ANNEX 5

REPORT OF THE WORKING GROUP ON FISH STOCK ASSESSMENT

(Hobart, Australia, 12 to 19 October 1993)

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INTRODUCTION

1.1 The meeting of the Working Group on Fish Stock Assessment (WG-FSA) was held at the CCAMLR Headquarters, Hobart, Australia from 12 to 19 October, 1993. The Convener, Dr I. Everson (UK), chaired the meeting.

1.2 The Convener welcomed participants to the meeting.

ORGANISATION OF THE MEETING

2.1 As in the past, the Convener suggested that the required assessments be undertaken in small task groups with periodic review, in the plenary, of the datasets and assessment and management advice as they are developed by the task groups. The Working Group agreed with this suggestion.

2.2 In accordance with established practice, all papers submitted to WG-FSA prior to the start of the meeting were accepted for consideration.

2.3 The report was prepared by Drs A. Constable and W. de la Mare (Australia), Mr D. Miller (South Africa), Drs C. Moreno (Chile), G. Parkes (UK), K. Sullivan (New Zealand), D. Agnew and E. Sabourenkov (Secretariat), and members of the various assessment subgroups.

ADOPTION OF THE AGENDA

3.1 The Provisional Agenda was circulated prior to the meeting. The Agenda was adopted with one amendment, the addition of sub-item “General Advice” to Agenda Item 6 “Assessment Work and Management Advice”. This was included to allow for discussion of various management issues of a general nature and, in particular, high seas fisheries and straddling stocks, a topic to be considered by the Scientific Committee under its agenda item on the United Nations Conference on Straddling Fish Stocks and Highly Migratory Species.

3.2 The adopted Agenda is included in this report as Appendix A, the List of Participants as Appendix B and the List of Documents presented to the meeting as Appendix C.

OBSERVATION AND INSPECTION

4.1 The Scheme of International Scientific Observation was adopted last year by the Commission. The pilot edition of the *Scientific Observers Manual* had been published and distributed to Members. The Scientific Committee had decided, that on implementation of the Scheme, the pilot edition of the Manual should be tested in the field as soon as possible and be reviewed or updated whenever necessary.

4.2 The first, and currently only, observation under this Scheme was conducted in the 1992/93 season in accordance with an agreement between Chile and the UK (SC-CAMLR-XII/BG/4). Under this agreement, a Scientific Observer nominated by the UK together with an observer nominated by Chile, undertook scientific observations on board the Chilean longliner, *Frio Sur V*, fishing for *Dissostichus eleginoides* in Subarea 48.4 (South Sandwich Islands).

4.3 Dr Moreno reported that the observers found the text of the Manual to be useful and easy to follow. However, they also found that the formats for collecting data given in the Manual were difficult to use in the confined space and often short time available for making observations. They also had several specific comments on Format 1B. The observers had, in fact, used a simplified form developed on board to record a subset of the recommended information.

4.4 In this context, the Working Group recommended that a short introduction should be added to a list of research priorities identified by the Scientific Committee for scientific observations on commercial vessels and included in the next edition of the Manual. This introduction should explain that observers are not required to conduct a full set of identified research tasks. The actual list of tasks undertaken by an observer would depend on the type of vessel, the number of observers involved and their professional skills.

4.5 The Working Group commended the observers for their efforts in implementing the Observation Scheme.

4.6 In conclusion, the Working Group recommended that in light of the limited experience acquired so far in using the Manual, the formats should not be changed at this stage. A new edition of the Manual should be considered only after more information about its use in the field becomes available.

REVIEW OF MATERIAL FOR THE MEETING

DATA REQUIREMENTS ENDORSED BY THE COMMISSION IN 1992

5.1 Various data were specifically requested by the Working Group in 1992 (SC-CAMLR-XI, Annex 5, Appendix D). Data submitted to the Secretariat in response to this request are listed in Appendix D.

5.2 Catch and biological information had been submitted from the two current fisheries for *D. eleginoides* at South Georgia and the Kerguelen Islands. Fine-scale data and length frequency information from the 1992 crab fishery in Subarea 48.3 had also been submitted. However, overall the submission of data requested by the Working Group from previous fishing seasons was disappointing.

CATCH AND EFFORT STATISTICS

5.3 The Secretariat has experienced problems in adequately preparing STATLANT data submitted by the 30 September deadline in time for WG-FSA's consideration. Members had therefore been requested to consider the implications of changing this deadline for the submission of STATLANT forms to 31 August (COMM CIRC 93/38 dated 2 August 1993). The Working Group agreed that bringing the deadline forward should serve to improve availability of data from the most recent fishing season for assessment purposes. Furthermore, no Members have objected to the suggested change in dates. Consequently, WG-FSA recommended that the annual submission date for STATLANT forms should be changed to 31 August.

5.4 Fishing for *D. eleginoides* in Subarea 48.3 was undertaken by longline vessels from Chile, Russia, Ukraine and Bulgaria. Data were reported to CCAMLR as part of the requirements of Conservation Measure 56/XI by all participants in the fishery.

5.5 The Working Group discussed the fishery for the straddling stock of *D. eleginoides* which was conducted in international waters by Chilean vessels. WG-FSA-93/21 provides a breakdown of catches in Chilean and international waters (as well as within Subarea 48.3) with reported positions of longline hauls. A large number of reported longline catches came from areas immediately adjacent to the boundaries of Subarea 48.3. It is presently not known whether vessels other than those from Chile undertake fishing for *D. eleginoides* in waters adjacent to the CCAMLR Convention Area.

5.6 The Working Group considers that as assessment and management of the whole stock is required, the question of straddling stocks fished within CCAMLR waters needs to be addressed urgently.

5.7 Given the proximity of the fisheries in international waters (FAO Statistical Divisions 41.3.2 and 41.3.3) to Subarea 48.3, the Working Group also requested the Scientific Committee to consider the consequences of misreporting of catch information, both with regard to the risk to fish stocks in CCAMLR waters and to the credibility of stock assessment and management by the Commission.

5.8 A TAC of 3 350 tonnes was set for *D. eleginoides* at the 1992 Commission meeting. The fishery was closed on 5 February 1993 when 2 886 tonnes had been reported caught; this resulted in the total catch falling short of the TAC for the season. As no report was received from the Ukrainian fishing vessel(s) at this point for the previous five-day period, a catch was assumed when in fact none had been taken, triggering the closure of the fishery. The final fine-scale reports which are assumed to be more accurate showed an additional 104 tonnes above the catch reported in the five-day periods, making a total reported catch of 2 990 tonnes.

5.9 Catch statistics were also reported from Division 58.5.1 (Kerguelen), 2 722 tonnes of *D. eleginoides* taken by the trawl fishery (see paragraph 6.109).

5.10 The only other reports of finfish catches in CCAMLR waters came from a Chilean exploratory fishing expedition in Subarea 48.4 (SC-CAMLR-XII/BG/4) and some Bulgarian longlining. All positions of longline hauls within Subareas 48.3 and 48.4 had been reported and were presented in WG-FSA-93/27.

EXPERIMENTS AFFECTING CATCHABILITY

5.11 A Polish paper on water flow through trawl codends was discussed (WG-FSA-93/11). This paper had previously been presented to ICES. The study shows that the design of meshes in the codend could be improved on theoretical grounds to ensure greater mesh opening efficiency and better selectivity of the codend. The new design had not yet been rigged and tested. The Working Group considered that this was one of a number of possible solutions to the problem of mesh selectivity, however, future tank and sea trials will be needed to evaluate the method further.

OTHER DOCUMENTS

5.12 The Working Group considered 29 documents submitted to the meeting and 10 other background papers. Those papers not reviewed in other sections of the report are briefly summarised here.

Feeding

5.13 WG-FSA-93/24 compared the diet and feeding intensity of *Champsocephalus gunnari* in Subarea 48.3 from a number of years. Although the preferred diet is likely to be krill, low abundance of krill in this area in 1991 may have led to replacement in the diet by the hyperiid *Themisto gaudichaudii*. Evidence was presented that the shortage of krill in 1991 may have resulted in poor gonad development of the fish in that spawning season.

Growth

5.14 The Working Group noted the importance of improving age determination methods for Antarctic fish. WG-FSA-93/6 described a validation study of the timing of annulus formation in *Notothenia corriiceps*[1] by scanning electron microscopy (SEM) and light microscopy techniques. The SEM was preferred to the other method. WG-FSA-93/7 described the use of the Bedford method for preparing large numbers of otolith sections embedded in resin blocks, followed by etching of the polished surface for SEM viewing (Bedford, 1983[2]).

5.15 WG-FSA-93/14 reviewed the early life history of *D. eleginoides* and compared the onset of scale formation and early growth throughout the Convention Area.

Maturity

5.16 WG-FSA-93/26 described ovarian maturation in *N. corriiceps* and found that the adolescent phase lasts for about four years. It was noted that if such a pattern was present in exploited species it would have implications in determining age at first spawning.

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1 Formerly *N. neglecta*

2 Bedford, B.C. 1983. A method for preparing sections of large numbers of otoliths embedded in black polyester resin. *J. Cons. int. Explor. Mer.*, 41: 4-12.

5.17 WG-FSA-93/19 covered the distribution and interannual variation in larval fish assemblages in Subarea 48.3 sampled off South Georgia by the British Antarctic Survey. It was noted that such studies would provide useful information on the distribution of larval fish for consideration with respect to the impact of krill fishing on fish stocks.

Taxonomy

5.18 WG-FSA-93/25 presented evidence that *Lepidonotothen squamifrons*, *L. kempi* and *L. macrophthalma* are in fact one species (*L. squamifrons*).

Recruitment Variability

5.19 WG-FSA-93/13 described the variability in abundance and size of juvenile *Notothenia rossii* in relation to the not commercially fished species *N. corriiceps* at Potter Cove, South Shetland Islands from 1983 to 1992, sampled by trammel nets.

Biology of *Electrona carlsbergi*

5.20 WG-FSA-93/17 detailed the trophic status of myctophids in the Southern Ocean ecosystem and provided a preliminary estimate of the yearly consumption of zooplankton by *E. carlsbergi*. WG-FSA-93/18 discussed the distribution of *E. carlsbergi* in Antarctic waters and the processes which possibly control the migration of immature and mature fish. The Working Group considered that full English translations of both of these papers would be useful.

ESTIMATES OF SEABED AREAS WITHIN SELECTED DEPTH RANGES

5.21 Last year the Working Group had requested the Secretariat to refine previous estimates of seabed areas of Statistical Area 48 (SC-CAMLR-XI, Annex 5, Appendix H) and to extend these estimates to 2 500 m depth. In the past, such estimates have been calculated by manually drawing contours on charts containing all available soundings and then tracing or digitising these contours to estimate areas. This method was found to be extremely laborious, prone to operator error and somewhat subjective. The estimates which can be made from these calculations are also constrained by the initial choice of depth ranges.

5.22 The Secretariat looked into alternative data sources available in a digital form (WG-FSA-93/19). The use of digital data should avoid most of the problems indicated above: once written, the code is applicable to many different areas and depth intervals and the methodology is objective. The Secretariat has conducted a pilot study using the digitised data set of the World Ocean bathymetry (ETOP05) published on CD-ROM by NOAA/NGDC. A set of seabed estimates was calculated for a section of the South Georgia area.

5.23 The pilot study has established that unless more information on the precise data sources used for the ETOP05 data set becomes available, it would be difficult to validate the estimates obtained.

5.24 The Working Group decided that, at present, estimates of seabed areas obtained from the digital database, for depths greater than 500 m would be of sufficient accuracy for fish stock assessment purposes. These estimates will complement the existing estimates for depths less than 500 m. The Secretariat was asked, during the intersessional period, to revise estimates published in 1992 (SC-CAMLR-XI, Annex 5, Appendix H) by adding estimates for depth ranges between 500 and 2 500 m.

ASSESSMENT WORK AND MANAGEMENT ADVICE

NEW FISHERIES

6.1 In 1992, Chile notified the Commission of its intention to investigate a new fishery for *D. eleginoides* in the South Sandwich Islands (Subarea 48.4). The Commission adopted Conservation Measure 44/XI which would enable one Chilean vessel to conduct exploratory fishing in this region, with a catch limit of 240 tonnes. However, a fishing vessel from a non-member state (Bulgaria) conducted a longline fishery in the South Sandwich Islands from 18 November to 4 December 1992, prior to the opening of the fishery in Subarea 48.3, taking a total catch of 39 tonnes of *D. eleginoides*. Bulgaria forwarded haul-by-haul catch and effort data from this vessel to CCAMLR.

6.2 A Chilean longline vessel attempted to carry out the planned exploratory fishery in February and March 1993, but the effort was abandoned after only a week, when it became obvious that no commercial concentrations of fish were available. Only 395 kg of the target species of fish were taken in seven hauls. The catch rate of 5.4 g/hook was less than 1% of that found in the fishery around South Georgia. A detailed report, based on data collected by Scientific Observers from Chile and the UK on board the fishing vessel, was available to WG-FSA (SC-CAMLR-XII/BG/4). Haul-by-haul catch and effort and biological data from the catches have been forwarded to CCAMLR.

6.3 The available catch and effort data were used to estimate local density using the Leslie method (Seber, 1985[3]). The locations of hauls and the region of the shelf area considered to contain the fishable stock of *D. eleginoides* in Subarea 48.4 is shown in Figure 1. The results in terms of density and biomass are given in Table 1 below. About 70% of the fishable area of 2 150 n miles^2 was fished by Chilean and Bulgarian vessels in 1992/93. Using the yield-per-recruit analyses reported in SC-CAMLR-XI (Annex 5, paragraph 6.171) for *D. eleginoides* in Subarea 48.3, gave an estimated yield of 28 tonnes for Subarea 48.4.

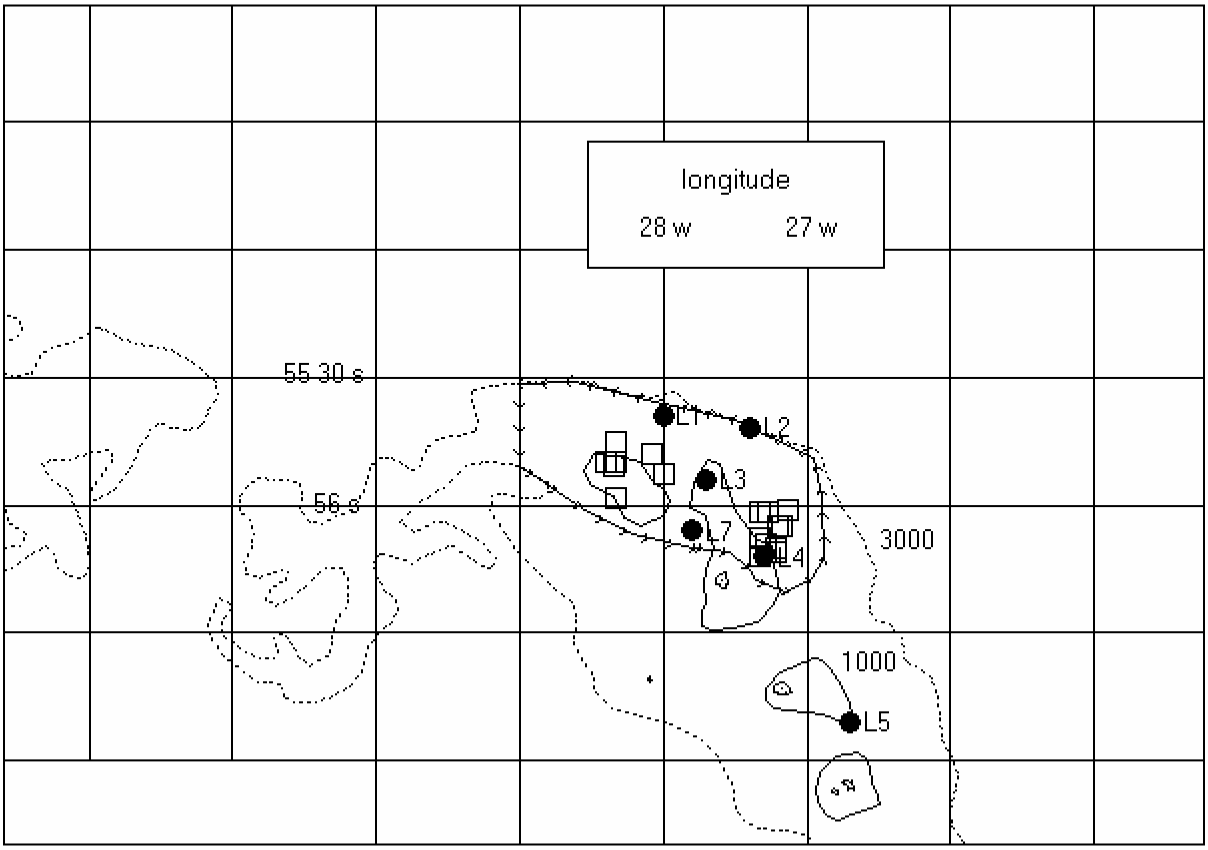

Figure 1: Position of catches by Bulgaria (☐) and experimental hauls by Chile (?) in Subarea 48.4. ->->-> represents the estimated extent of the fishable shelf area. 3 000 and 1 000 m depth contours are shown.

3 Seber, G.A.F. 1985. *The Estimation of Animal Abundance and Related Parameters*. Second Edition. Charles Griffin & Co. Ltd., London: 654 pp.

Table 1: Assessment summary for *D. eleginoides* in Subarea 48.4 (South Sandwich Islands).

	Biomass (tonnes)	Area (n miles^2)	Density (tonnes/n mile^2)
Small area 1 (Bulgarian CPUE)	37.0	178	0.21
Small area 2 (Bulgarian CPUE)	52.0	434	0.12
Small area 3 (Chilean CPUE)	0.4	908	0.0004

Mean density on fishing grounds	=	0.11 tonnes/n mile^2
Total area of fishable ground	=	2 150 n miles^2
Stock estimate at start of season	=	235 tonnes
$F_{0.1}$	=	0.12
TAC	=	28 tonnes

Management Advice

6.4 The fishing grounds for *D. eleginoides* in Subarea 48.4 are around three of the South Sandwich Islands, which lie on a narrow ridge which falls steeply into deep waters. Consequently, the area of bottom suitable for fishing is limited, being confined mostly to a small plateau at the northern end of the island chain. The islands are not generally considered to be in a region of high marine productivity. They are also considered to be at the extreme southern end of the range of *D. eleginoides*. Consequently, the Working Group agreed that the prospects for developing a commercial fishery for *D. eleginoides* in the region are very poor. In case there is any further interest in exploratory fishing in the area, the Working Group recommends a TAC of 28 tonnes for *D. eleginoides* in the South Sandwich Islands.

SOUTH GEORGIA (SUBAREA 48.3) - FINFISH

6.5 Summaries of the assessments presented in the following section are given in Appendix F.

Reported Catches

6.6 The catch history for Subarea 48.3 is shown in Table 2. The only finfish to be taken in this Subarea in the 1992/93 season was *D. eleginoides*, although other fisheries were open and TACs had been set for *E. carlsbergi* (245 000 tonnes), and the midwater trawl fishery for *C. gunnari* (9 200 tonnes). All other directed fisheries were closed.

6.7 The longline fishery for *D. eleginoides* (3 350 tonnes TAC) was open from 6 December 1992 to 5 February 1993 and took 2 990 tonnes in this time. A further 59 tonnes which appears in Table 2 was taken in July 1992 as part of a Russian research cruise.

Table 2 : Catches of various finfish species from Subarea 48.3 (South Georgia subarea) by year. Species are designated by abbreviations as follows: KCV (*Paralomis spinosissima*, SSI (*Chaenocephalus aceratus*), ANI (*Champsocephalus gunnari*), SGI (*Pseudochaenichthys georgianus*) and ELC (*Electrona carlsbergi*), TOP (*Dissostichus eleginoides*), NOG (*Notothenia gibberifrons*), NOR (*Notothenia rossii*), NOS (*Notothenia squamifrons*), NOT (*Patagonotothen guntheri*). "Others" includes Rajiformes, unidentified Channichthyidae, unidentified Nototheniidae and other Osteichthyes.

