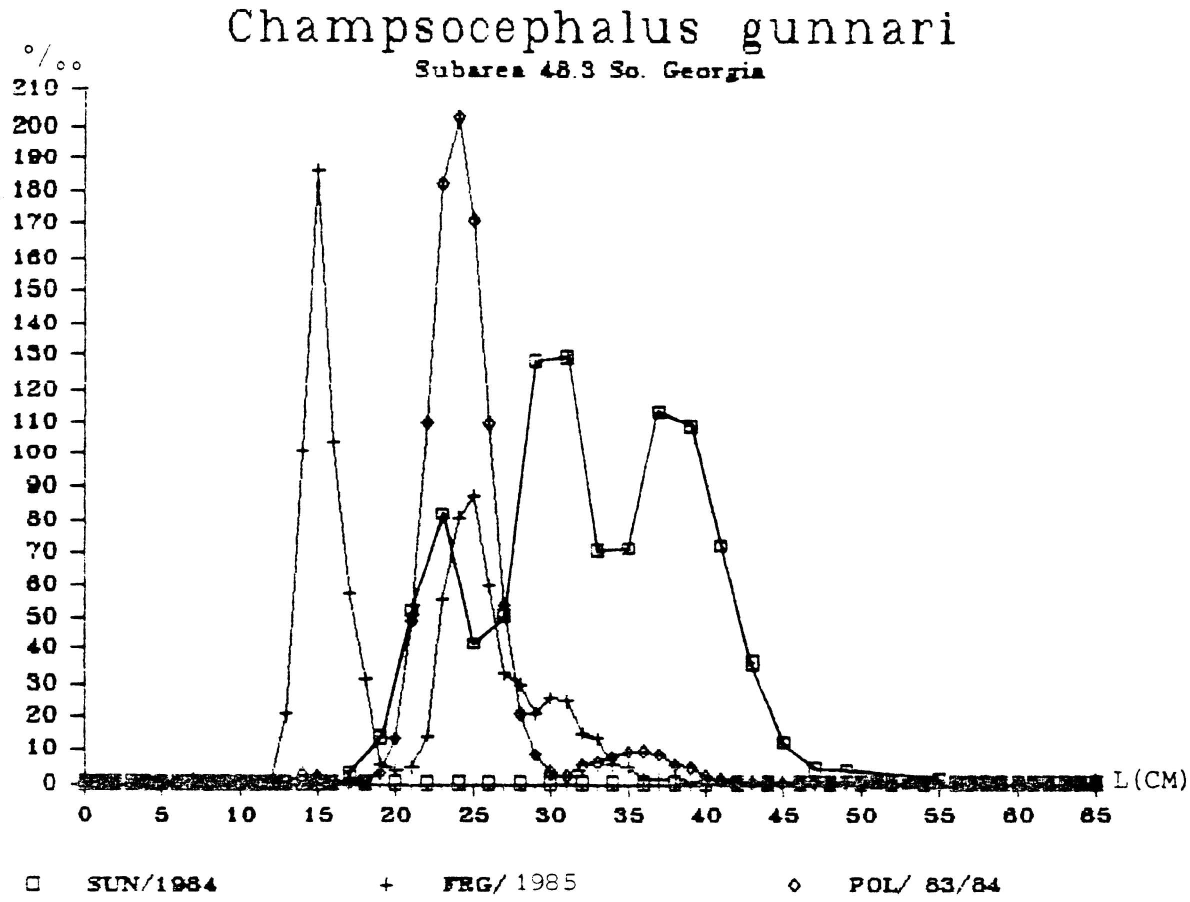

Figure 3: Length composition of *C. gunnari* at S. Georgia showing the effect of selectivity.