Split year	KCV	SSI	ANI	SGI	ELC[e]	TOP	NOG	NOR	NOS	NOT	Others	Total
1970	0	0	0	0	0	0	0	399704	0	0	0	399704
1971	0	0	10701	0	0	0	0	101558	0	0	1424	113713
1972	0	0	551	0	0	0	0	2738	35	0	27	3351
1973	0	0	1830	0	0	0	0	0	765	0	0	2595
1974	0	0	254	0	0	0	0	0	0	0	493	747
1975	0	0	746	0	0	0	0	0	1900	0	1407	4053
1976	0	0	12290	0	0	0	4999	10753	500	0	190	28732
1977	0	293	93400	1608	0	441	3357	7945	2937	0	14630[a]	124611
1978	0	2066	7557	13015	0	635	11758	2192	0	0	403	37626
1979	0	464	641	1104	0	70	2540	2137	0	15011	2738[b]	24705
1980	0	1084	7592	665	505	255	8143	24897	272	7381	5870	56664
1981	0	1272	29384	1661	0	239	7971	1651	544	36758	12197[c]	9167
1982	0	676	46311	956	0	324	2605	1100	812	31351	4901	89036
1983	0	0	128194	0	524	116	0	866	0	5029	11753[d]	146482
1984	0	161	79997	888	2401	109	3304	3022	0	10586	4274	104742
1985	0	1042	14148	1097	523	285	2081	1891	1289	11923	4238	38517
1986	0	504	11107	156	1187	564	1678	70	41	16002	1414	32723
1987	0	339	71151	120	1102	1199	2844	216	190	8810	1911	87882
1988	0	313	34620	401	14868	1809	5222	197	1553	13424	1387	73794
1989	0	1	21359	1	29673	4138	838	152	927	13016	55	70160
1990	0	2	8027	1	23623	8311	11	2	24	145	2	40148
1991	0	2	92	2	78488	3641[f]	3	1	0	0	1	82423
1992	0	2	5	2	46960	3703[g]	4	1	0	0	1	50678
1993	299	0	0	0	0	3049[h]	0	0	0	0	0	3348

[a] Includes 13 724 tonnes of unspecified fish caught by the Soviet Union
[b] Includes 2 387 tonnes of unspecified Nototheniidae caught by Bulgaria
[c] Includes 4 554 tonnes of unspecified Channichthyidae caught by the GDR
[d] Includes 11 753 tonnes of unspecified fish caught by the Soviet Union
[e] Before 1988, it is not confirmed that these were *E. carlsbergi*
[f] Includes 1 440 tonnes taken before 2 November 1990
[g] Includes 1 tonne taken as research catch by the UK, 132 tonnes taken as research catch by Russia before 30 June
[h] 59 tonnes taken by Russian research cruise July 1992, 2 990 tonnes by the longline fishery December 1992 to February 1993.

Dissostichus eleginoides (Subarea 48.3)

6.8 The total catch of *D. eleginoides* for the period 6 December 1992 to 5 February 1993 was 2 990 tonnes, which was less than the TAC of 3 350 tonnes specified in Conservation Measure 55/XI. The reason for this shortfall is due to a problem of projecting the closure date, described in paragraph 5.8. Conservation Measures 56/XI and 51/XI, relating to the reporting of catch, effort and biological data, were also in force.

6.9 The 1992/1993 fishing season for *D. eleginoides* was shorter than the previous one, not only because of the problem with projecting the closure date, but also because the efficiency of the different fleets improved, with the CPUE increasing, especially for Chilean and Russian vessels (Figure 2).

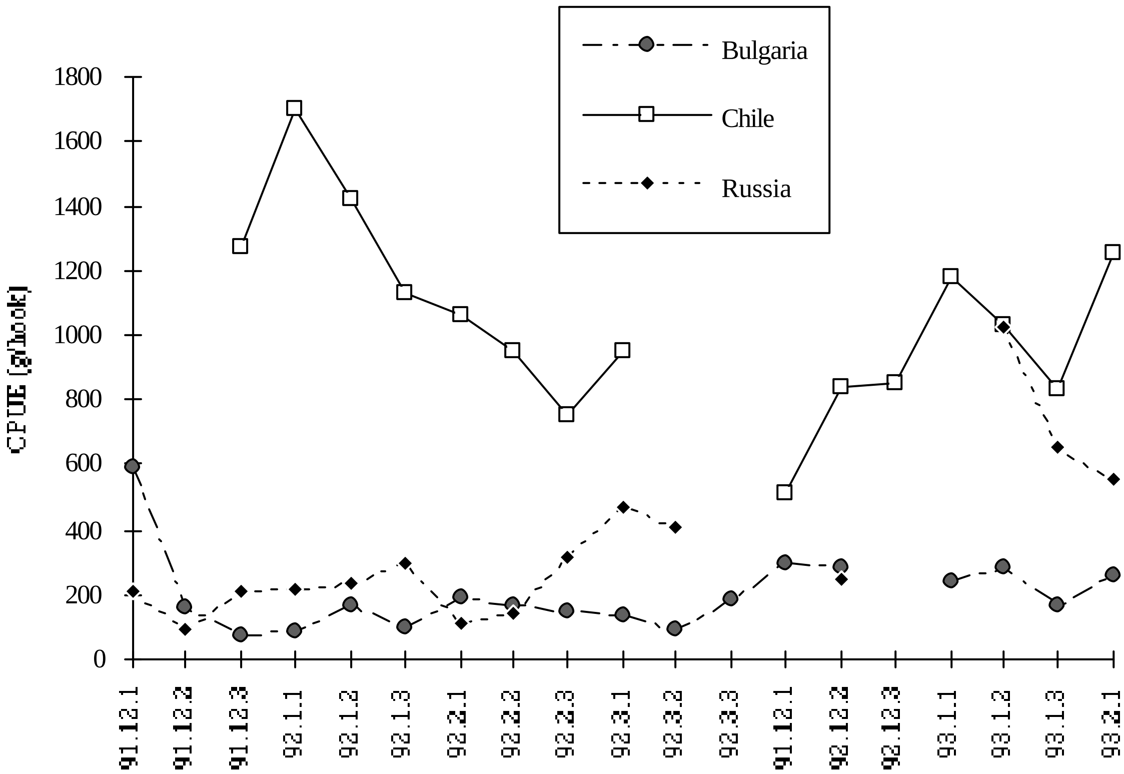

Figure 2: CPUE for the *D. eleginoides* fishery in Subarea 48.3 by 10-day periods (e.g., 91.12.2 = second 10-day period [11-20] of December 1991).

6.10 The total effort during the season comprised one Bulgarian, two Ukrainian, two Russian and between three and nine Chilean vessels, fishing for different periods as shown in Figure 3. The total effort was similar to the 1991/1992 season (in accordance with Conservation Measure 55/XI).

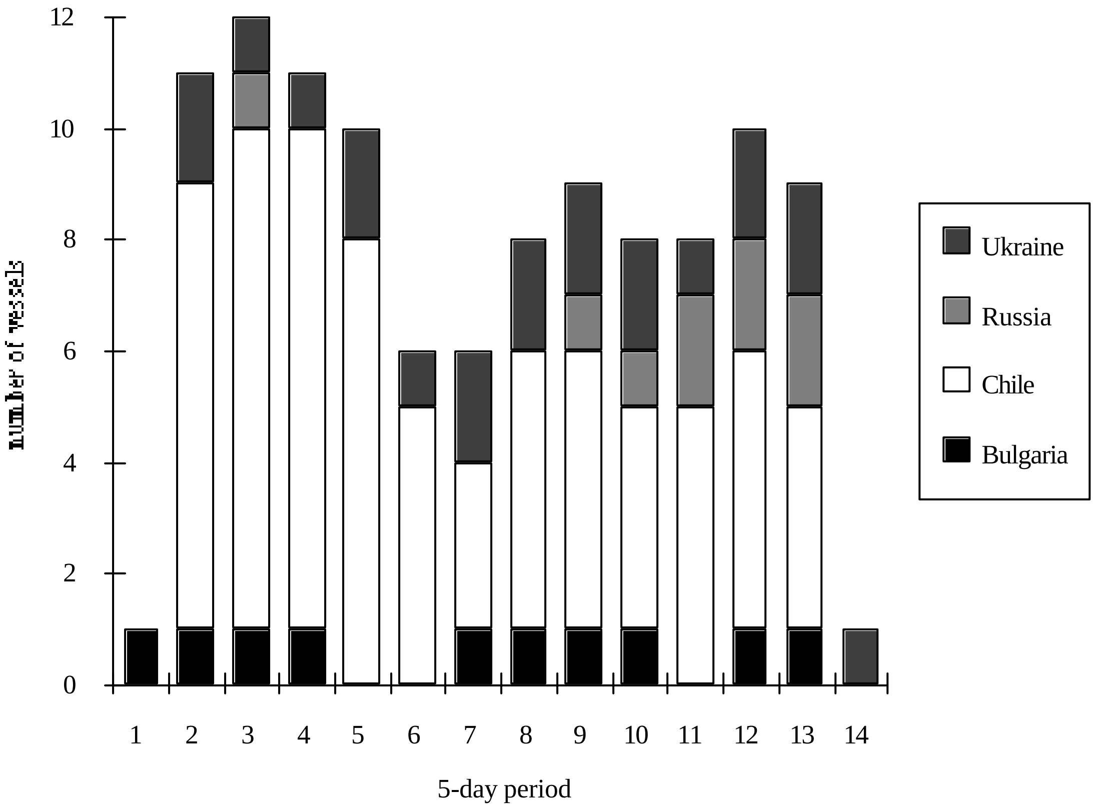

Figure 3: Number of vessels involved in *D. eleginoides* fishing in the 1992/93 season, Subarea 48.3.

Review of Catch and Effort Data

Catch Location from Fine-scale Data

6.11 The position of all catches by Russia, Chile, Ukraine and Bulgaria is shown in Figure 4. The fishery took place around Shag Rocks and South Georgia, as was the case in the 1991/92 season. The depth of fishing was also similar to the last season, ranging from 500 to 2 000 m with highest effort between 1 300 and 1 400 m depth.

6.12 In addition, two fishing sites located in the high seas adjacent to Subarea 48.3 were exploited by the Chilean fleet. Data relating to these fishing grounds were reported in WG-FSA-93/21. In the northern bank the total catch was 1 958 tonnes and in the western Rhine Bank the catch was 2 036 tonnes. Since these two fishing grounds are contiguous with Subarea 48.3, it was suggested that the fish taken on these grounds belong to the same stock as that found within Subarea 48.3.

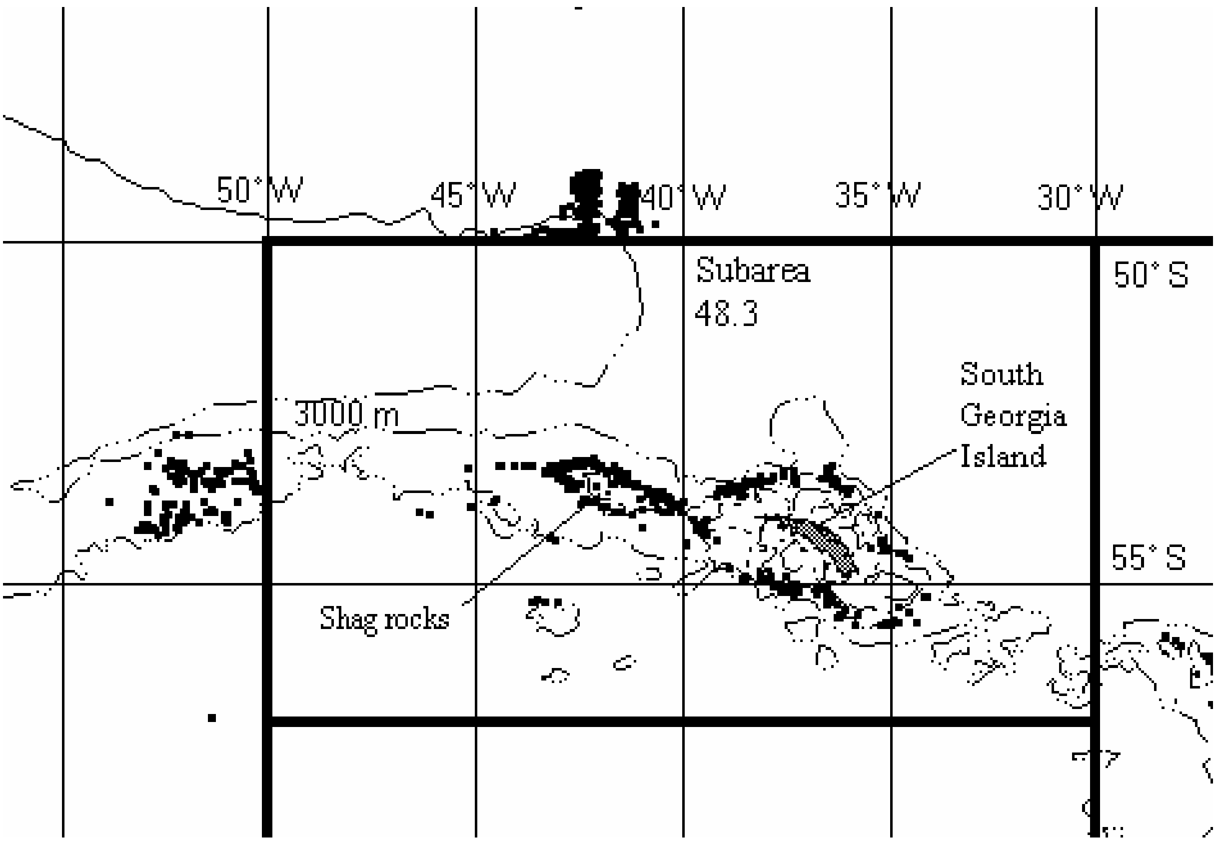

Figure 4: Position of catches of *D. eleginoides* by Chile, Russia, Bulgaria and Ukraine in Subarea 48.3 and adjacent waters (¦).

Review of Other Data

6.13 A substantial review of biological information was undertaken in last year's assessment. No new estimates of biological parameters for *D. eleginoides* were received, and the values accepted by the Working Group last year were used in the assessments.

Assessment Work

6.14 The data over several years, plotted in Figure 2, indicate some decline in CPUE, although there are also indications of increasing efficiency, particularly in the last season, and particularly for the Russian fleet. An examination of the total CPUE data for the most recent season did not show any declining trend within the season. However, this is not unexpected, because the likely effect of pooling different vessels, possibly using different hook types, and operating on different fishing grounds, is to obscure trends in CPUE. Moreover, the usual fishing pattern is for vessels to make a number of hauls in the same vicinity, which often results in declining catch rates, and then move to another location which results in a sharp recovery in catch rate.

6.15 Estimates of abundance were calculated using the procedure adopted last year (see SC-CAMLR-XI, Annex 5, paragraphs 6.143 to 6.158 for a detailed description of the method and its underlying assumptions) in which local densities were estimated from the change in CPUE for a number of single fishing vessels fishing in a small area over a limited period of time. A simple regression of CPUE against cumulative catch is used to estimate the biomass in the small area at the start of fishing (modified Leslie's method - Ricker, 1975[4]). Identifying data suitable for this method of analysis involves a detailed examination of the large volume of haul-by-haul data. As a result, only the Chilean data could be analysed in the time available during the meeting. Since the Chilean fleet is the largest, and has not increased its efficiency to a substantial extent (unlike the large increase in efficiency since last season observed for the Russian vessels), it is likely that the Chilean data will be representative for the stock on the fishing grounds. The catch rates for the Bulgarian vessel are much lower than the Chilean vessels, and so it is less likely that this vessel will fish down the local stock to the extent required for reliable density estimation.

6.16 The area fished was calculated as that lying within a boundary which enclosed the reported positions of the group of hauls. However, in some cases the reported positions fell within a very small area, and in such cases the area was calculated as the area of a circle with a diameter of the length of a longline plus one nautical mile (to allow for an end-effect). The particular end-effect distance was selected because of the correspondence between the local density estimates obtained last year by the area enclosure method with those obtained using an assumed effective fishing width for longlines of one nautical mile (see SC-CAMLR-XI, Annex 5, Table 11). Vessels from the Chilean fleet use a longline of approximately 22 km in length, which results in a minimum area fished of 133 n miles^2 per location. This is less than the arbitrary lower bound used in last year's analysis of 200 n miles^2. Consequently, this year's abundance estimates will be slightly higher than they would be if calculated using last year's lower bound. Improved estimates of the area fished would be obtained if the bearing of the longline, or the positions of both ends of line were to be reported.

6.17 Three major fishing grounds within Subarea 48.3 were identified last year; one to the north of South Georgia (SGN), one to the south (SGS), and another around Shag Rocks (SHG) (see Figure 4). The 1992/93 estimates of the local density for each of these fishing grounds are given in Table 3, along with the extrapolated biomass for each fishing ground. These density estimates are similar to those estimated last year of 0.43 to 1.5 tonnes/n mile^2 (SC-CAMLR-XI, Annex 5, paragraph 6.161 and Table 11), using the same basic methods.

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4 Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. *Bull. Fish. Res. Board of Canada*, 191: 149-161.

Table 3: Local density estimates for the three fishing grounds around South Georgia and Shag Rocks, estimated using Leslie's method with the local change in CPUE for individual fishing vessels.

Number of Hauls	Fishing Ground	Area Fished (nm^2)	Biomass (tonnes)	Density (t/nm^2)	Mean Density (t/nm^2)	SD	CV	Seabed Area (nm^2)	Biomass (tonnes)
5	SGN	133.0	96.89	0.73					
5	SGN	133.0	226.84	1.71	1.22	0.49	40.14	2374.9	2890.34
9	SGS	133.0	325.90	2.45					
7	SGS	133.0	487.76	3.67					
6	SGS	133.0	139.96	1.05					
5	SGS	136.5	164.98	1.21					
4	SGS	245.7	393.27	1.60	2.00	0.97	48.40	3244.8	6476.17
6	SHG	1661.1	57.40	0.03					
4	SHG	270.5	13.66	0.05					
5	SHG	2843.8	98.53	0.03					
5	SHG	133.0	126.40	0.95					
9	SHG	164.6	154.87	0.94	0.40	0.44	110.34	3380.7	1359.53

6.18 The mean density for the fishable ground in the whole of the subarea is assumed to be estimated by the mean of the local density estimates on the recognised fishing grounds. The total biomass for the subarea is obtained by extrapolation to the whole of the seabed area in the depth range 500 m to 2 000 m in Subarea 48.3. The total exploitable biomass estimate for the beginning of the 1992/93 season is 10 700 tonnes. Given that this extrapolation assumes that the density of fish outside the currently recognised fishing grounds is the same as that within them, the biomass estimates may tend to be biased upwards.

6.19 Similar calculations were made for the two fishing grounds outside the CCAMLR boundary but immediately adjacent to Subarea 48.3. These results are given in Table 4 for the northern bank, and Table 5 for the Rhine (western) Bank. If it is assumed that the fish on these banks are part of the same stock found in Subarea 48.3, then the estimated exploitable biomass for the total stock is 17 450 tonnes at the start of the 1992/93 season.

Table 4: Local density estimates for the adjacent fishing grounds to the north of Subarea 48.3, estimated using Leslie's method with the local change in CPUE for individual fishing vessels.

Number of Hauls	Biomass (tonnes)	Area fished (n miles^2)	Density (tonnes/n mile^2)
8	35.3	133	0.27
5	4.2	133	0.03
5	97.5	133	0.73
6	175.7	1 436	0.12
6	868.4	133	6.54
Mean density	=	1.54 tonnes/n mile^2	
Standard error	=	1.12	
Area of fishing ground	=	2 758 n miles^2	
Total biomass (1992/93)	=	4 250 tonnes	
Yield for $F_{0.1}$=0.12	=	510 tonnes	

Table 5: Local density estimates for the adjacent fishing grounds to the west of Subarea 48.3 (Rhine Bank), estimated using Leslie's method with the local change in CPUE for individual fishing vessels.

Number of Hauls	Biomass (tonnes)	Area fished (n miles^2)	Density (tonnes/n mile^2)
6	544.8	1797	0.30
10	533.9	945	0.56
5	693.4	133	5.21
5	290.1	1256	0.23
5	180.0	133	1.35
3	225.2	133	1.69
4	200.0	133	1.51
5	472.0	133	3.55
Mean density	=	1.80 tonnes/n mile^2	
Standard error	=	0.57	
Area of fishing ground	=	1 387 n miles^2	
Total biomass (1992/93)	=	2 500 tonnes	
Yield for $F_{0.1}$=0.12	=	300 tonnes	

Population Projections

6.20 In order to calculate the approximate ratio of the current stock biomass relative to the unexploited stock level, a simple, deterministic biomass projection model based on the following difference equation was used:

$$B_{t+1} = \gamma(B_t - C_t) \cdot e^{-M} + \alpha B_0(1-e^{-M})$$

where B_t is the biomass at the beginning of season t, C_t is the catch in season t, M is the natural mortality (0.13), γ is the proportional increase in biomass of the survivors from fishing and natural mortality through growth to the start of the following season, and α is the proportion of annual increment in biomass in the unfished stock which is due to recruitment. Thus, the second term in the equation represents a constant level of recruitment. The value of γ is determined so that the population has an equilibrium biomass B_o in the absence of fishing.

6.21 Values of B_o and α were found such that the biomass trajectory would pass through the 1992/93 biomass estimate, and give a rate of increase in biomass in the absence of fishing in the following year equal to the $F_{0.1}$ exploitation rate of 0.12. This leads to an approximate estimate of the stock depletion relative to the unfished stock level B_o, and a projected biomass at the start of the next fishing season, which is required to calculate the TAC.

6.22 Two projections were calculated, one using the estimated biomass for Subarea 48.3 without considering the possible component of the stock in the immediately adjacent fishing grounds, and one in which the stock's range includes these two areas. The results of both projections, with corresponding yields, for the range of $F_{0.1}$ values given in Table 13 of WG-FSA-92 (SC-CAMLR-XI, Annex 5), are shown in Table 6. The calculations show that the stock is projected to have a current biomass at roughly 30% of the unexploited level. This result is not sensitive to the choice of whether or not to include the biomass and catches from the adjacent fishing grounds. The yield, however, is sensitive to the value of M used in calculating $F_{0.1}$ (see SC-CAMLR-XI, Annex 5, Table 13). The range of yields is 900 to 1 700 tonnes.

Table 6: Assessment based on the deterministic population projection passing through the biomass estimate at the start of the 1992/93 season.

	Subarea 48.3 Data Only	Including Adjacent Fishing Grounds
Initial biomass (1976/77)	31 600 tonnes	37 450 tonnes
Biomass start of 1992/93 season	10 700 tonnes	17 450 tonnes
Projected biomass 1993/94 season	8 980 tonnes	12 140 tonnes
α	0.45	0.54
γ	1.076	1.064
1993/94 biomass ÷ 1976/77 biomass	28.4%	32.4%
Yield using $F_{0.1}$ = 0.10	900 tonnes	1 210 tonnes
Yield using $F_{0.1}$ = 0.12	1 080 tonnes	1 460 tonnes
Yield using $F_{0.1}$ = 0.14	1 260 tonnes	1 700 tonnes

6.23 The Working Group recalled the concerns expressed last year about assessments obtained using local density estimates on the fishing grounds to extrapolate a biomass estimate for the whole subarea. It also recalled its concerns about the other assumptions relating to the nature of the CPUE data, described in detail in WG-FSA-92. Nonetheless, the Working Group agreed that the assessment presented here was the best scientific advice that it could offer at this time on yields and the status of the stock.

Management Advice

6.24 The Working Group noted that the stock projections indicate that the stock may have been depleted to around 30% of its unfished abundance. This is below the level which would be attained when the stock is fished at $F_{0.1}$, and is approaching the level of depletion where the probability of recruitment failure increases. The Working Group recommends that a substantial reduction in catch is required to allow the stock to begin to rebuild. The Working Group noted that the spawning stock biomass depletion obtained when fishing at $F_{0.1}$ is around 40%. Fishing at $F_{0.1}$ should allow a slow recovery in the stock towards this level.

6.25 Advice on possible TACs is complicated by the fact that the stock may be vulnerable to fishing outside the CCAMLR Convention Area. If the stock is considered only to be that found in Subarea 48.3, a TAC in the range 900 to 1 260 tonnes is indicated. In this case, catch levels of about 500 and 300 tonnes would be indicated for the stocks on northern and western fishing grounds adjacent to Subarea 48.3 respectively. If the fish on the adjacent fishing grounds belong to the stock found in Subarea 48.3 then a higher TAC in the range 1 210 to 1 700 tonnes could be contemplated, but a difficulty could arise in ensuring that the TAC would not be exceeded due to fishing on the adjacent fishing grounds outside the CCAMLR Convention Area.

6.26 The Working Group noted last year that the TAC in 1991/92 was reached early in the fishing season, and agreed then that further expansion in the number of vessels taking part in the fishery would not be appropriate. This year, although the number of participating vessels remained similar to the number in 1991/92, the TAC was reached even earlier in the season due to increasing efficiency. If there is a substantial reduction in the TAC, and there is no corresponding reduction in vessel numbers, the TAC will be reached during a very short fishing season, which could introduce complications into the CPUE and other fine-scale data, with consequent deleterious effects on the assessments. The Working Group noted that to avoid such problems any reduction in TAC should also lead to a reconsideration of the number of vessels operating in the fishery at any one time.

Champsocephalus gunnari (Subarea 48.3)

Commercial Catch

6.27 The TAC of *C. gunnari* in Subarea 48.3 for the 1992/93 season was set at 9 200 tonnes (Conservation Measure 49/XI). There was, however, no reported catch of *C. gunnari* in Subarea 48.3 during the season. The fishery was closed on 1 April 1993 until the end of the Commission meeting on 5 November 1993 in accordance with Conservation Measure 49/XI. There has therefore been no significant commercial catch of *C. gunnari* since the 1989/90 season, during which 8 027 tonnes were taken.

Research Surveys

6.28 The Working Group received no reports of any research surveys designed to assess the status of the *C. gunnari* stock in Subarea 48.3 during the 1992/93 season. The Working Group therefore had no new information from the 1992/93 season with which to update the assessment undertaken at last year's meeting.

Background Documents

6.29 WG-FSA-93/29 presented a revision of the catch-at-age of *C. gunnari* in Subarea 48.3 between 1976/77 and 1991/92. This revision was based on a more statistically reliable method for calculating age distributions than has been used previously. The catch-at-age presented in WG-FSA-89/8 and used subsequently by the Working Group was calculated by applying only two age/length keys to length distributions over the period 1971/72 to 1988/89. An age distribution calculated from a length distribution and an age/length key derived from samples taken at different times can be a biased representation of the true age distribution of the catch. Iterative application of the age/length key as described by Kimura and Chikuni (1987)[5] corrects this problem and provides unique maximum likelihood estimates of age distributions. The Working Group suggested that the revised catch-at-age presented in WG-FSA-93/29 be used for future assessment of the *C. gunnari* fishery in Subarea 48.3 using VPA.

Stock Assessment

6.30 Assessment of the *C. gunnari* fishery in Subarea 48.3 was attempted at last year's meeting using VPA. The results of the VPA were not considered to provide a reliable representation of the status of the *C. gunnari* stock in the most recent years and were not used for estimating the level of TAC for the 1992/93 season. The VPA predicted a large proportion of 4 and 5 year olds in the population in 1991/92. These cohorts were not detected in abundance during the 1991/92 survey by the UK. The problems with the VPA arose from two sources; the assumption of constant M over the period 1989/90 to 1990/91 when research surveys indicated a substantial drop in biomass in the absence of substantial F, and contradictions between the year class strength in the commercial catch-at-age and that of the survey series used for tuning. The Working Group had insufficient time to investigate these problems in detail at its 1992 meeting and resorted to using the results of the 1991/92 survey as a basis for projecting population size and potential catch in 1992/93.

6.31 With no commercial catch and no survey in 1992/93 the Working Group was unable to extend the time-scale of the VPA beyond that at last year's meeting (i.e., terminating in 1990/91). The UK survey in January 1992 provides the most recent information on the status of the population. This results in there being a high degree of uncertainty associated with any assessment of the population size and potential commercial catch in 1993/94.

6.32 In order to provide guidance for an appropriate level of TAC in 1993/94 the Working Group decided to extend the projection made at last year's meeting by an extra year, incorporating simulated recruitment levels to indicate the uncertainty in the assessment of population size.

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[5] Kimura, D.K. and S. Chikuni. 1987. Mixtures of empirical distributions: an iterative application of the age/length key. *Biometrics*, 43: 23-35.

6.33 In addition it was decided to re-run the VPA with the revised catch-at-age presented in WG-FSA-93/29, tuned to a survey series re-calculated using the method described in WG-FSA-93/20. This would provide an indication of the potential for improvement in the performance of the VPA resulting from the revision of some of the data inputs.

Survey Estimates

6.34 Biomass estimates from a series of bottom trawl surveys (see Table 7) had been used to tune the VPA at last year's meeting. For reasons discussed at previous Working Group meetings (e.g., SC-CAMLR-X, Annex 6, paragraph 7.46) abundance estimates for South Georgia only (excluding Shag Rocks) have been used. These biomass estimates were recalculated according to the method provided in WG-FSA-93/20. The results are presented in Table 7.

Table 7: *C. gunnari* survey biomass estimates - UK surveys 1989 to 1992, South Georgia only.

Estimator:	Sample Mean		MVUE*			
	Estimate	CV (%)	Estimate	CV(%)	Lower CI	Upper CI
1988/89 survey - *Professor Siedlecki*						
50-150 m	3 384	75.6	1 976		804	10 065
150-250 m	27 879	49.7	21 900		10 101	73 485
250-500 m	423	69.4	364		91	5 407
Total	31 700	44.5	24 241	38.1	12 177	75 849
1989/90 survey - *Hill Cove*						
50-150 m	1 235	49.7	2 482		392	175 652
150-250 m	93 533	64.2	68 103		15 620	702 185
250-500 m	667	30.4	1 504		368	24 929
Total	95 435	62.9	72 090	65.2	18 951	576 718
1990/91 survey - *Falklands Protector*						
50-150 m	5 392	49.0	4 294		2 518	533
150-250 m	15 126	15.2	21 522		12 052	49 837
250-500 m	1 569	58.3	1 295		566	5 008
Total	22 089	16.4	27 111	25.9	17 163	55 506
1991/92 survey - *Falklands Protector*						
50-150 m	2 359	29.4	4 276		1 528	26 776
150-250 m	30 522	20.9	33 096		21 417	60 472
250-500 m	4 430	53.5	6 392		1 638	86 930
Total	37 311	18.3	43 763	21.4	28 997	124 747

* MVUE = Minimum Variance Unbiased Estimate

6.35 The alternative abundance estimates are of a similar magnitude to those presented previously, however, those derived from surveys with patchy distributions (1988/89 and 1989/90) are about 24% lower, whilst those from surveys with more even distributions of fish (1990/91 and 1991/92) are about 17 and 23% higher respectively. The decline in abundance between surveys in 1989/90 and 1990/91 was therefore less when estimated by this method, but was still of the order of 60%.

VPA

6.36 Six VPAs were run with the revised catch-at-age in WG-FSA-93/29, using the version of the ADAPT program used by CCAMLR (FADAPT8). The details of the inputs to these runs are provided in Table 8. The first three runs were equivalent to the first three runs at last year's meeting (SC-CAMLR-XI, Annex 5, Table 5). Runs 4, 5 and 6 were tuned to a survey series, calculated using abundance estimates for 1989 to 1991 as in Table 7. The catch-at-age for Run 6 was a combination of the revised version in WG-FSA-93/29 and that provided in WG-FSA-91/27 for the period 1982/83 to 1985/86.

Table 8: VPA runs for *C. gunnari* at WG-FSA-93 using revised catch-at-age (WG-FSA-93/29).

Run Number	Period	Catch-at-age	M	Tuning Index	Treatment
1	1977 - 1991	WG-FSA-93/29, Table 2b	0.48	Surveys 1987-1991 Sample mean	Unweighted
2	1977 - 1991	WG-FSA-93/29, Table 2b	0.48	Surveys 1987 -1991 Sample mean	Inverse variance weighting
3	1977 - 1990	WG-FSA-93/29, Table 2b	0.48	Commercial CPUE 1983-1990 (WG-FSA-91/27)	Unweighted
4	1977 - 1991	WG-FSA-93/29, Table 2b	0.48	Surveys 1987-1991 MVUE (1989-1991)	Unweighted
5	1977 - 1991	WG-FSA-93/29, Table 2b	0.48	Surveys 1987 - 1991 MVUE (1989-1991)	Unweighted Standardised to 1 July
6	1977 - 1991	WG-FSA-93/29, Hybrid	0.48	Surveys 1987-1991 MVUE (1989-1991)	Unweighted

6.37 The surveys used to generate the index for tuning are listed in Table 9.

Table 9: Source of survey data.

Season	Vessel	Reference
1986/87	*Professor Siedlecki*	SC-CAMLR-VI/BG/12
1987/88	*Professor Siedlecki*	SC-CAMLR-VII/BG/23
1988/89	*Professor Siedlecki*	Parkes, 1993*
1989/90	*Hill Cove*	WG-FSA-90/11
1990/91	*Falklands Protector*	WG-FSA-91/14
1991/92	*Falklands Protector*	WG-FSA-92/17

* Parkes, G.B. 1993. The fishery for Antarctic icefish *Champsocephalus gunnari* around South Georgia. Ph. D. Thesis. Imperial College of Science Technology and Medicine, London University: 465 pp.

6.38 The methods and sampling equipment used during these surveys were similar and have been discussed at previous meetings (e.g., SC-CAMLR-X, Annex 6, paragraph 7.46). Despite changes in the survey vessel between years, Table 9 was considered by the Working Group to represent the most consistent available series of surveys from which to generate an index of abundance for tuning the VPA.

6.39 No satisfactory results were obtained from runs tuned to survey and CPUE indices together because the indices are incompatible.

6.40 Total abundance of fish age ≥2 years over the period 1976/77 to 1990/91 is illustrated in Figure 5. Runs 1 to 5 show similar patterns of abundance over time up to 1987/88. The CPUE tuned run (Run 3) then indicates a slight increase, while the survey tuned runs all show a continued drop in abundance. The survey-tuned runs indicate total biomass of fish ≥2 years old in 1990/91 to be in the range 40 000 to 67 000 tonnes.

6.41 Run 6 indicates much higher abundance than the other runs over the period 1977/78 to 1982/83. This run used a hybrid catch-at-age as described in paragraph 6.36. The catch-at-age from WG-FSA-91/27 over the period 1982/83 to 1985/86 indicated substantially higher numbers of older fish in the catch than estimated in the revised version (WG-FSA-93/29), particularly with regard to 3 year olds in 1983/84. The Working Group was unable to determine which of these was the most accurate over this period.

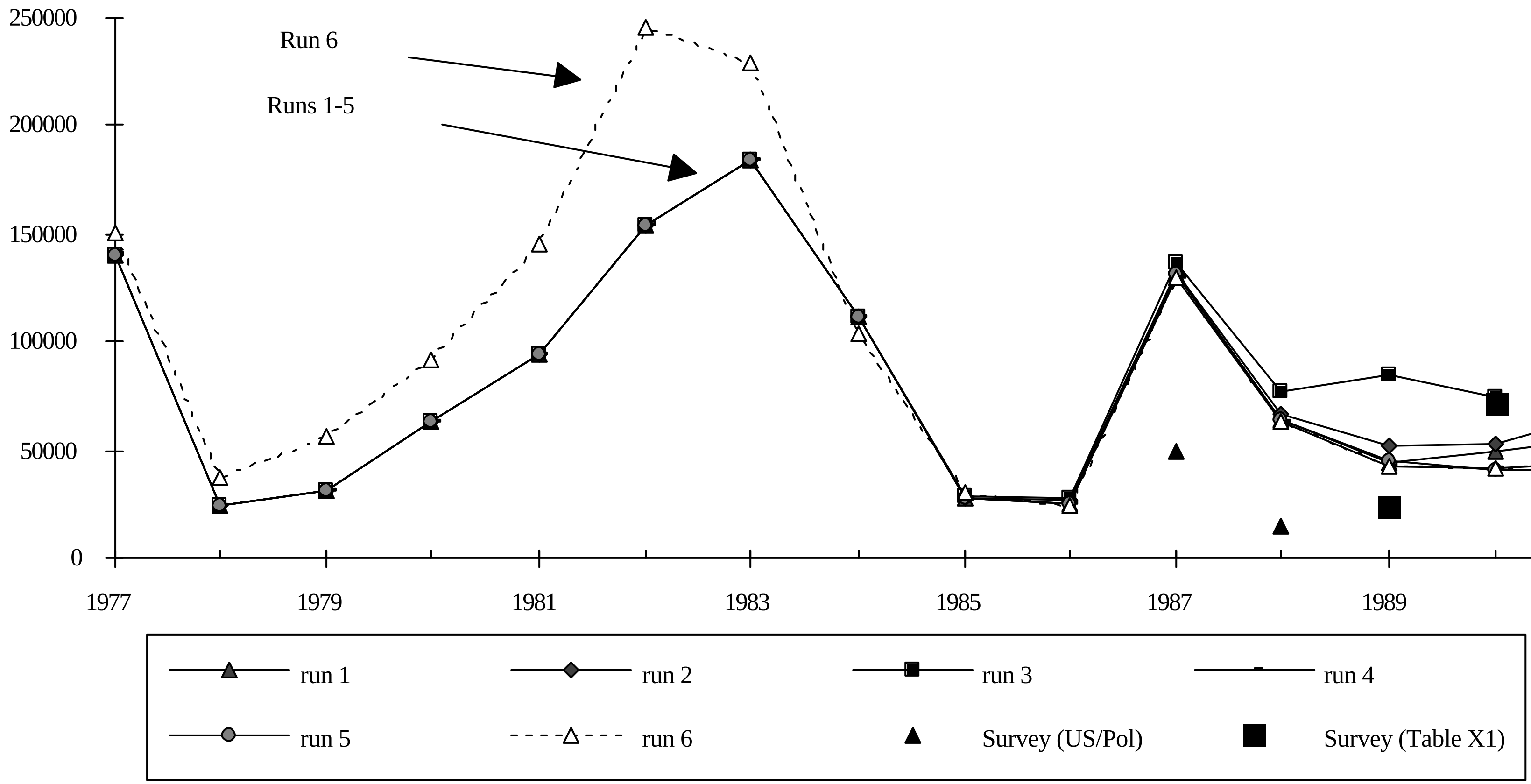

Figure 5: Results of VPA runs for *C. gunnari* in Subarea 48.3.

6.42 Run 1 (survey tuned) is compared to its equivalent VPA run made at last year's meeting (SC-CAMLR-XI, Annex 5, Table 5, Run 1) in Figure 6. The abundance over time estimated by the revised VPA was generally lower than previously estimated. The pattern of change in total abundance over time was, however, broadly similar to those shown at last year's meeting with marked peaks in biomass in 1982/83 and 1986/87. Minor differences were noted, such as the lower biomass in 1986, which is consistent with the low commercial catch in that year (11 107 tonnes).

6.43 The recruitment of 1 year olds over the period of the VPA is illustrated in Figure 7. The big 1987 year class (1 year olds in 1987/88) shown by previous VPA does not appear (e.g., SC-CAMLR-X, Annex 6, Figure 4). The current VPA indicates that the year class spawned in 1984/85 has been the strongest cohort in recent years. This appeared strongly in both the commercial catches (2 year olds in 1986/87 and 3 year olds in 1987/88) and in the survey index (2 year olds in 1986/87). Run 6 again showed very different results to the other runs due to differences in the catch-at-age between 1982/83 and 1985/86.

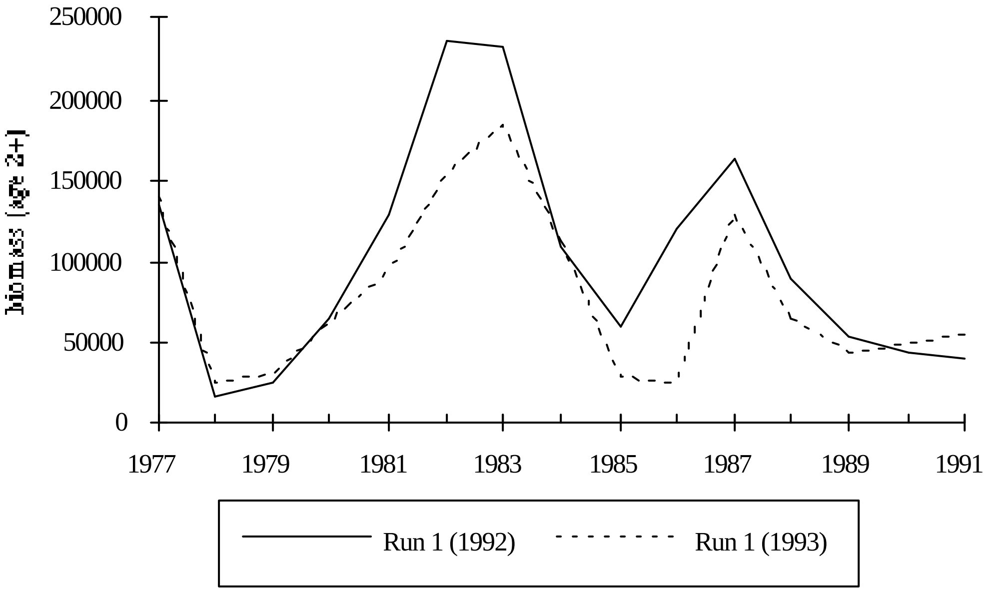

Figure 6: Run 1 of the VPA for *C. gunnari* in Subarea 48.3: results obtained in 1992 are compared with the results obtained at this year's meeting (1993).