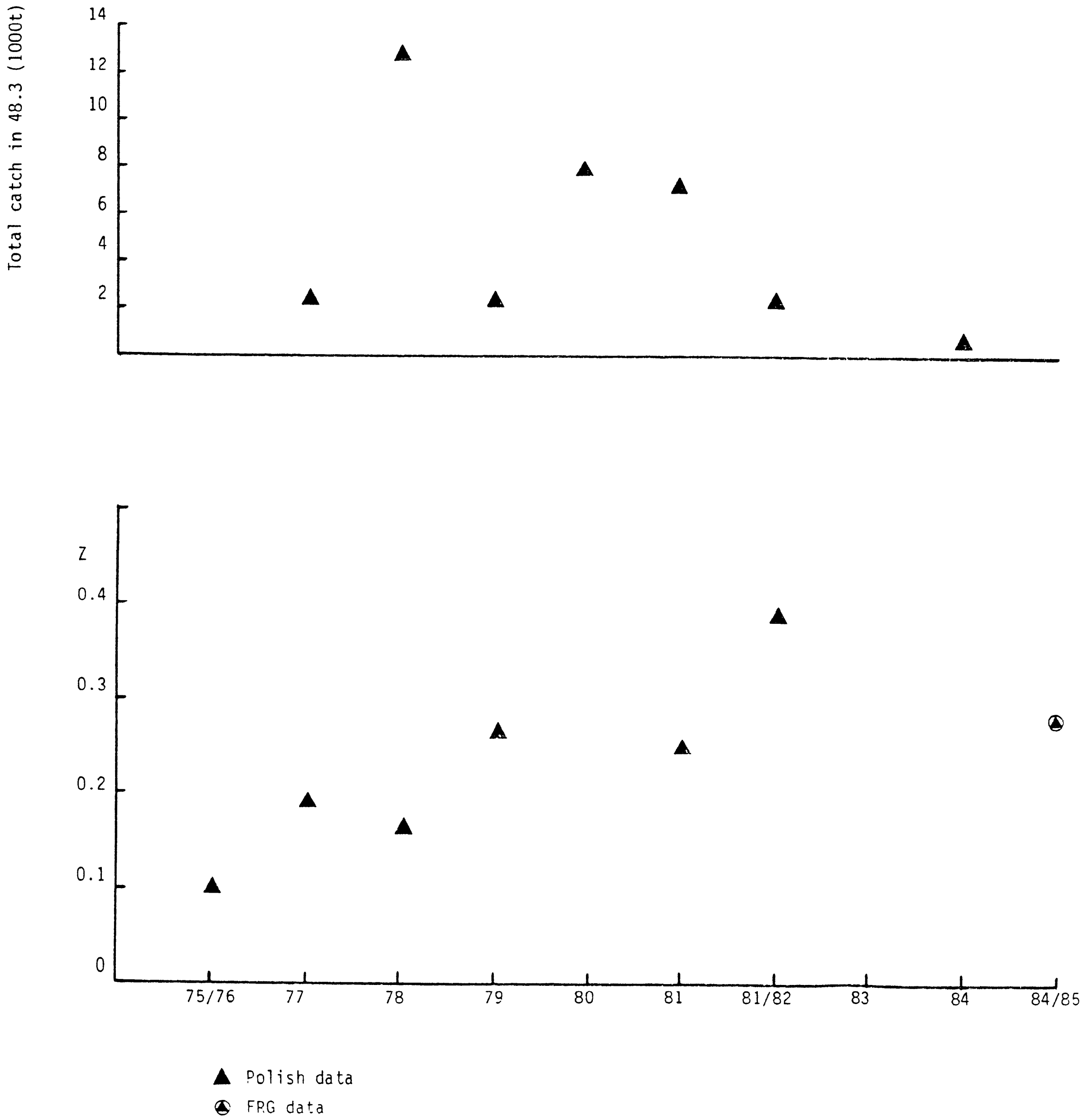

Figure 4: Estimates of total mortality for *N. gibberifrons*, based on average length.