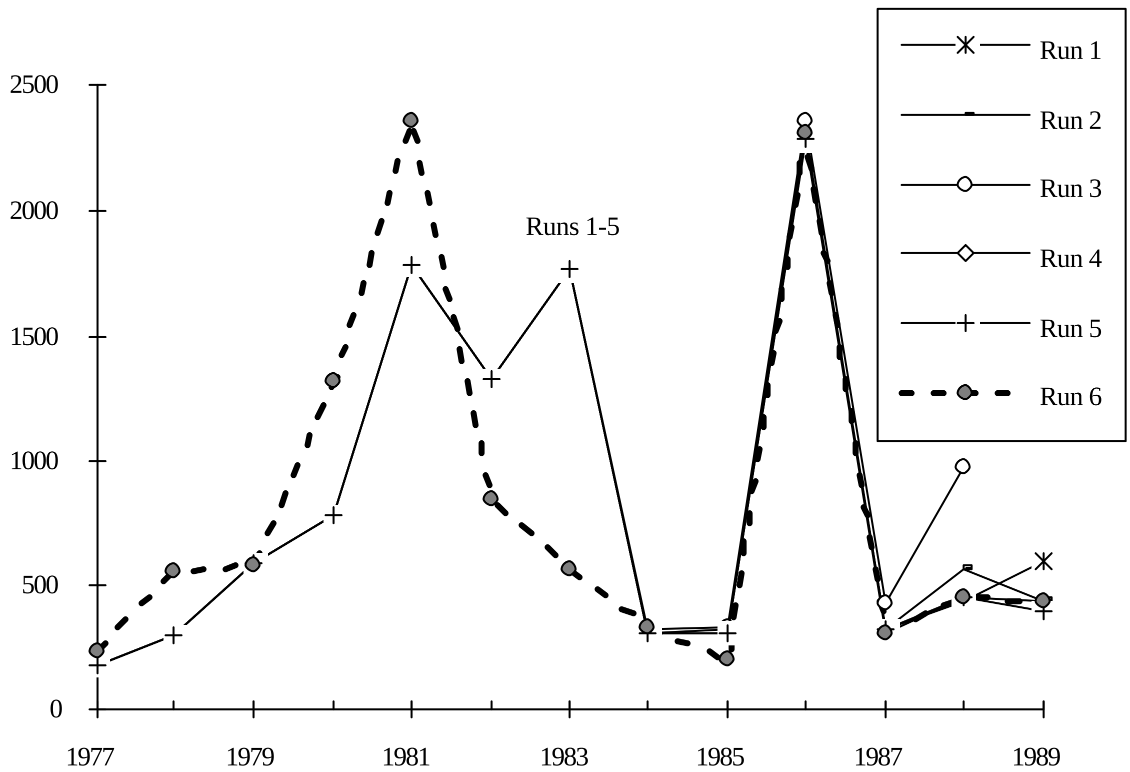

Figure 7: Recruitment of *C. gunnari* (1 year olds) from VPA runs.

Proportionality Coefficient (q) from the Surveys

6.44 There has been discussion at previous Working Group meetings suggesting that the q (the constant of proportionality between the index and absolute abundances[6]) of biomass estimates of *C. gunnari* from bottom trawl surveys is likely to be less than 1 (e.g., SC-CAMLR-IX, Annex 5, paragraphs 114 to 116). Average values of q by age varied between survey tuned VPA runs as indicated in Table 10.

Table 10: Average values of q by age for VPA runs on *C. gunnari*, Subarea 48.3.

Age	Run 1	Run 2	Run 4	Run 5	Run 6
2	0.42	0.21	0.46	1.0	0.46
3	0.85	0.28	0.84	1.35	0.84
4	0.61	0.29	0.61	0.82	0.61
5	0.37	0.24	0.51	0.38	0.51

6 Index = q • absolute abundance

6.45 Weighting the survey index by the inverse of the variance of the survey biomass estimate (Run 2) resulted in lower *q*s compared to unweighted runs, due to the severe down weighting of the large 1989/90 survey estimate. The effect of this down-weighting was therefore to increase estimated abundance in recent years compared to other survey tuned runs (Figure 5). Run 5 produced the highest estimates of *q*, with values ranging from 0.38 (age 5) to 1.35 (age 3). For Run 5 the survey index was standardised to 1 July to account for between-year differences in the size of the reported commercial catch taken between the start of the split-year and the time of the survey. These differences have been substantial: 10 500 tonnes, 19 900 tonnes and 21 356 tonnes in 1986/87, 1987/88 and 1988/89 respectively, but negligible in 1989/90 and 1990/91 (Parkes, 1992[7]). The Working Group therefore considered that the standardised index used in VPA Run 5 was the most realistic basis for tuning the analysis.

6.46 The precision of the estimates of *q* and F estimated by the VPA as indicated by the CV was of the order of 20 to 30% for the former and 40 to 50% for the latter. These figures were generally much lower than those from VPAs run at last year's meeting.

Stock Projections

6.47 The VPA terminated in 1990/91. Stock size for years beyond this must be projected by accounting for M, F and recruitment. The survey in January 1992 provides an independent estimate of relative stock size for the 1991/92 season (this was not used for tuning the VPA). The projection from the VPA (Run 5) was compared to this survey estimate, using the *q* from the VPA to adjust the latter to provide an estimate of absolute abundance. Recruitment for this projection was fixed as the mean from VPA Run 5 over the period 1976/77 to 1988/89. The total biomass of fish ≥2 years old from the adjusted survey was 51 000 tonnes and that from the VPA projection was 72 000 tonnes.

6.48 Figure 8 compares the age distribution of the VPA projection and the survey in 1991/92. The survey result is plotted both with and without the *q* adjustment. A similar figure was presented in last year's Working Group report (SC-CAMLR-XI, Annex 5, Figure 2). Concern was expressed at that meeting that the VPA was predicting a significantly greater proportion of 4 and 5 year old fish than was observed during the 1992 survey. The prediction from the revised VPA at this year's meeting was more in line with the 1992 survey, however, there is still a much larger proportion of 4 year olds in the VPA prediction than in the survey samples.

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[7] Parkes, G.B. 1992. Notes on the use of virtual population analysis for stock assessment of the mackerel icefish, *Champsocephalus gunnari* (Lönnberg, 1906) in Subarea 48.3 for the 1990/91 and 1991/92 seasons. In: *Selected Scientific Papers, 1992 (SC-CAMLR-SSP/9)*. CCAMLR, Hobart, Australia: 49-79.

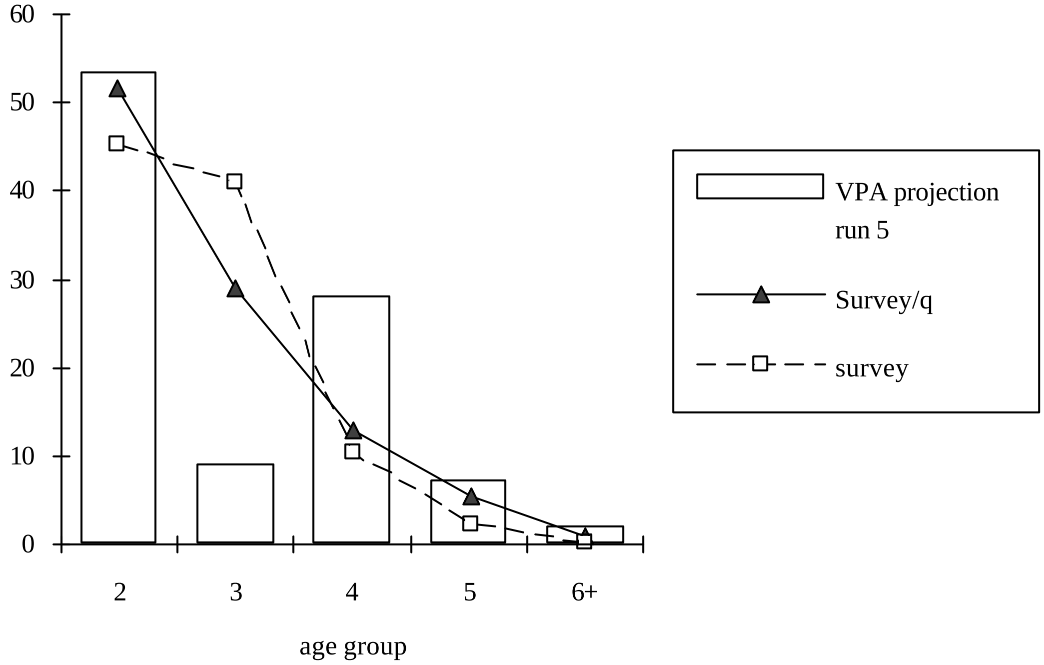

Figure 8: Comparison of age distributions of *C. gunnari* in 1992 derived from VPA projections and the 1991/92 survey.

6.49 The Working Group considered that the VPA based on the revised catch-at-age provides a more consistent picture than previous analyses, but there remained some problems in recent years, arising from the marked decline in abundance shown by the research survey in 1992 (SC-CAMLR-XI, paragraph 3.56), which was not explicitly taken into account by the VPA.

6.50 The VPA terminated in 1990/91, leaving three years between the most recent estimates from this source and the season for which an assessment is required (1993/94). The Working Group considered that using the VPA results for projecting forwards in time would be a risky method of estimating population status in 1993/94 because of the discrepancy indicated in Figure 8 and also the extra year required in the projection, which would increase the level of uncertainty (SC-CAMLR-XI, paragraph 3.59).

6.51 The results from the survey in January 1992 were used to provide a starting point for projections of population size to estimate an appropriate level of TAC in 1993/94. Two starting points were considered by the Working Group: the mean alternative survey biomass estimate (Table 7) adjusted using q at age from VPA Run 5 (Projection 1) and the lower confidence interval of this survey estimate, without the q adjustment (Projection 2).

6.52 The starting point for Projection 2 only used the survey biomass estimate from South Georgia and was not adjusted using the *q* from the VPA. The fishery, however, has operated in the past at both South Georgia and Shag Rocks. The biomass at Shag Rocks estimated from the survey in 1991/92 was of the order of 7% of the total for Subarea 48.3. This starting point therefore represents a slight underestimate of the biomass from the survey in 1991/92. The projection to 1993/94, however, includes two years of simulated recruitment. The Working Group did not feel that this had given rise to a significant underestimation of the TAC based on $F_{0.1}$ in Projection 2.

6.53 Recruitment was simulated according to the method used at last year's meeting (SC-CAMLR-XI, Annex 5, paragraph 6.59), using the mean and variance of *ln* recruitment from VPA run 5 (850 x 10^6 individuals and 0.61 respectively). Confidence limits based solely on recruitment variability were estimated from 500 runs (a parametric bootstrap technique).

6.54 The results of these projections are presented in Table 11 and illustrated in Figure 9. The catch equivalent to $F_{0.1}$ (0.39, assuming t_c=2 years) in 1993/94 is estimated to be 35 000 tonnes in Projection 1 and 27 000 tonnes in Projection 2. There is considerable uncertainty around these estimates arising from recruitment variability, as indicated by the 95% confidence limits. In accordance with the approach adopted at last year's meeting the Working Group considered that the lower 95% confidence limits (20 800 and 13 200 for Projections 1 and 2 respectively) provided a range of possible TACs for the 1993/94 season.

Table 11: Biomass and yield projections for *C. gunnari*, Subarea 48.3.

	1991/92 Survey Back-calculated to 1 July	1992/93 Biomass	1993/94 Biomass	$F_{0.1}$ Yield	1994/95 Biomass
Projection 1:					
Upper 95% CL		20 3967	396 239	103 208	435 073
Median	63 327	97 243	133 157	34 683	124 185
Lower 95% CL		74 157	80 047	20 850	57 880
Projection 2:					
Upper 95% CL		174 573	370 496	96 503	434 498
Median	34 651	68 647	102 083	26 590	111 547
Lower 95% CL		44 500	50 713	13 209	40 753

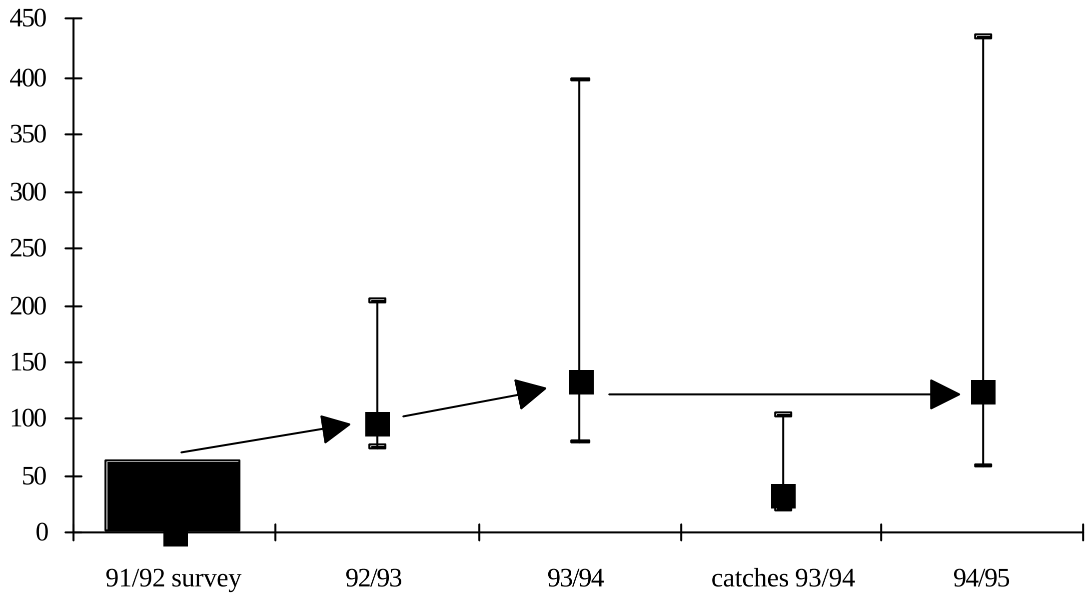

Figure 9: Biomass and yield projection for *C. gunnari* starting with the 1991/92 UK survey. Projection 1 from Table 11 is plotted.

By-catch Consideration

6.55 The by-catch of other finfish species in a fishery targeting *C. gunnari* was discussed at last year's meeting (SC-CAMLR-XI, Annex 5, paragraphs 6.66 to 6.74). The TAC of *C. gunnari* in Subarea 48.3 in 1992/93 was set on the basis of a simple multiple of the potential MSY of *Notothenia gibberifrons*, assuming a by-catch proportion of 16% in pelagic trawls targeting *C. gunnari*. The potential ceiling on the TAC of *C. gunnari* based on the by-catch of *N. gibberifrons* could remain the same as last year, as indicated in Table 12.

Table 12: Potential catch of *C. gunnari* where the by-catch of *N. gibberifrons* is limited to 1 470 tonnes.

Fishery	By-catch Percentage by Weight	By-catch Limit	Potential Ceiling of *C. gunnari* catch
Bottom trawl fishery	16.7	1 470	8 800
Pelagic trawl fishery	16	1 470	9 200
Pelagic trawl fishery	3	1 470	49 000

Management Advice

6.56 Given the uncertainty surrounding the current status of the exploitable stock of *C. gunnari* in Subarea 48.3, the Working Group considered that a conservative approach to management is appropriate in the immediate future.

6.57 The Working Group recommended that a scientific survey to estimate the abundance of *C. gunnari* and other species be carried out during the 1993/94 season.

6.58 The Working Group considered a number of possible TAC levels (Table 13) and recommended two options for possible levels of TAC for the 1993/94 season.

(i) The TAC for *C. gunnari* should remain at the same level as last year (i.e., 9 200 tonnes), because no new information on the by-catch of *N. gibberifrons*, *Chaenocephalus aceratus* and *Pseudochaenichthys georgianus* in pelagic trawls targeting *C. gunnari* was available to the Working Group to revise the by-catch figures estimated at last year's meeting (SC-CAMLR-XI, Annex 5, paragraphs 6.66 to 6.74).

(ii) Provided it would be possible to monitor continuously the by-catch of other species for which Conservation Measures apply in the fishery on *C. gunnari*, for example, by means of an Inspector on board, an increase of the TAC to 13 000-21 000 tonnes (lower 95% confidence limits for Projections 1 and 2 respectively) could be envisaged.

Table 13: TAC levels and assumptions for *C. gunnari* in Subarea 48.3.

C. gunnari TAC (tonnes)	Assumptions/Rationale
21 000	Lower 95% confidence limit of Projection 1
13 000	Lower 95% confidence limit of Projection 2
9 200 - 21 000	Pelagic trawl fishery only Maximum by-catch of *N. gibberifrons* = 1 470 tonnes (SC-CAMLR-X, Annex 6, Table 16) and *N. gibberifrons* $\leq$16% of *C. gunnari* catch
8 800	Bottom trawl fishery only *C. gunnari* catch = 6 x maximum by-catch of *N. gibberifrons* (1 470 tonnes)

6.59 The Working Group stressed that biological information and information on by-catch from any commercial trawl fishery in Subarea 48.3 during 1993/94 is of vital importance for future assessments. The Working Group felt that the effort and biological reporting system introduced in 1992 (Conservation Measure 51/XI) should be maintained.

6.60 The Working Group recommended the closure of directed fishing for *C. gunnari* between 1 April 1994 and the end of the Commission meeting in 1994 (as in the 1992/93 season; Conservation Measure 52/XI) to protect spawning.

6.61 The Working Group noted that a pelagic trawl fishery in Subarea 48.3 would allow both a higher TAC of *C. gunnari* than bottom trawling (Table 13) and would also avoid the possible adverse affects of bottom trawling on the benthic community. It was therefore concluded that the ban on bottom trawling (as in Conservation Measure 20/IX) should be maintained.

6.62 No new information was presented to the Working Group concerning *C. gunnari* mesh selectivity. The Working Group therefore had no reason to propose changes to the 90 mm mesh size regulation (Conservation Measure 19/IX).

Notothenia rossii (Subarea 48.3) - Management Advice

6.63 No new information was available to the Working Group on this stock. Accordingly, the Working Group reiterated the advice offered in 1992 that in view of the likely low stock size of *N. rossii* at present, all Conservation Measures for this species should remain in force (Conservation Measures 2/III, 3/IV and 50/XI).

Notothenia gibberifrons, Chaenocephalus aceratus and *Pseudochaenichthys georgianus* (Subarea 48.3) - Management Advice

6.64 No new information was available to the Working Group on these stocks. Accordingly, the Working Group reiterated the advice offered in 1992 that stocks of *N. gibberifrons* and *C. aceratus* have apparently recovered to a high proportion of their initial levels. *P. georgianus* may not have recovered to the same extent. A re-opening of the fishery on these species might be considered. All three species have been taken in quantity only by bottom trawling in the commercial fishery. None of these species can be taken without a significant by-catch of other species. The Working Group recommended that a directed fishery on these three species should remain prohibited because the potential yields could be entirely taken as by-catch in the *C. gunnari* fishery (Conservation Measures 48/XI and 50/XI).

Patagonotothen guntheri (Subarea 48.3) - Management Advice

6.65 No new information was available to the Working Group on this stock. Accordingly, the Working Group reiterated the advice offered in 1992 that the present Conservation Measure should be retained until information which would allow a re-assessment of the stock to be made becomes available (Conservation Measure 48/XI).

Notothenia squamifrons (Subarea 48.3) - Management Advice

6.66 No new information was available to the Working Group on this stock. Accordingly, the Working Group reiterated the advice offered in 1992 that in the absence of any information which would allow an assessment of the stock to be made, the Conservation Measures presently in force should be retained (Conservation Measures 48/XI and 50/XI).

Electrona carlsbergi (Subarea 48.3)

6.67 No new information was available to enable the Working Group to assess this stock.

6.68 The Commission has adopted the use of $F_{50\%SSB}$ (fishing mortality for which the spawning-biomass-per-recruit would be reduced to 50%) as its policy in managing this fishery. At the present meeting it was noted that myctophids in general, are important prey for many predators in the sub-Antarctic pelagic ecosystem (WG-FSA-93/17 and 18; see paragraph 5.20). The choice of TACs based on $F_{50\%SSB}$ rather than $F_{0.1}$ is even more appropriate in this case, since one of the management objectives should be to ensure sufficient escapement in the fishery to avoid serious consequences to dependent predators. It was suggested that a higher level of escapement from the fishery may be required in some circumstances to meet this management objective.

Management Advice

6.69 The Working Group noted the difficulty in providing advice based on data and assessments which are no longer current. The assessments provided in 1991 are now even more out of date than they were in 1992.

6.70 On the basis of the known biological characteristics of the stock, the TAC of 245 000 tonnes set in Conservation Measure 53/XI for *E. carlsbergi* in Subarea 48.3 may be sustainable. However, any fishery would be based on a stock for which the age structure and biomass are unknown, and in the light of this uncertainty a precautionary TAC should be set below 245 000 tonnes. The species composition and biological characteristics of the by-catch are also unknown. Therefore the Working Group recommends that a new biomass survey be conducted if any fishery on this species is resumed.

SOUTH GEORGIA (SUBAREA 48.3) - CRABS

6.71 Fishing for crabs in Subarea 48.3 was undertaken by one US vessel, *Pro Surveyor*, between 10 July and 12 November 1992.

6.72 Two species (*Paralomis spinosissima* and *P. formosa*) were caught with *P. spinosissima* being the targeted species. A description of the fishery was provided in SC-CAMLR-XI, Annex 5, paragraphs 6.1 to 6.7.

6.73 Large uncertainties are associated with estimating the standing stock of these species (SC-CAMLR-XI, paragraph 4.15). Consequently, the Commission, at its last meeting, adopted a precautionary approach to the development of this fishery and established Conservation Measure 60/XI as an interim management approach pending the development of a longterm management plan for the fishery (CCAMLR-XI, paragraph 9.52).

6.74 The Commission also requested that the Scientific Committee develop a Longterm Management Plan for the Exploratory Crab Fishery and conduct a workshop to begin this process and to advise on data to be reported from this exploratory fishery (CCAMLR-XI, paragraphs 9.48 to 9.50).

Workshop on the Longterm Management of the Antarctic Crab Fishery

6.75 The Workshop was convened by Dr R. Holt (USA) and took place between 26 and 28 April 1993 at the Southwest Fisheries Science Centre, La Jolla, USA. Its terms of reference are set out in SC-CAMLR-XI, paragraph 4.17 and the Workshop report is attached as Appendix E.

6.76 The Working Group recognised the substantial input of data and practical experience provided by the single USA vessel, *Pro Surveyor*, operating in the fishery at this time. Such input was used extensively at the Workshop. The Working Group used the Workshop report as a basis for the following discussion and recommendations on the development of a longterm approach to the management of this fishery.

Population Characteristics

6.77 In spite of the detailed information provided by the exploratory survey, very little life history, ecological or demographic data on *Paralomis* spp. are available (see Appendix E, paragraphs 2.1 to 2.11). A summary of research topics, data needs and their respective priorities for acquisition identified by the Workshop is presented in Table 1 of the Workshop report.

6.78 The extent and potential impact of parasitic infestation was considered by the Workshop at some length (Appendix E, paragraphs 2.12 to 2.20) and the Working Group agreed that host-parasite interactions in crab stocks subject to fishing should be more extensively modelled in order to assess the potential impact on demographic characteristics and stock yield(s) more effectively.

Stock Assessment

6.79 Various methods have been used to assess other crustacean fisheries and the Workshop identified those which may be applicable to the *Paralomis* fishery. With the exception of yield-per-recruit assessment, the data requirements, assumptions and outputs of these methods were compiled by the Workshop (Appendix E, paragraphs 3.1 to 3.31 and Table 2).

6.80 The Workshop specifically recommended investigations of the application of stock assessment techniques (Appendix E, paragraph 3.1).

6.81 In response to this recommendation, WG-FSA-93/23 describes the application of four production models to a time series of daily catch and effort data from the 1991/92 crab fishery. Preliminary estimates of abundance, catchability, and daily recruitment rate were made in the paper. Using parameters from the best-fitting model, alternative TACs were evaluated for a fishery with spatial and temporal scales similar to those of the 1991/92 fishery. The possible TACs were evaluated under the assumption that an equilibrium catch could be estimated by summing daily net input of crabs to the fishery. Since movement (immigration) was likely to be the most significant input to the 1991/92 fishery, the Working Group noted that this assumption would result in the estimate of an unsustainable TAC.

6.82 The Working Group recognised that the application of production models to analyse catch/effort data for the crab fishery was an improvement over the previous efforts (SC-CAMLR-XI, Annex 5, paragraph 6.11). However, the method was constrained by lack of data outside the small area fished during the 1991/92 season. A further constraint was the lack of knowledge on immigration into the fishing area. In the worst case, the catch rates in the fishing area could remain constant until the number of commercially-sized male crabs located outside the fishing area were substantially reduced.

6.83 Given these constraints, the Working Group agreed that it would not be appropriate at this time to estimate a TAC for the 1993/94 fishery from the analysis in WG-FSA-93/23. Further development along these lines was encouraged.

Developing Longterm Approaches to Management

6.84 The Commission has noted that: "an exploratory fishery should not be allowed to expand faster than the acquisition of information necessary to ensure that the fishery can and will be conducted in accordance with the principles in Article II of the Convention" (CCAMLR-XI, paragraph 4.28; SC-CAMLR-XI, paragraph 3.49).

6.85 The Workshop discussed a number of options for the interim management of the crab fishery while the longterm approach is developed (Appendix E, paragraphs 4.1 to 4.6).

6.86 It had identified the following possible catch controls: (i) indirect controls on catch through regulated minimum legal size, seasonal closures and prohibitions on harvesting females; and (ii) direct controls through catch or effort limits (Appendix E, paragraph 4.1).

6.87 The Workshop had noted that the combination of direct and indirect controls can mean that catch limits need not be set precisely or conservatively, since the indirect controls should protect the stock from reproductive failure in the short-term even if the catch is too high to be sustainable in the longterm. However, if the catches exceed the longterm sustainable level, the fishery will be affected by having greater sensitivity to variations in recruitment, lower average catch rates, and greater proportion of the catch with new shells and thus low meat quality (Appendix E, paragraph 4.4).

6.88 The current management approaches adopted at CCAMLR-XI (Conservation Measure 60/XI) include both direct and indirect controls on harvesting. The Working Group agreed that these should continue to be applied in management of the crab fishery. In this context, it considered further measures that could be applied as well as the requirements for a longterm management plan.

6.89 Specific suggestions for additional measures were identified by the Workshop and subsequently endorsed by WG-FSA as having high priority for investigation. These include:

(i) the use of time-release or biodegradable devices to reduce the effects of ghost fishing should pots be lost from a line, should be considered;

(ii) a minimum mesh size should be adopted and/or an escape port included in pots (usually a metal ring set into the side of the pot) following research on mesh or port selectivity. This will serve to select only crabs of harvestable size more effectively as well as reducing the number of potential discards but will reduce the ability to monitor parasitic infection; and

(iii) experiments should be conducted using pots with finer mesh or escape ports added to commercial pot lines in order to obtain more representative length frequency information from harvested stocks.

6.90 The Working Group agreed that the development of a management approach for the crab fishery should be based on the following actions:

(i) design of methods, taking into account limitations of resources available, for acquiring data necessary for assessments of:

(a) target species,
(b) the strengths of multi-species interactions;

(ii) evaluation (using simulations where appropriate) to determine whether the methods are likely, in principle, to achieve their objectives; and

(iii) development of a feedback management framework within which the methods and assessments will be used for providing advice to the Scientific Committee and Commission (CCAMLR-X, paragraph 6.13). As part of this process the methods used for data acquisition should be reviewed on a regular basis.

6.91 The Working Group endorsed the Workshop recommendation that, for all the methods available for assessing crab stocks, estimates of uncertainty of current stock status should be made and sensitivity to underlying assumptions and data quality should be explored (Appendix E, paragraph 3.1).

6.92 The Working Group noted that data for stock assessment are currently limited to those obtainable during commercial fishing operations. On the basis of this restriction and the need to assess the suitability of the different stock assessment methods to this type of fishery, the Working Group recommends that depletion- and production-based methods should be considered in more detail at this stage.

6.93 WG-FSA-93/22 proposes a refined method for assessing *Paralomis* stocks using a depletion experiment around South Georgia conducted within a commercial fishery. The strategy was drawn up in collaboration with a commercial fishing captain and was designed to answer specific, *a priori* questions about the population dynamics of *P. spinosissima*, and consisted of three phases to be conducted over a period of two fishing seasons:

Phase 1 - survey of the crab distribution around South Georgia at the start of the first fishing season by fishing in designated blocks. After completion, normal fishing operations would continue until the TAC for that season was attained or the vessels voluntarily left the fishery.

Phase 2 - series of depletion experiments conducted in local areas to start at the beginning of the second fishing season. After Phase 2 normal fishing operations would be conducted.

Phase 3 - fishing effort would be redirected to the local areas depleted during Phase 2. This would occur towards the end of the second fishing season. It would commence just prior to cessation of the fishery resulting from the TAC being attained or by each vessel wishing to voluntarily leave the fishery.

6.94 In order to maximise the potential output of the experiment, WG-FSA-93/22 also noted that all phases of the experiment should be conducted by all vessels entering the fishery, that they be required to participate independently in the experiment and that the catches should come from the TACs for the respective seasons.

6.95 The Working Group agreed that this type of experimental approach was necessary for obtaining the best possible data required for making assessments. WG-FSA-93/22 identified a number of objectives that could only be met using this approach. These were endorsed by the Working Group:

(i) to elucidate large-scale distribution patterns, how these change with time, and the numbers and locations of centres of aggregation;

(ii) to determine how trends in catchability and movement of crabs affect length-frequency distributions and estimates of local abundance;

(iii) to determine the effects of harvesting on the dynamics of local populations and the importance of movement, recruitment and parasitism; and

(iv) to assess the comparative values in the assessment of crab stocks of data arising from normal commercial fisheries operations with those derived from the more structured experimental approach.

6.96 In addition, the Working Group recognised that the proposal put forward in WG-FSA-93/22 to integrate the experimental and commercial fisheries was a useful approach while resources for independent stock assessment are limited. Also, the Working Group agreed that such integration must still allow vessels to fish in a rational manner.

6.97 The analyses that can be attempted with the data from the experimental fishery are outlined in Table 14.

Table 14: Potential analyses using data collected during the experimental phase of the crab fishery.

Experimental Phase	Analyses with One Vessel	Additional Analyses with More than One Vessel
Phase 1 -- "Survey"	• Spatial analysis of variance components in CPUE and biological data. • Mapping general boundaries of areas of high abundance (may allow extrapolation of localised estimates of abundance).	• Change-in-ratio estimates of abundance. • Index-removal estimates of abundance. • Mapping crab distribution patterns over time (may allow model construction of spatial dynamics).
Phases 2/3 -- "Depletions"	• Depletion estimates of local abundance (Leslie-De Lury methods). • Estimation of movement/recolonisation rates.	• Analysis of variance components in CPUE data associated with vessels that have different fishing powers.
Normal Operations	• Traditional analyses of catch and effort and biological data from the fishery.	

6.98 In line with the general objectives for developing a longterm management plan, the Working Group agreed that an important consideration for the implementation of Phase 1 should be to collect data necessary for evaluating the methods to be employed in Phases 2 and 3. Simulations are required to evaluate the power of the experimental design to address the objectives specified in paragraph 6.95. The Working Group encouraged Members to undertake this evaluation in the intersessional period in order that the experimental design for Phases 2 and 3 could be refined, if required, as soon as possible.

6.99 In this context, the Working Group recommends that, if possible, Phase 1 be conducted in such a way as to provide useful information on stock abundance and distribution in relation to depth strata within the designated blocks around South Georgia. In addition, the commercial fishing operators are encouraged, after Phase 1 in the first fishing season, to concentrate catches in two squares (26 n miles^2 each) for 50 000 pot hours to determine if it is possible to deplete local populations in the time designated for such manipulations in Phase 2.

6.100 For the evaluation of Phases 2 and 3, the Working Group suggests the following points for consideration:

(i) Is there value in monitoring a square with no fishing (control) for each experimental depletion square? Such controls could be useful for determining the magnitude of effect of the experimental fishing on stock size. How many replicates are required to be able to discriminate between depletion and control treatments if an effect of depletion occurs? How much effort needs to be expended assessing the control squares?

(ii) What size of area surrounding the experimental squares is required in which commercial fishing should be excluded in order that the experimental fishing areas are kept independent of effects that may arise from the commercial fishery? Also, what configuration of experimental, control and commercially fished areas should be employed for cost-effective experimental and commercial operations?

(iii) What magnitude of depletion is required for adequately addressing the objectives? How long should a square be fished to ensure a significant depletion has occurred?

(iv) Should Phases 1, 2 and 3 recur in order to maintain adequate stock assessments in a longterm management plan? If so, at what frequency?

(v) What method should the Secretariat use to advise when Phase 3 should begin such that the TAC will not be exceeded and Phase 3 will be completed.

6.101 The Working Group identified that stock assessments independent of the fishery are important for determining the utility of data from the commercial operations in assessing the status of stocks. Consequently, the Working Group recommends that surveys of crab stocks independent of commercial fishing operations using trawls or video transects should be given a high priority.

6.102 Data required for stock assessments identified by the Workshop (Appendix E, paragraphs 5.1 to 5.18) and agreed by the Working Group are:

Catch and Effort Data:

Cruise Descriptions

cruise code, vessel code, permit number, year.

Pot Descriptions

pot shape, dimensions, mesh size, funnel attitude, number of chambers, presence of an escape port.

Effort Descriptions

date, time, latitude and longitude of the start of the set, compass bearing of the set, total number of pots set, spacing of pots on the line, number of pots lost, depth, soak time, bait type.

Catch Descriptions

retained catch in numbers, by-catch of all species, incremental record number for linking with sample information.

Biological Data:

For these data, crabs are to be sampled from the line hauled just prior to noon, by collecting the entire contents of a number of pots spaced at intervals along the line so that at least 35 specimens are represented in the subsample.

Cruise Descriptions

cruise code, vessel code, permit number.

Sample Descriptions

date, position at the start of the set, compass bearing of the set, line number.

Data

species, sex, length of at least 35 individuals, presence/absence of rhizocephalan parasites, record of the destination of the crab (kept, discarded, destroyed), record of the pot number from which the crab comes.

6.103 The Workshop discussed data reporting and the spatial and temporal scales for which data should be reported (Appendix E, paragraphs 5.11 to 5.18). No recommendation on these issues was provided by the Workshop. The Working Group agreed that haul-by-haul data are important for effective development and evaluation of longterm management plans but recognised that these data may be confidential. The Working Group noted that the issue of industrial confidentiality associated with the provision of very fine-scale catch information (Appendix E, paragraph 5.13) is an issue of policy on which the Commission needs to provide guidance.

Management Advice

6.104 Topics for high priority for future research are identified in paragraph 6.89 and should be investigated as soon as possible.

6.105 The experimental fishery design outlined in paragraph 6.93 should be instituted from 1993/94 season onwards:

(i) every vessel participating in the fishery should undertake sampling according to the experimental design, regardless of what year they enter, until the experimental design is modified or terminated by the Commission;

(ii) catches from the experimental fishery should be considered as part of any prevailing TAC; and

(iii) the experimental fishery will be subject to any other Conservation Measures in force.

6.106 The current TAC of 1 600 tonnes and other measures contained in Conservation Measure 60/XI revised in light of this report should remain in force at this time.

6.107 The data required for collection from the fishery are detailed in paragraph 6.102 and these should be submitted to CCAMLR in haul-by-haul form.

ANTARCTIC PENINSULA (SUBAREA 48.1)
AND SOUTH ORKNEY ISLANDS (SUBAREA 48.2)

Champsocephalus gunnari, *Notothenia gibberifrons*, *Chaenocephalus aceratus*, *Pseudochaenichthys georgianus*, *Chionodraco rastrospinosus* and *Notothenia kempi* - Management Advice

6.108 No new information was available to enable the Working Group to assess stocks in these subareas. Previous biomass assessments from research surveys have become completely out of date. Accordingly, the Working Group reiterated the advice offered in 1992 that the fisheries in Subareas 48.1 and 48.2 should remain closed until a survey is conducted to provide more accurate estimates of the status of these stocks (Conservation Measures 57/XI and 58/XI).

STATISTICAL AREA 58

6.109 In 1992/93 fishing took place only for *D. eleginoides* in Division 58.5.1. The catch comprised 2 722 tonnes (Table 15) of which 1 896 tonnes were taken by Ukraine and 826 tonnes were taken by France. The bulk of the catch (2 630 tonnes) was caught in the northern sector by trawling. Only 92 tonnes were caught in the western sector by a single longline vessel.

6.110 No fishing or research activities were reported from any of the other divisions of Statistical Area 58. The Working Group was unable to provide new assessments on the fish stocks of Ob and Lena Banks and off the coast of the Antarctic continent.

Table 15: Total catches by species and subarea in Statistical Area 58. Species are designated by abbreviations as follows: ANI (*Champsocephalus gunnari*), LIC (*Channichthys rhinoceratus*), TOP (*Dissostichus eleginoides*), NOR (*Notothenia rossii*), NOS (*Notothenia squamifrons*), ANS (*Pleuragramma antarcticum*), MZZ (Unknown), SRX (*Rajiformes spp.*), WIC (*Chaenodraco wilsoni*).

Split-Year	ANI		LIC	WIC	TOP				NOR			NOS			ANS		MZZ			SRX
	58	58.5	58.5	58.4	58	58.4	58.5	58.6	58	58.4	58.5	58	58.4	58.4	58	58.4	58	58.4	58.5	58.5.1
1971	10231				XX				63636			24545					679			
1972	53857				XX				104588			52912					8195			
1973	6512				XX				20361			2368					3444			
1974	7392				XX				20906			19977					1759			
1975	47784				XX				10248			10198					575			
1976	10424				XX				6061			12200					548			
1977	10450				XX				97			308					11			
1978	72643	250	82		196	-	2	-	46155			31582		98	234		261			
1979				101	3	-	-	-				1307					1218			
1980		1631	8	14		56	138	-			1742		4370	11308				239		
1981		1122	2			16	40	-		217	7924		2926	6239				375	21	
1982		16083				83	121	-		237	9812		785	4038		50		364	7	
1983		25852				4	128	17			1829		95	1832		229		4	17	1
1984		7127				1	145	-		50	744		203	3794					611[1]	17
1985		8253		279		8	6677	-		34	1707		27	7394		966		11	7	4
1986		17137		757		8	459	-		-	801		61	2464		692				3
1987		2625		1099		34	3144	-		2	482		930	1641		28		22		
1988		159		1816		4	554	488		-	21		5302	41		66				

Split-Year	ANI		WIC	TOP			NOR	NOS		ANS	
	58.5.1	58.5.2	58.4.2	58.4.4	58.5.1	58.6	58.5.1	58.4.4	58.5.1	58.4.2	58.4.4
1989	23628	-	306	35	1630	21	245	3660	-	30	17
1990	226	-	339	5	1062	-	155	1450	-	-	-
1991	13283[2]	-	-	-	1944	-	287	575	-	-	-
1992	44	3	-	-	7492[3]	-	-	-	1	-	-
1993	-	-	-	-	2722	-	-	-	-	-	-

1 Mainly *Rajiformes spp.*

2 There are some discrepancies between the French statistics for the Soviet fishery under licence (12 644 tonnes) in Division 58.5.1 and the STATLANT A data provided by the USSR (13 268 tonnes). It may be explained by the inclusion of 826 tonnes of by-catch (mainly Rajiformes) in this total.

3 1 589 tonnes, France; 5 903 tonnes, Ukraine of which 705 tonnes were caught by longline.

NB: Before 1979/80 catches reported in Statistical Area 58 mainly concem Division 58.5.1 (Kerguelen subarea). Catch reporting was not divided into Divisions 58.5.1 and 58.5.2 until the 1989 season.

Kerguelen Islands (Division 58.5.1)

Notothenia rossii and *Notothenia squamifrons*
(Division 58.5.1) - Management Advice

6.111 No new data on these species were submitted in the last year. The existing prohibition of fishing for *N. rossii* should remain in force. Given the low stock size of *N. squamifrons* estimated in previous assessments, the fishery on *N. squamifrons* should remain closed.

Dissostichus eleginoides (Division 58.5.1)

Life History

6.112 WG-FSA-93/15 summarised the life cycle of *D. eleginoides* at the Kerguelen Islands. Ichthyoplankton surveys provide evidence of winter pelagic development of eggs offshore and on the shelf zone. After a juvenile phase of several years on the shallower shelf, fish migrate progressively to the shelf break. Here the size range of fish is depth dependent. Length compositions collected from the commercial catches from 1984/85 to 1991/92 show no consistent trend, but rather suggest that different depth strata have been exploited in different years. There appeared to be a trend towards fishing in deeper strata in recent years.

Development of the Fishery

6.113 WG-FSA 93/15 provided a description of the course of the fishery. A directed fishery on *D. eleginoides* has being conducted since 1984/85 mainly by trawling. In contrast to South Georgia, longlining was not introduced before 1991/92, after some trials had been carried out in 1990/91.

6.114 Three separate fishing grounds have been identified (Figure 10):

- the western sector from 48°10’S to 50°10’S and 67°00’E to 68°10’E;
- the northern sector from 47°00’S to 47°30’S and 69°00’E to 69°40’E;
- the northeastern sector from 48°05’S to 48°25’S and 71°00’E to 71°20’E.