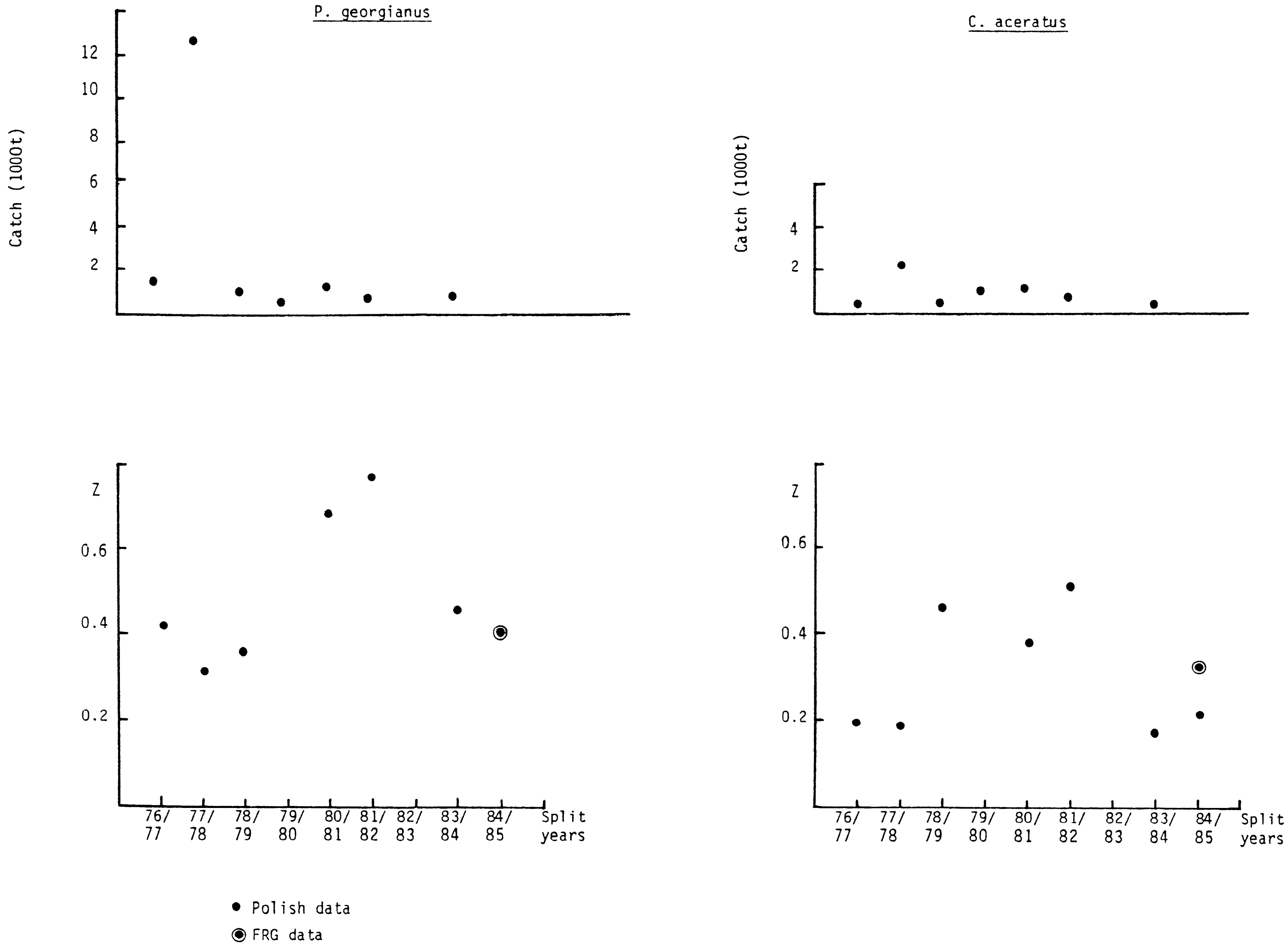

Figure 5: Estimates of total mortality for *P. georgianus* and *C. aceratus* based on average length.