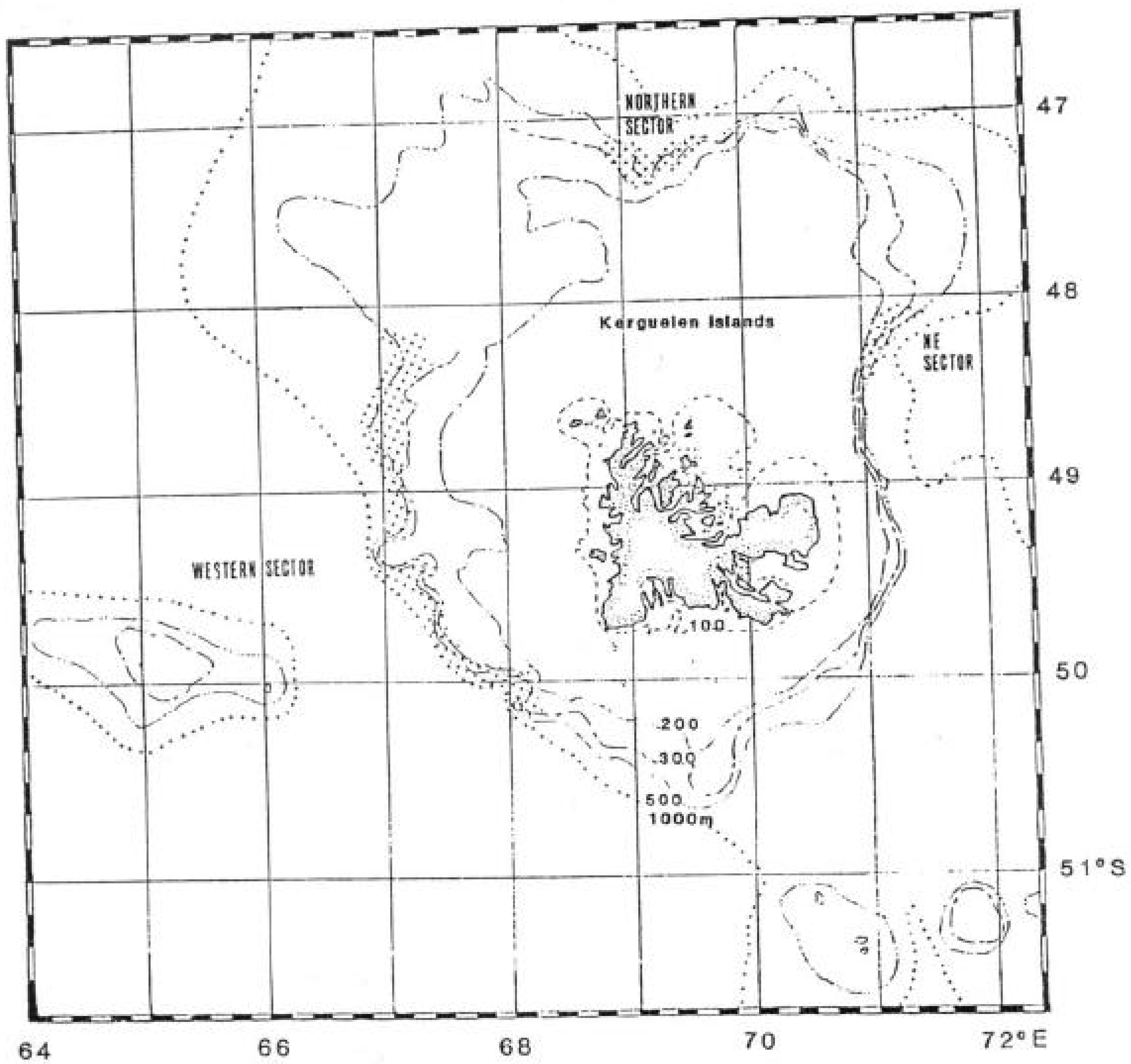

Figure 10: Fishing grounds (geographical sectors) of *D. eleginoides* around the Kerguelen Islands.

6.115 The western sector was the first fishing ground to be exploited (1984/85) and was fished by trawlers in the depth range 300 to 600 m until 1991/92. Longlining has since replaced trawling in this area, exploiting a similar and slightly deeper depth range (350 to 640 m).

6.116 The largest annual catch of 6 465 tonnes was taken in 1984/85 when the fishing ground was discovered. From 1984/85 to 1992/93, a total catch of 14 317 tonnes has been reported from the western sector, including 903 tonnes (6.3%) taken by longlining.

6.117 The northern sector was first fished in 1990/91 after some experimental fishing in 1989/90. A similar depth range to the western sector of 300 to 600 m is being exploited by trawling. The highest annual catch of 6 379 tonnes was taken in the 1991/92 season. From 1990/91 to 1992/93, a total catch of 10 505 tonnes has been reported from the northern sector.

6.118 Based on the difference in catch rates between the western and northern sectors, there are believed to be at least two separate stocks which should be analysed separately (WG-FSA-93/15). From 1992/93 the western and northern sectors have been subject to catch and effort limitations.

6.119 The northeastern sector has not yet been exploited on a commercial scale.

Assessment of Western Stock

6.120 Two surveys of the Kerguelen area were completed in the summers of 1986/87 and 1987/88. The biomass in 1988 was estimated to be 27 200 tonnes following restratification of the survey area (SC-CAMLR-VIII, Appendix 10). Of this total biomass, 19 000 tonnes were estimated to be in the western sector. However, it appears that the main fishing ground discovered in the northern sector was not included in these surveys and therefore stock size is unknown for this area.

6.121 The length frequency of the fish taken in the 1988 survey on the western grounds shows a restricted size distribution mainly between 50 and 110 cm (Duhamel, 1993[8], Figure 18). The total biomass of the western *D. eleginoides* stock is much larger than the survey estimate, which represents the biomass in the age groups from about 4 to 12 years only.

6.122 The trawl fishery on the western grounds has mainly taken fish in the size range from 35 to 120 cm (WG-FSA-93/15). However, very few fish over 110 cm were taken, although the mean size has increased as deeper fishing grounds have been explored. It is assumed that the larger fish are not vulnerable to the trawl fishery and may live in deeper water. Longline catches in the last few years in the same area as the trawl fishery have included larger fish over 140 cm but have been dominated by the medium size range from 90 to 100 cm.

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[8] Duhamel, G. 1993. Distribution, abondance et principales caractéristiques biologiques des espèces de la ZEE des îles Kerguelen. In: Duhamel, G. (Ed.). *Les Rapports des campagnes à la mer: Campagnes SKALP 1987 et 1988 aux îles Kerguelen. Les Publications de l'Institut Français pour la Recherche et la Technologie Polaires*, 93-01: 194-251.

Yield Calculations

6.123 The following assumptions were made to estimate longterm sustainable yields:

(i) the unexploited biomass of *D. eleginoides* in the age range 4 to 12 years in the western stock was taken to be 29 000 tonnes. This is based on the survey estimate of 19 000 tonnes plus the sum of the catches in the area from 1984/85 to 1986/87;

(ii) natural mortality (M) was taken to be 0.1;

(iii) fish from 4 to 12 years were considered vulnerable to the trawl fishery, but younger and older fish were not considered to suffer fishing mortality; and

(iv) fish growth (L_8=214 cm, K=0.055, t_0=0.039) and length/weight relationship (a=$0.682 \cdot 10^{-5}$ and b=3.072) followed the pattern described in WG-FSA-92/9.

YPR Model

6.124 Based on growth and mortality rates in the population, the biomass of *D. eleginoides* in the age range 4 to 12 years in an unexploited population makes up 15% of the total stock biomass. Therefore the unexploited population would have been about 190 000 tonnes.

6.125 The $F_{0.1}$ for the fishery was 0.151, which corresponded to a catch/biomass ratio of 13.3% of the fish in the age range 4 to 12 years. The $F_{0.1}$ yield was 1 820 tonnes based on an equilibrium biomass of 47.3% of the unexploited biomass (29 000 tonnes). However, at this exploitation rate the spawning biomass was reduced to only 28% of the unexploited spawning stock biomass. This was regarded as too low a proportion. Therefore yield was estimated for $F_{50\%SSB}$ (fishing mortality at which the spawning stock biomass was half the unexploited level). At this value of F (0.08) longterm equilibrium yield from the western stock based on the deterministic YPR model was 1 400 tonnes. This represents a catch/biomass ratio of 7.3% of the fish in the age range 4 to 12, with the stock size at 66% of the unexploited abundance.

Sensitivity Analysis

6.126 To take account of the uncertainty associated with the yield estimated above, sensitivity to three of the assumptions listed above was considered.

(i) The unexploited biomass was varied between 25 000 and 35 000 tonnes. This resulted in a proportional change in the yield, ranging from 1 210 tonnes to 1 690 tonnes.

(ii) Natural mortality was varied between 0.05 and 0.15. The yield was not very sensitive to M changes and varied between 1 390 tonnes (M=0.05) and 1 420 tonnes (M=0.15).

(iii) The range of ages at which the fish are vulnerable to the trawl was extended to between 4-14 and 4-16 years. The yields dropped with increased age range to 1 170 tonnes (4 to 14 years) and 1 020 tonnes (4 to 16 years).

Assessment of Northern Stock

6.127 The history of the fishery has been similar to that of the first few seasons in the western grounds. The mean and range of lengths of fish caught are very similar to those from western grounds. Initially, smaller size classes were caught, but mean size increased as deeper grounds were exploited. Catch-per-unit-effort in the northern area has been higher than for equivalent stages of exploitation in the western sector, ranging between 2.87 and 5.04 tonnes/hour for French trawlers and 1.67 and 3.22 tonnes/hour for Ukrainian trawlers. As yet the time series is too short to indicate the effects of fishing on the stock. Catch rates have increased in the fishery as knowledge of the distribution and depth range of the fish has improved (WG-FSA-93/16). The longterm sustainable yield is unknown.

Management Advice

6.128 The Working Group noted that there is some evidence for at least two stocks of *D. eleginoides* in this area and agreed that they should be managed separately. Although there is information available for the fishery in the western sector since 1984/85, a detailed stock assessment was not possible. No assessment was attempted for the northern sector.

6.129 Based on YPR considerations, the sustainable fishing rate which maintained a spawning stock biomass of 50% of the unexploited level was determined. As this fish is slow growing, sustainable yield is low. Using a biomass estimate of the western stock from the 1988 trawl survey and the history of catches from 1984/85, the unexploited stock size was determined. A longterm sustainable yield of 1 400 tonnes was estimated for the western stock.

6.130 It is likely that the western spawning stock biomass is still above 50% of the unexploited level, based on the catches reported since 1984/85. The fishery in this area has more recently been carried out by longlining. This could increase the sustainable yield above 1 400 tonnes if larger fish were taken in the fishery.

6.131 The status of the northern stock is unknown. Over 6 000 tonnes was taken in 1991/92, but the impact of these catches cannot be determined. A precautionary approach should be taken in setting catch levels to prevent the spawning stock size falling to low levels before the stock has been adequately assessed.

6.132 The Working Group considered the type of information required to assess these stocks, in addition to the biological and fishery data already being collected. For depletion methods, catch and effort data on a haul-by-haul basis within small areas would be required. Trawl surveys of the whole stock could also provide indices of abundance to model the stock dynamics and sustainable yield.

Champsocephalus gunnari (Division 58.5.1)

Kerguelen Plateau

6.133 No commercial fishing was reported for this species in Division 58.5.1.

6.134 In the past, the Working Group has been able to estimate stock sizes for *C. gunnari* from 1982 to 1992 using cohort analysis (SC-CAMLR-X, Annex 6, Figure 20). In order to complete its understanding of the fishery the Working Group has requested biological data from the fishery prior to 1980 (SC-CAMLR-XI, Annex 5, Appendix D). A paper by V. Gerasimchuk (1993)[9], available to the Working Group this year, provided figures of size composition of the *C. gunnari* fishery collected by 'search and scientific research vessels' from 1968/69.

6.135 These length compositions show that in 1971 and 1972 a number of ages (predominantly age 2 to 4) were taken, but from 1973 the fishery was dominated by a number of strong cohorts

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[9] Gerasimchuk, V.V. 1993. States of stocks *Champsocephalus gunnari* on the shelf of the Kerguelen Islands. In: Duhamel, G. (Ed). *Les Rapports des campagnes à la mer: Campagnes SKALP 1987 et 1988 aux îles Kerguelen. Les Publications de l'Institut Français pour la Recherche et la Technologie Polaires*, 93-01: 266-276.

appearing singly in the fishery at three year intervals. The first of these was spawned in 1970 and taken in small numbers in 1972 before dominating the fishery as 2 year olds in 1973. In several years (1975, 1978, 1981 and 1987) some old-cohort age 4+ fish were caught in addition to age 1+ fish from a more recent cohort. In 1971 and 1972 the fishery took place over the northwest, north and northeast edges of the Kerguelen plateau but gradually moved to be concentrated to the east and northeast of the island.

6.136 Although these length frequency distributions give useful information about the stock, information about their origin and the state of the early fishery was not considered sufficient to enable a calculation of historical extensions to the cohort analysis performed by the Working Group in 1991 (SC-CAMLR-X, Annex 6, paragraph 7.241). They have been used, however, to create approximate splits of the catch tonnages from 1971 for illustrative purposes in Figure 11.

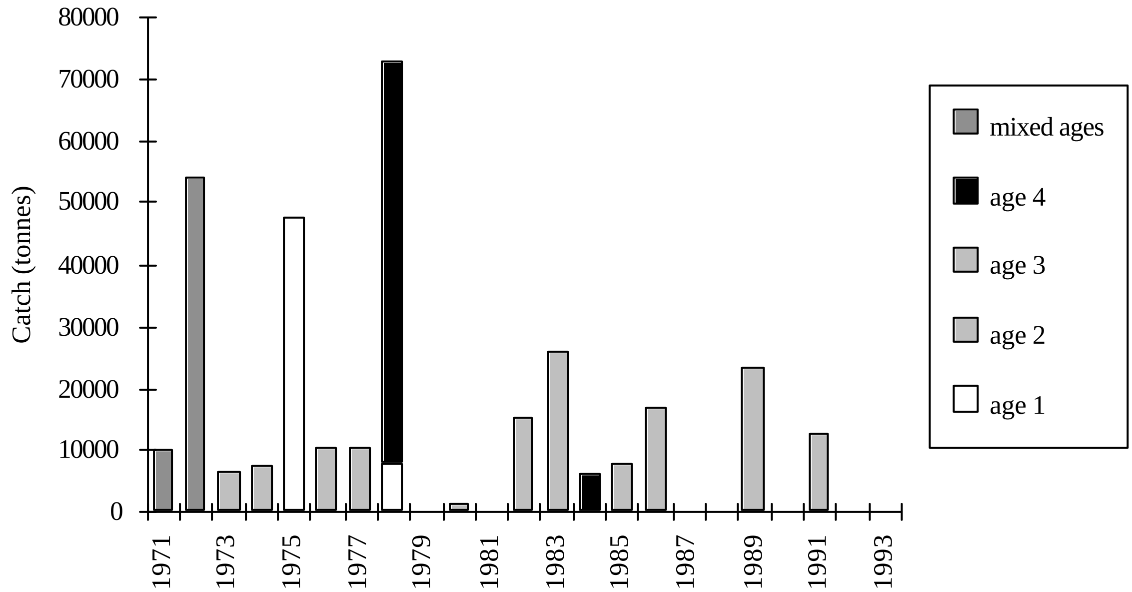

Figure 11: Catches of *C. gunnari* on the Kerguelen plateau. Note: Small, unquantifiable catches of age 4 fish were taken in 1973 and 1975. The area was closed in 1979.

6.137 This figure, together with Figure 20 in the 1991 report (SC-CAMLR-X, Annex 6), contributes to evidence that the 1982, 1985 and 1988 cohorts have not been as large as earlier cohorts. The 1988 cohort appears to have been especially small, although last year the Working Group was unclear whether the extremely low catch of age 3 fish in 1992 was due to lack of fish or low effort.

6.138 No information is available on the size of the 1991 cohort. However, if the 1991 cohort is no larger than the previous three cohorts have been, the greatest yield could be expected to be derived from age 3 fish, and would not be more than the maximum obtained from the last three cohorts, 24 000 tonnes.

6.139 The existence of the three-year cycle of cohort recruitment implies that these fish have their major spawning event at age 2. Since the fishery takes place before spawning, postponing the fishery until fish are aged 3+ would maximise the spawning potential of the stock.

Management Advice

6.140 In view of the lack of information on the status of the currently recruiting cohort, the Working Group recommends that fishing is delayed until 1994/95 season, and only restricted fishing on the 3+ age group that is expected to form the fishery in that year should be allowed. Additional precautionary measures limiting the catch are likely to improve the chances for improved future recruitment.

Skif Bank

6.141 Separate catches and cohort analyses for Skif Bank were presented to the 1990 Working Group in WG-FSA-90/17. This fishery was also dominated by single cohorts appearing at three year intervals not coincident with the Kerguelen Shelf stock, with the first identified being a 1980 cohort. No further information was available to the Working Group to assess this stock.

Heard Island (Division 58.5.2)

6.142 An Australian research survey to assess the stocks of *C. gunnari* and *D. eleginoides* was completed from the end of August to the end of September 1993. As on previous occasions, *D. eleginoides* was widely distributed over the plateau but in low densities. There were two areas where concentrations of *C. gunnari* were found. Some of their biological properties, such as length frequency distributions, sexual maturity, were different from those observed in *C. gunnari* in the Kerguelen area at the same time of the year. This suggests that the fish in the two areas should be treated separately for management purposes. A more detailed report on results from this cruise will be presented at next year's meeting.

Coastal Areas of the Antarctic Continent
(Divisions 58.4.1 and 58.4.2)

6.143 No new data on the fish stocks in these areas became available. Therefore, no management advice can be provided for these areas.

Ob and Lena Banks (Division 58.4.4)

6.144 A TAC of 1 150 tonnes of *N. squamifrons* (715 tonnes for Lena Bank and 435 tonnes for Ob Bank) valid for a two-year period was set by CCAMLR in 1992.

6.145 A survey scheduled for January/February 1993 proposed by Ukraine to assess the state of the stocks of *N. squamifrons* on these banks did not take place. A similar survey is proposed for the 1993/94 season (WG-FSA-93/10). A discussion on the proposal is provided in paragraph 8.5.

Management Advice

6.146 There is a TAC already in force until the end of the Commission meeting in 1994 (Conservation Measure 59/XI). One of the requirements of Conservation Measure 59/XI was that the fishing will be subject to review at the 1993 meetings of the Scientific Committee and the Commission. The proposed survey by Ukraine was not undertaken in 1992/93. Therefore the Working Group was unable to revise its assessment carried out in 1992. The Working Group reiterates its recommendation from the 1992 meeting that a survey to determine age structure and stock size on both banks be conducted and the stock be re-assessed before the fishery is re-opened (SC-CAMLR-XI, Annex 5, paragraph 6.231).

GENERAL ADVICE ON THE MANAGEMENT OF FISH STOCKS

6.147 There have been a number of initiatives recently, by the UN and FAO, concerning high seas fisheries and straddling stocks. In particular, the UN Conference on Straddling Stocks and Highly Migratory Fish Stocks (New York, July 1993) charged FAO with: (i) providing further information on the suitability of the MSY concept; (ii) providing information on implementation of the precautionary approach; and (iii) developing a system of statistics for high seas fisheries. These matters are due to be discussed by the Scientific Committee and the Working Group considered that it could advise the Scientific Committee accordingly.

High Seas Fisheries and Straddling Stocks

6.148 Regarding straddling stocks, it was noted that there is evidence that *D. eleginoides* in the South Atlantic is a straddling stock, occurring around South Georgia and to the north and west of Subarea 48.3 in FAO Statistical Divisions 41.3.2 and 41.3.3. Furthermore, other species also probably come into the category of straddling stocks: myctophids, squids and *Micromesistius australis*. Subject to Article XI of the Convention such species may be viewed as stocks or associated species which occur both inside and outside the Convention Area. Thus the initiatives concerning high seas fisheries and straddling stocks should be pertinent to CCAMLR with a view to harmonising the development of measures in respect of such stocks.

6.149 From data available to the Working Group, it was clear that substantial fishing has occurred on *D. eleginoides* not only in Subarea 48.3 but also in areas immediately adjacent to but outside the CCAMLR Convention Area. Effective management of this fishery is obviously contingent on managing the stock as a whole. Therefore guidance of the Commission is sought on the effective harmonisation of management measures across the Convention's boundaries.

MSY

6.150 In regard to MSY, the Working Group noted that Article II of CCAMLR does not use this concept, addressing itself instead to "population ... levels below those which ensure ... stable recruitment" and "greatest net annual increment".

6.151 A management objective of MSY usually leads to the setting of highly variable catch limits from year to year, as the catch which gives MSY depends on estimated stock size and composition. This brings the MSY approach into conflict with another frequent objective of management, the maintenance of stable catches over a number of years. The MSY approach becomes hardly meaningful when biological interactions are taken into account as it is not possible to maximise the yield from both a predator and its prey species simultaneously. For this reason, MSY is not often a suitable management approach.

6.152 In this context, the Working Group noted that WG-Krill had considered the problem of stability in the krill fishery under changing management advice, and had sought Commission guidance on the frequency at which precautionary catch levels should be revised to ensure the fishery's stability (SC-CAMLR-XII/4, paragraph 6.18).

Precautionary Approach

6.153 The guiding principle of a precautionary approach should be able to evaluate in advance if the methods used for fisheries management are sufficient to achieve their management objectives. The Revised Management Procedure recently developed by the Scientific Committee of the International Whaling Commission is a good example of such a "textbook" precautionary approach. However, the term "precautionary approach" is also applied to management procedures which take into account uncertain or unknown effects of that management so that, on available information at least, the chances of the management objectives not being met are minimised.

6.154 Examples of the latter such precautionary approaches have been introduced by CCAMLR,

(i) to prevent uncontrolled expansion of the krill fishery by setting precautionary catch limits for krill fisheries in the Convention Area;

(ii) to create provision for advance notification and data requirements prior to the development of new fisheries which led to catch and effort regulations being applied to exploratory fishing (e.g., crabs in Subarea 48.3 and *D. eleginoides* in Subarea 48.4); and

(iii) to safeguard against unknown effects of bottom trawling on mixed fish communities and benthos by prohibiting bottom trawling.

6.155 The practice of providing a range of management options together with an evaluation of the risks associated with these options, a format adopted by WG-FSA in the past, is another example of contribution to a precautionary approach.

Management Under Uncertainty

6.156 In 1992 the question of setting TACs when there is no or insufficient advice due to uncertainty about stock size and sustainable yield was raised by the Commission (CCAMLR-XI, paragraph 9.23) which asked the Scientific Committee to provide advice on the matter. The consideration of what management measures are appropriate under conditions of uncertainty also contributes to a precautionary approach.

6.157 It was pointed out that this question had arisen partly in response to the situation with *E. carlsbergi* in 1992. The Working Group had expressed reservations about using its old assessments to set a TAC for the stock since the life span of these fish was so short that there were no data on the current biomass of the stock (SC-CAMLR-XI, Annex 5, paragraph 6.105). Despite this uncertainty, the Commission maintained the TAC for the 1992/93 season.

6.158 It was agreed that there were two extremes of data availability and uncertainty:

(A) HIGH DATA AVAILABILITY/LOW UNCERTAINTY, when sufficient data are available to enable a complete assessment of stock and short term future yield; under these conditions, specific advice on catch levels or other management measures is possible.

(B) LOW DATA AVAILABILITY/HIGH UNCERTAINTY, when little information is available from which to assess the current status of a stock, which may or may not have supported a fishery recently; under these conditions, a precautionary approach to management, for example based on risk analysis of potential yield, and the choice of conservative (low risk) management measures with low precautionary catch limits would be appropriate.

6.159 The Working Group envisaged that under conditions of increasingly poor data availability, as situation (A) becomes situation (B) (for instance when no new data have been reported for a number of years) management measures would most appropriately start to follow options from a choice of precautionary low catch levels, as specific advice on TACs from traditional assessments became less reliable. However, the Working Group stressed that an arbitrary phase-out rule, for instance where TACs would drop to zero following a fixed number of years of low data availability either in the presence or absence of fishing, may not be appropriate. Rather, a range of precautionary limits including rationale for reducing TACs to be applied under conditions of uncertainty should be developed taking into account the dynamics of various exploitable stocks.

6.160 The Working Group noted that the recently Revised Management Procedure developed by the International Whaling Commission explicitly and automatically takes uncertainty in the stock assessments into account when calculating catch limits. The procedure has the property that when assessments have high coefficients of variation (CV), catch limits are low. Catch limits increase when the CVs become lower, for example, as more data accumulate about the status of the stocks, or when more precise estimates become available.

6.161 It was pointed out that the time scale over which a stock is judged to have moved from situation (A) to situation (B) might be influenced by the life expectancy of the species concerned. Thus for a long-lived species such as *D. eleginoides*, assessments provided five years ago may still be appropriate to the majority of the stock, but for *E. carlsbergi* a 5-year old assessment would be entirely inappropriate as none of the fish now alive would have been spawned five years ago.

Safe Biological Limits

6.162 Dr K-H. Kock (Germany) drew attention to the use of Minimum Biologically Acceptable Limits (MBAL) by ICES. The MBAL is an estimated stock size at which recruitment is likely to fall below a level necessary for maintenance of the stock. It may alternatively be formulated in terms of increasing probabilities of recruitment failure.

6.163 The Working Group noted that there may be other methods to estimate safe biological limits of fish populations and recommended that these approaches be investigated for application to stocks in the CCAMLR Convention Area at next year's meeting.

Development of High Seas Fishery Statistics

6.164 At present FAO plans several meetings to pursue this issue further. In particular, an *Ad Hoc* Consultation on the Role of Regional Fishery Agencies in Relation to High Seas Fishery Statistics is planned to be held from 13 to 16 December 1993 at La Jolla, California, USA. This meeting will advise guidelines for the type of statistics and data reporting systems necessary for the collection of high seas fisheries statistics by FAO (see (iii) in paragraph 6.147 above). The Secretariat has received an invitation to participate at the above meeting (SC-CAMLR-XII/BG/12).

6.165 The Working Group noted that the FAO initiative on high seas fisheries statistics should be of importance for CCAMLR. The Working Group therefore recommended that the CCAMLR Secretariat be represented at the FAO Consultation in December 1993.

CONSIDERATION OF ECOSYSTEM MANAGEMENT

INTERACTIONS WITH WG-KRILL

Mortality of Larval and Juvenile Fish in Krill Trawls

7.1 The Scientific Committee has recognised that an assessment of the by-catch of young and larval fish in krill trawling is an urgent problem (SC-CAMLR-XI, paragraph 3.17). The Commission has noted that measures may need to be taken to reduce the by-catch of fish in krill trawls (CCAMLR-XI, paragraph 4.17). Three papers evaluating this problem were presented to the Working Group (WG-FSA-93/8 Rev. 1, WG-Krill-93/50 and 51).

7.2 WG-FSA-93/8 documented juvenile Antarctic fish caught during fishing by the krill trawler, *Grigory Kovtun*, in the region of South Georgia during May-June 1992. Juvenile fish were observed in 18.2% of all 55 krill hauls. If only hauls taken over the shelf were considered, juvenile fish occurred in 45.5% of tows. For *C. gunnari*, the number of fish per tonne of krill caught were 966±225 and 2 434±579 for all hauls and for shelf hauls respectively. Similarly, for *Lepidonotothen larseni*, the corresponding averages were 557±103 and 1 388±248.

7.3 WG-Krill-93/51 presented observations of juvenile fish in commercial trawls near South Georgia during July and August 1992. 27% of trawls had juvenile fish present. The results, when calculated in the same units as for WG-FSA-93/8, showed that a maximum of 520 fish were caught per tonne of krill, most of which were *L. larseni* with some *C. gunnari*. WG-Krill-93/50 presents comparable results for the 1990/1991 season with 24.5% of hauls during scientific sampling having juvenile fish present. There was no data in either paper to determine the proportion of trawls or abundance of by-catch in trawls taken only over the shelf.

7.4 The Working Group noted that the results of these three papers are comparable and that mortality of juvenile *C. gunnari* in krill trawls may be an important source of mortality for this species. Two estimates of the potential impact were made:

(i) the krill catch in Subarea 48.3 was 36 000 tonnes in May-June 1992 (the same time as the survey in WG-FSA-93/8 Rev. 1). Thus, the mean number of *C. gunnari* caught in krill trawls in May-June 1992 was approximately 35 million individuals. Recruitment of one year old *C. gunnari* between 1977 and 1989 estimated from Run 5 of the VPAs (paragraph 6.53) averaged 850 million individuals. If this is taken to be the average recruitment in any year then the proportion of juvenile *C. gunnari* eliminated in the krill fishery would have been approximately 4% in those two months. If the commercial fishery is concentrated over the shelf area then this mortality rate would be higher; and

(ii) an estimate based on the number of *C. gunnari* juveniles caught in the krill catch for 1992 and a population projection of these juveniles assuming a constant natural mortality rate of 0.48 showed the potential loss of *C. gunnari* from the stock to be approximately 12 000 tonnes.

7.5 The Working Group agreed that the issue of fish mortality in commercial krill trawls over the shelf area warrants serious attention by the Scientific Committee. Particular topics identified were the relative catch rates of fish compared to catch rates of krill and whether krill hauls were taken on the shelf. It was agreed that a methodology should be developed for assessing the significance of reported rates of by-catch of young fish in conjunction with estimates of recruitment provided by assessment methods such as VPA. Further information will also be required and should be submitted on the locations and time of year during which juvenile fish would be most vulnerable to krill fishing activities.

Importance of Krill as Prey of Fish

7.6 WG-FSA-93/24 describes temporal and spatial variation in the diet composition and feeding intensity of *C. gunnari* around South Georgia. Notably, the reproductive performance of *C. gunnari* seems directly related to the availability of krill. The Working Group noted that the presence of krill in the diet of the icefish is likely to be due to a combination of downward movement of krill into deep water and upward movement of icefish into surface waters. The potential importance of krill in the diets of demersal fish species suggests that WG-Krill may need to investigate in more detail the proportion of the krill population that moves to depths greater than the 150 m.

INTERACTIONS WITH WG-CEMP

Indicator Species

7.7 Two papers were made available to the Working Group for consideration of the blue-eyed shag (*Phalacrocorax atriceps bransfieldensis*) as an indicator species in the CCAMLR Ecosystem Monitoring Program (WG-CEMP-93/25 Rev. 1 and 26 Rev. 1). WG-CEMP-93/26 Rev. 1 describes a study from South Shetland Islands in which the fish species represented by the examination of otoliths in shag pellets corresponds qualitatively, and also in order of abundance, with the fish species regularly caught in trammel nets nearby. WG-CEMP-93/25 Rev. 1 presents a rationale for using these pellets to monitor the species composition of littoral fish fauna and for identifying when commercial species may be declining in the region by their absence in pellets.

7.8 The Working Group noted that the purpose to be served by these observations needs to be specified. Given such a specification, it would then be possible to evaluate whether the proposed observations would be able to fulfil this purpose. Also, the Working Group identified a number of criteria that need to be met before accepting that monitoring pellets of blue-eyed shags would contribute to its work:

(i) otoliths from fish species important to the work of the Commission found in pellets of blue-eyed shags are related to the abundance of those species;

(ii) the absence of otoliths of these species is not due to preferential feeding by shags for other fish species or due to differential digestion rates of otoliths of different species or differences in rates of digestion at different times, such as occurs during egg production by the birds; and

(iii) there is a direct relationship between composition of nearshore fish assemblages and the status of offshore stocks of interest to CCAMLR.

7.9 The Working Group noted that these studies highlight the need for a good understanding of the biology and natural history of species being proposed for use as indicator species.

7.10 The Working Group agreed that, should these criteria be met, an index of recruitment from otolith abundance in pellets might be useful as a qualitative signal for recruitment of commercial species.

Incidental Mortality of Birds During Longline Fishing

7.11 Streamer lines for use in longline operations to minimise the incidental mortality of seabirds were introduced by CCAMLR in 1992 in Conservation Measure 29/XI. These streamer lines were tested by New Zealand and modifications are proposed in SC-CAMLR-XII/BG/13. The Working Group briefly discussed these modifications but were unable to agree on advice to the Scientific Committee due to the lack of information as to why the current streamer lines should be modified. The Working Group noted that a comparison of the performance of the current and proposed streamer lines should be based on their (i) effectiveness in deterring birds from striking bait; and (ii) efficiency of operation (deployment, retrieval and maintenance).

7.12 The Working Group noted that the practice of some fishing vessels to discard by-catches of fish in longline activities during fishing operations may contribute to attracting and subsequent fouling of birds in longlines (SC-CAMLR-XII/BG/4).

Ecological Interactions

7.13 Two papers were presented to the Working Group on the role of myctophids in the Southern Ocean ecosystem (WG-FSA-93/17 and 18). WG-FSA-93/17 describes these species as being zooplanktivores that are important prey of higher predators such as squid, nototheniid fish, sea birds and mammals. WG-FSA-93/18 discusses the mechanisms by which *E. carlsbergi* might migrate across the South Polar Frontal Zone.

Prey Requirements of Predators

7.14 At its 1992 meeting, the Working Group discussed how it might contribute to the deliberations of WG-CEMP on parameters that could assist in interpreting changes in abundance and distribution of predator and prey species (SC-CAMLR-XI, paragraph 5.61; SC-CAMLR-XI, Annex 5, paragraphs 7.9 to 7.12). Submissions on this topic have been encouraged by the Working Group but no new information was presented.

OTHER INTERACTIONS

7.15 No new information is available on the potential impact of bottom trawling on benthic assemblages. The Working Group was informed that Australia is currently doing quantitative assessments of benthos in Prydz Bay that may help with these assessments.

RESEARCH SURVEYS

TRAWL SURVEY SIMULATION STUDIES

8.1 In 1991 and 1992 the Working Group drew priority attention to the difficulties which had been experienced in the application of the swept area method (Saville, 1977[10]) and associated *t*-statistics, to species with patchy distributions, such as *C. gunnari*. WG-FSA-93/20 addressed some of the statistical issues related to this issue, and reported the results of some simulation studies on trawl survey estimation based on using Aitchison's delta distribution to model the underlying statistical distribution of trawl survey densities. The paper also developed a method for calculating confidence intervals for the abundance estimates. Tests of the method showed that unbiased estimates of

[10] Saville, A. (Ed.). Survey methods of appraising fisheries resources. *FAO Fish. Tech. Pap.*, 71: 76.

abundance were obtained, along with confidence intervals which give approximately the correct coverage probability.

8.2 A computer program which implemented these methods has been submitted to CCAMLR, and was used in preparing the assessment for *C. gunnari*. The Working Group agreed that the methods appeared to be an improvement over the use of the usual simple sample statistics in the analysis of trawl surveys. Dr de la Mare indicated that he would be carrying out further simulation testing of the method to examine the robustness of the delta distribution estimators to different underlying statistical distributions.

8.3 The need for further work on the formulation of a range of fish behaviours to determine the possible forms of such statistical distributions, as specified in WG-FSA-92 (SC-CAMLR-XI, Annex 5, paragraphs 8.5 to 8.7) was reiterated. The Convener, Dr de la Mare, and Dr Kock agreed to continue to coordinate this activity.

DRAFT MANUAL FOR BOTTOM TRAWL SURVEYS

8.4 The Draft Manual for Bottom Trawl Surveys in the Convention Area (SC-CAMLR-XI, Annex 5, Appendix H, Attachment E) was circulated during the intersessional period. Only one survey has been conducted in the Convention Area since last year, and so too little experience has been gained in the use of the Manual to suggest any major revision at this stage. However, Dr de la Mare drew attention to the common practice of using the same set of stations when conducting repeat surveys, rather than choosing a new set of random stations. He noted that, although this practice had important practical advantages (e.g., in cases where there was rough trawling ground), it would not lead to the estimates being statistically consistent, in the sense of the mean of series of survey estimates converging on the true abundance, if the physical distribution of fish had a persistent geographic pattern. Using the same stations may be appropriate for the case where a time series of estimates is to be used as an index of abundance. In such cases, the estimation of a proportionality coefficient (q) would be desirable. Using re-randomised stations would be appropriate for improving the precision and accuracy of a total abundance estimate from repeat surveys. In the recent Australian survey at Heard Island the survey design was based on half of the stations being repeated, with the remainder being newly selected at random. It was suggested that it would be appropriate for some brief discussion of this matter to be included in the Draft Manual.

RECENT AND PROPOSED SURVEYS

8.5 The design of a bottom trawling survey on the Ob and Lena Banks has been proposed by Ukraine in WG-FSA-93/10. A review of the TACs for these banks is pending the outcome of this survey (paragraphs 6.144 and 6.145). The Working Group raised a number of points from the proposal that should be addressed:

(i) Why are net monitor cables required? The reasons given in the proposal indicate that an acoustic net monitor transmission would be preferred.

(ii) Why are trawls to be of one hour duration when survey trawls around South Georgia Island can be conducted successfully over a half hour period in the same depth range?

(iii) The results of the survey should be reported in the CCAMLR research database format.

8.6 A UK scientific research cruise for finfish in Subarea 48.3 is planned for the 1993/94 season. The proposal is detailed in WG-FSA-93/28. The survey design is similar to those of recent years with approximately 80 randomly located stations covering three depth strata. An additional element noted by the Working Group is the plan to study concentrations of *C. gunnari* if they are encountered during the survey.

8.7 Resolution 9/XI requires the Scientific Committee, in consultation with its Working Groups, to develop standardised guidelines and formats for Members to submit research plans for use of "commercial fishing or fishing support vessels or vessels of a similar catching capacity to conduct fishing for research purposes when the estimated catch of finfish may exceed 50 tonnes". The Working Group agreed that the format proposed in WG-FSA-93/12 Rev. 1 is suitable for attachment to this resolution.

8.8 The Working Group noted that a 50 tonne limit for normal research operations was a practical restriction intended to ensure that sufficient survey work could be undertaken without having a substantial impact on stocks, without a requirement to notify CCAMLR. It was noted that this restriction will be unlikely to affect the operation of research vessels carrying out typical bottom trawl surveys, but that it would affect those vessels used for other research purposes which catch commercial quantities of fish. Consequently, the requirement to submit plans to CCAMLR is unlikely to be applicable to most research operations. In this context, the Working Group recognised that the Resolution aimed to create a distinction between research fishing on a commercial scale and the scale of fishing usually required for the purposes of scientific research.

DATA REQUIREMENTS

9.1 Details of data requirements identified by the Working Group are given in Appendix D.

SOFTWARE AND ANALYSES REQUIRED FOR THE 1994 MEETING

9.2 Following the principles adopted at other Working Groups, the Secretariat was requested to undertake validation of the method of analysing trawl surveys described in WG-FSA-93/20. Following validation, receipt of detailed user instructions and final versions of the programs, this software will be made available for distribution through the Secretariat to interested researchers.

9.3 The Secretariat was requested to provide an enhancement to its stochastic population projection program to incorporate drawing the starting population age structure at random from a choice of prior distributions. Drs de la Mare and Constable agreed to liaise with the Secretariat on this matter.

9.4 This year much time was spent by several participants in identifying local depletion events in the haul-by-haul longline dataset for *D. eleginoides*. The Working Group requested that the Secretariat develop a program to scan these data automatically to assist in the identification of depletion events, or to provide some software which would allow rapid visual scanning.

9.5 The CCAMLR ADAPT VPA program, developed initially for the 1992 meeting of WG-FSA, has now been used for two years and has undergone some minor development. Participants were requested to contact the Secretariat with suggestions for improvements to the output or input to make the software more user-friendly.

OTHER BUSINESS

10.1 Some participants have experienced problems in using files generated by applications not available at the Secretariat. Fixing these problems requires considerable effort by the Secretariat's Computer Specialist.

10.2 In an attempt to alleviate this problem, the Working Group decided the following:

(i) the Secretariat should prepare and circulate with the invitation to the WG-FSA meeting, a summary of all software and hardware maintained at the Secretariat;

(ii) for the more specialised assessment and analysis packages, participants should be asked to keep this summary under constant review and advise the Secretariat when new versions of the software are released; and

(iii) it will be the responsibility of participants to bring with them licensed copies of any software they intend to use at the meeting which is not maintained at the Secretariat, and bring compatible drivers for these applications.

10.3 The report of the Workshop on the Management of the Antarctic Crab Fishery contains a suggestion that it would be useful for CCAMLR to maintain an ongoing bibliography for Antarctic crabs (Appendix E, paragraph 7.1).

10.4 At present, the Secretariat is working on a complete bibliography of papers presented at CCAMLR meetings. It also maintains a bibliography of reprints of published papers provided to the Secretariat by the CCAMLR scientists. A bibliography on Antarctic oceanography, hydrology and related aspects of krill distribution was recently compiled by the Secretariat on request from WG-Krill.

10.5 Compiling and maintaining such specialised bibliographies takes a considerable amount of time and effort by the Secretariat. At the same time, such bibliographies are being maintained by individual CCAMLR scientists working on specific projects.

10.6 The Working Group decided that as a common approach, the Secretariat should compile a register of scientists working on specific projects of interest to CCAMLR and of bibliographies they maintain, including any available bibliographies on Antarctic crabs. The register should be readily available to all CCAMLR scientists on request to the Secretariat.

10.7 The Working Group also requested that the Secretariat continue cataloguing its reprints. In order to keep the catalogue complete and updated, scientists are requested to send reprints of their publications to the CCAMLR library.

10.8 WG-Krill and WG-CEMP have both discussed the development of the Southern Ocean - International Global Ecosystem Dynamics (SO-GLOBEC) (see SC-CAMLR-XII/4, paragraphs 7.4

to 7.10; SC-CAMLR-XII/3, paragraphs 9.7 to 9.12). Both Working Groups have suggested that the Scientific Committee should consider nominating an observer to the SO-GLOBEC Program and that the liaison between SO-GLOBEC and the Scientific Committee and its Working Groups should continue.

10.9 The Working Group decided that having a full knowledge of the SO-GLOBEC development and implementation is of importance to CCAMLR. This would help to avoid certain overlap and competition between SO-GLOBEC and various programs of the CCAMLR Scientific Committee.

ADOPTION OF THE REPORT AND CLOSE OF THE MEETING

11.1 The report of the meeting was adopted.

11.2 In closing the meeting the Convener thanked the rapporteurs, conveners of various *ad hoc* subgroups and the Secretariat for their hard work which had enabled the meeting to be conducted in a most effective manner. Due to their efforts, the report of the meeting was prepared and adopted in the shortest time ever.

11.3 Dr Kock (Chairman of the Scientific Committee) congratulated the Convener for conducting the meeting in an efficient and productive fashion. He also extended his thanks to the Convener and participants on behalf of the Scientific Committee.

AGENDA

Working Group on Fish Stock Assessment
(Hobart, Australia, 12 to 19 October 1993)

1. Opening of the Meeting

2. Organisation of the Meeting

3. Adoption of the Agenda

4. Observation and Inspection

5. Review of Material for the Meeting
    - 5.1 Data Requirements Endorsed by the Commission in 1992
    - 5.2 Catch and Effort Statistics
    - 5.3 Mesh/Hook Selectivity and Related Experiments Affecting Catchability
    - 5.4 Other Documents
    - 5.5 Seabed Areas

6. Assessment Work and Management Advice
    - 6.1 New Fisheries
    - 6.2 South Georgia (Subarea 48.3) - Finfish
    - 6.3 South Georgia (Subarea 48.3) - Crabs
    - 6.4 South Orkney Islands (Subarea 48.2)
    - 6.5 Antarctic Peninsula (Subarea 48.1)
    - 6.6 Kerguelen Islands (Division 58.5.1)
    - 6.7 Ob and Lena Banks (Division 58.4.4)
    - 6.8 Coastal Areas of Antarctic Continent (Divisions 58.4.1 and 58.4.2)
    - 6.9 Pacific Ocean Sector (Area 88)
    - 6.10 General Advice

7. Considerations of Ecosystem Management
    - 7.1 Interactions with WG-Krill
    - 7.2 Interactions with WG-CEMP

7.3 Other Interactions (e.g. Multispecies, Benthos, etc.)
7.4 Coordination with Other Working Groups

8. Research Surveys
   8.1 Trawl Survey Simulation Studies
   8.2 Draft Manual for Bottom Trawl Surveys
   8.3 Recent and Proposed Surveys

9. Future Work
   9.1 Data Requirements
   9.2 Software to be Prepared or Developed Prior to the Next Meeting and Data Analyses Required

10. Other Business

11. Adoption of the Report

12. Close of the Meeting.

LIST OF PARTICIPANTS

Working Group on Fish Stock Assessment
(Hobart, Australia, 12 to 19 October 1993)

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LIST OF DOCUMENTS

Working Group on Fish Stock Assessment
(Hobart, Australia, 12 to 19 October 1993)

WG-FSA-93/1	PROVISIONAL AGENDA AND ANNOTATION TO THE PROVISIONAL AGENDA FOR THE 1993 MEETING OF THE WORKING GROUP ON FISH STOCK ASSESSMENT (WG-FSA)
WG-FSA-93/2	LIST OF PARTICIPANTS
WG-FSA-93/3	LIST OF DOCUMENTS
WG-FSA-93/4	REPORT OF THE WORKSHOP ON THE MANAGEMENT OF THE ANTARCTIC CRAB FISHERY (La Jolla, California, USA, 26 to 28 April 1993)
WG-FSA-93/5	ANALYSES PERFORMED AT THE 1992 MEETING OF THE WORKING GROUP ON FISH STOCK ASSESSMENT D.J. Agnew (Secretariat)
WG-FSA-93/6 Rev. 1	CROSS-SECTIONAL STRUCTURE AND VALIDATION OF THE TIMING OF ANNULUS FORMATION IN OTOLITHS OF THE ANTARCTIC FISH *NOTOTHENIA CORIICEPS* RICHARDSON (NOTOTHENIIDAE) Julian R. Ashford and Martin G. White (United Kingdom)
WG-FSA-93/7	A METHOD FOR PREPARING LARGE NUMBERS OF OTOLITH SECTIONS FOR VIEWING BY SCANNING ELECTRON MICROSCOPE J.R. Ashford, K. Robinson and M.G. White (United Kingdom)
WG-FSA-93/8 Rev. 1	BY-CATCH OF JUVENILE ANTARCTIC FISH FROM KRILL (*EUPHAUSIA SUPERBA* DANA) FISHERIES IN THE SOUTH GEORGIA AREA, IN 1992 E.A. Pakhomov and S.A. Pankratov (Ukraine)
WG-FSA-93/9	ASPECTS OF THE DISTRIBUTION AND INTERANNUAL VARIATIONS IN LARVAL FISH ASSEMBLAGES AT SOUTH GEORGIA, ANTARCTICA Martin G. White (United Kingdom)
WG-FSA-93/10	A SUGGESTED BOTTOM TRAWLING SURVEY ON THE OB AND LENA BANKS (Ukraine)
WG-FSA-93/11	SOME PROBLEMS OF WATER FLOW THROUGH TRAWL CODEND Waldemar Moderhak (Poland)

WG-FSA-93/12 Rev. 1	SUBMISSION OF PLANS FOR CONDUCTING FINFISH SURVEYS IN THE CONVENTION AREA Secretariat
WG-FSA-93/13	SIZE VARIATIONS ASSOCIATED WITH ABUNDANCE CHANGES IN JUVENILE *NOTOTHENIA ROSSII*, OBSERVED AT POTTER COVE, SOUTH SHETLAND ISLANDS, SINCE THE END OF THE FISHERY IN THE AREA Enrique R. Marschoff and Esteban R. Barrera-Oro (Argentina)
WG-FSA-93/14	THE EARLY LIFE HISTORY AND THE ONSET OF SCALE FORMATION IN THE PATAGONIAN TOOTHFISH, *DISSOSTICHUS ELEGINOIDES* SMITT, 1898 Karl-Hermann Kock (Germany)
WG-FSA-93/15	THE *DISSOSTICHUS ELEGINOIDES* FISHERY IN DIVISION 58.5.1 (KERGUELEN ISLANDS) G. Duhamel (France)
WG-FSA-93/16	THE PATAGONIAN TOOTHFISH (*DISSOSTICHUS ELEGINOIDES*) FISHERY ON THE KERGUELEN ISLAND SHELF V.G. Prutko (Ukraine)
WG-FSA-93/17	ON THE STATUS OF MESOPELAGIC FISH (MYCTOPHIDAE) IN THE SOUTHERN OCEAN ECOSYSTEM A.N. Kozlov (Russia)
WG-FSA-93/18	THE MIGRATION PATTERNS OF *ELECTRONA CARLSBERGI* (TÅNING, 1932) A.N. Kozlov (Russia)
WG-FSA-93/19	ESTIMATES OF SEABED AREAS WITHIN SELECTED DEPTH RANGES E.N. Sabourenkov, A. Blake and D.J. Agnew (Secretariat)
WG-FSA-93/20	ESTIMATING CONFIDENCE INTERVALS FOR FISH STOCK ABUNDANCE ESTIMATES FROM TRAWL SURVEYS William K. de la Mare (Australia)
WG-FSA-93/21	STOCK STATE OF *DISSOSTICHUS ELEGINOIDES* AT SUBAREA 48.3 AND ADJACENT ZONES C.A. Moreno and P.S. Rubilar (Chile)
WG-FSA-93/22	PROPOSAL FOR AN EXPERIMENTAL CRAB FISHERY IN SUBAREA 48.3 George Watters (USA)
WG-FSA-93/23	USING PRODUCTION MODELS TO ASSESS THE STOCK OF *PARALOMIS SPINOSISSIMA* AROUND SOUTH GEORGIA ISLAND George Watters (USA)

WG-FSA-93/24	VARIATIONS IN THE DIET COMPOSITION AND FEEDING INTENSITY OF MACKEREL ICEFISH (*CHAMPSOCEPHALUS GUNNARI*) AT SOUTH GEORGIA (ANTARCTIC) K.-H. Kock and S. Wilhelms (Germany), I. Everson (UK) and J. Gröger (Germany)
WG-FSA-93/25	ON THE TAXONOMY OF THE *LEPIDONOTOTHEN SQUAMIFRONS* GROUP (PISCES, PERCIFORMES, NOTOTHENIOIDEI) R. Schneppenheim and K.-H. Kock (Germany), G. Duhamel (France) and G. Janssen (Germany)
WG-FSA-93/26	TIMESCALE OF OVARIAN MATURATION IN *NOTOTHENIA CORIICEPS* (RICHARDSON); EVIDENCE FOR A PROLONGED ADOLESCENT PHASE Inigo Everson (UK)
WG-FSA-93/27	DISTRIBUTION OF CATCHES OF *DISSOSTICHUS ELEGINOIDES* IN SUBAREAS 48.3 AND 48.4, 1992/93 SEASON Secretariat
WG-FSA-93/28	UK SCIENTIFIC RESEARCH CRUISE FOR FINFISH: SUBAREA 48.3 Delegation of UK
WG-FSA-93/29	REVISION OF THE COMMERCIAL CATCH AT AGE OF THE ANTARCTIC ICEFISH *CHAMPSOCEPHALUS GUNNARI* OVER THE PERIOD 1976/77 TO 1990/91 G.B. Parkes (UK)

OTHER DOCUMENTS

WG-Krill-93/50	FISHES IN PELAGIC CATCHES IN THE VICINITY OF THE SOUTH SHETLAND ISLAND DURING THE 6TH ANTARCTIC EXPEDITION OF RV *KAIYO MARU*, 1990/1991 Tetsuo Iwami, Taro Ichii, Haruto Ishii and Mikio Naganobu (Japan)
WG-Krill-93/51	FISHES CAUGHT ALONG WITH THE ANTARCTIC KRILL IN THE VICINITY OF THE SOUTH GEORGIA ISLAND DURING THE AUSTRAL WINTER MONTHS OF 1992 Tetsuo Iwami (Japan)
WG-CEMP-93/25 Rev. 1	BLUE-EYED SHAGS AS INDICATORS OF CHANGES IN LITTORAL FISH POPULATIONS Ricardo Casaux and Esteban Barrera-Oro (Argentina)
WG-CEMP-93/26 Rev. 1	THE DIET OF THE BLUE-EYED SHAG, *PHALACROCORAX ATRICEPS BRANSFIELDENSIS* AT THE WEST ANTARCTIC PENINSULA Ricardo Casaux and Esteban Barrera-Oro (Argentina)

CCAMLR-XII/5	EVALUATING NEW AND EXPLORATORY FISHERIES Delegation of USA
SC-CAMLR-XII/BG/2	CCAMLR DATABASES AND DATA AVAILABILITY Secretariat
SC-CAMLR-XII/BG/3	REPORT OF A COORDINATION MEETING OF THE CONVENERS OF THE WORKING GROUPS ON KRILL, CEMP AND FISH AND THE CHAIRMAN OF THE SCIENTIFIC COMMITTEE
SC-CAMLR-XII/BG/4	AN EXPLORATORY FISHING EXPEDITION FOR *DISSOSTICHUS ELEGINOIDES* AROUND THE SOUTH SANDWICH ISLANDS, ANTARCTICA Delegations of Chile and United Kingdom
SC-CAMLR-XII/BG/11	FISHING AND CONSERVATION IN SOUTHERN WATERS Delegation of Germany
SC-CAMLR-XII/BG/13	OBSERVATIONS ON CCAMLR SPECIFICATIONS FOR STREAMER LINES TO REDUCE LONGLINE BY-CATCH OF SEABIRDS Delegation of New Zealand

APPENDIX D

DATA REQUIREMENTS FOR THE WORKING GROUP

I Data Required by WG-FSA-92	II Data Received by WG-FSA-93	III Data Requested by WG-FSA-93
1. Data from the crab fishery should be collected and submitted (paragraphs 6.20 (v) and (vi))	Data reported	-
2. *D. eleginoides*, Subarea 48.3 (paragraph 6.176) • studies on hook selection factors required • studies on loss rates of fish	None received	*D. eleginoides*, Subarea 48.3 • studies on hook selection factors required • studies on loss rates of fish
3. *D. eleginoides*, Subarea 48.3 • age and maturity determination required for an expanded range of lengths from historical and current commercial and research catches (paragraph 6.123 to 6.126) • fish should be measured in 1 cm length classes and all data should be submitted to CCAMLR (paragraph 6.142)	Data received from current fishery	*D. eleginoides*, Subarea 48.3 • age and maturity determination required for an expanded range of lengths from historical and current commercial and research catches
4. *E. carlsbergi*, Subarea 48.3: • description of operation (CCAMLR-IX, paragraph 4.27) • further information requested on by-catch in commercial *E. carlsbergi* fishery (paragraph 6.103) • new surveys required (paragraph 6.105)	No information	-
5. Representative length frequency from the commercial catch of *C. gunnari* in Subarea 48.3 should be reported for the most recent years of the fishery	No information but no fishery	Representative length frequency from the commercial catch of *C. gunnari* in Subarea 48.3 should be reported for the most recent years of the fishery
6. Trawl fisheries in Subarea 48.3: • detailed data on the by-catch in pelagic (midwater) and demersal (bottom) trawl fisheries in Subarea 48.3 are urgently required to establish management advice (paragraphs 6.72 and 6.93) • research data should be submitted to the Secretariat	No information	Trawl fisheries in Subarea 48.3 • detailed data on the by-catch in pelagic (midwater) and demersal (bottom) trawl fisheries in Subarea 48.3 are urgently required to establish management advice (paragraph 6.64) • research data should be submitted to the Secretariat
7. *N. rossii*, Subarea 48.3 • biological information on incidental catch • haul-by-haul data from historical fishery requested (paragraph 6.34)	No information	-
8. Length and age, *N. squamifrons*, Subarea 48.3 - commercial data for past years (paragraph 6.90)	No information	-
9. Commercial age and length data for *N. gibberifrons*	No information	-

I	II	III
10. *P. guntheri*, Subarea 48.3 - clarification of position of past catches around South Georgia requested (paragraph 6.86)	No information	-
11. *E. carlsbergi* • clarification of position and time of catch of 1 518 tonnes reported for Subarea 48.2 in 1990/91 (paragraph 6.178) • clarification of position and time of catch of 50 tonnes in Subarea 48.1 in 1991/92 (paragraph 6.203)	No information	*E. carlsbergi* • clarification of position and time of catch of 1 518 tonnes reported for Subarea 48.2 in 1990/91 • clarification of position and time of catch of 50 tonnes in Subarea 48.1 in 1991/92
12. Age/length data from catches of *C. gunnari* in Division 58.5.1 prior to 1980	Data in Gerasimchuk, 1993[1]	-
13. Commercial length and age data for the *D. eleginoides* trawl and longline fisheries in Division 58.5.1	Submitted by France	-
14. *N. squamifrons*, Division 58.5.1 • length and age/length key data • catch data separated for Division 58.5.1 • data consistency	No further data are available Zaitsev, 1989[2]	-
15. Information on levels of discarding and conversion rates from fish products to nominal weight are required	No information	-
16. Call for detailed charts to assist the Secretariat in the calculation of seabed areas (paragraph 8.11)	Charts received by Secretariat	-
17. Call for historic information from surveys to assist the Workshop on the Design of Bottom Trawl Surveys in investigating the internnual variability in the occurrence of fish aggregations (paragraphs 8.5 and 8.6)		Call for historic information from surveys to assist the Workshop on the Design of Bottom Trawl Surveys in investigating the interannual variability in the occurrence of fish aggregations
18.		*D. eleginoides*, Subarea 48.3 • stock identification studies • data on the position or bearing of each end of longlines (paragraph 6.16)
19.		Crab fishery, Subarea 48.3 Investigations on the use of time-release devices, escape ports and pot selectivity (paragraph 6.89)

[1] Gerasimchuk, V.V. 1993. States of stocks *Champsocephalus gunnari* on the shelf of the Kerguelen Islands. In: Duhamel, G. (Ed). *Les Rapports des campagnes à la mer: Campagnes SKALP 1987 et 1988 aux îles Kerguelen. Les Publications de l'Institut Français pour la Recherche et la Technologie Polaires*, 93-01: 266-276.

[2] Zaitsev, A.K. 1989. Growth and age/length structure of populations of *Notothenia (Lepidonotothen) squamifrons* (Nototheniidae) in various areas of the Indian sector of the Southern Ocean. In: *Selected Scientific Papers, 1989 (SC-CAMLR-SSP/6)*. CCAMLR, Hobart, Australia: 123-139.

REPORT OF THE WORKSHOP ON THE MANAGEMENT OF THE ANTARCTIC CRAB FISHERY

(La Jolla, California, USA, 26 to 28 April 1993)

REPORT OF THE WORKSHOP ON THE MANAGEMENT OF THE ANTARCTIC CRAB FISHERY

(La Jolla, California, USA, 26 to 28 April 1993)

OPENING OF THE MEETING

1.1 The Workshop was held at the Southwest Fisheries Science Center, La Jolla, California, from 26 to 28 April 1993. The Convener, Dr R. Holt (USA) chaired the Workshop.

1.2 The participants of the Workshop were welcomed by the Director of the Southwest Fisheries Science Center, Dr M. Tillman, on behalf of the US Government.

ORGANISATION OF THE MEETING AND APPOINTMENT OF RAPPORTEURS

1.3 The following were appointed rapporteurs:

Dr R. Holt, Agenda Items 1, 6, 7, 8 and 9;
Dr R. Otto (USA), Agenda Item 2 (i) to (iii);
Dr I. Everson (UK), Agenda Item 2 (iv);
Dr M. Basson (UK), Agenda Item 3;
Dr A. Rosenberg (USA), Agenda Item 4; and
Dr D. Agnew (CCAMLR Secretariat), Agenda Items 5 and 6.

A list of participants is given in Attachment A. A list of papers tabled at the meeting is given in Attachment B.

ADOPTION OF THE AGENDA

1.4 A draft agenda had been prepared by the Convener and the CCAMLR Secretariat. This agenda was adopted and is included as Attachment C.

BACKGROUND OF THE MEETING

1.5 Following notification to the Commission by the United States in 1991 of a potential new fishery for Antarctic crab *Paralomis* in Subarea 48.3 (CCAMLR-X, paragraphs 6.7 to 6.12), a fishery operated in Subarea 48.3 from July to November 1992.

1.6 The Scientific Committee had recommended that a conservative management strategy be followed in the development of the fishery for the species, and had recommended a series of measures to manage the fishery in this stage of its development.

1.7 The Commission requested the Scientific Committee to develop a Longterm Management Plan for the Exploratory Crab Fishery. This CCAMLR Workshop was asked to specify the data needed and the actions required to acquire the relevant information from the exploratory crab fishery that will allow the estimation of appropriate harvest levels and methods in accordance with Article II of the Convention, for review by the Scientific Committee (CCAMLR-XI, paragraphs 9.48 to 9.50).

OBJECTIVES OF THE MEETING

1.8 The objectives of the Workshop (SC-CAMLR-XI, paragraph 4.17) were:

(i) to design an approach to management of this fishery that will enable WG-FSA to measure:

(a) the productivity and abundance of the stock; and
(b) the effect of different harvest strategies;

(ii) to establish the types and scale of data necessary to implement the above approach to management; and

(iii) to establish reporting requirements for the fishery.

INFORMATION ON THE *PARALOMIS SPINOSISSIMA* STOCK

Biological Characteristics

2.1 A summary of the types of data discussed in this section, their methods of acquisition and priority for acquisition is given in Table 1.

2.2 The Workshop considered available information on *Paralomis* spp. contained in WS-Crab-93/4, 24 and 25 as well as WG-FSA-92/29. The working group noted that two species of *Paralomis* are found in Subarea 48.3. *Paralomis spinosissima* is of major concern as this was the target species during the 1992 fishery but *Paralomis formosa* is also found in abundance and may be of commercial interest in the future.

2.3 The two species have similar geographic distributions and are known from the Scotia Sea north to the Atlantic continental shelf waters of South America. They are not known from the eastern Atlantic or from Pacific Ocean waters. Available records summarized by Macpherson (WS-Crab-93/25) show *P. spinosissima* occurs in areas west of 34° longitude ranging north to 46°S latitude at depths of 132 to 824 m. *Paralomis formosa* ranges north to about 37°S latitude and is found at depths to 1 600 m. Records from a Spanish trawl survey in 1987 and 1991 show that both species occur to the south of South Georgia (56°S) (WS-Crab-93/19) but were not found at South Orkney or the South Sandwich Islands. Little is known of their abundance in areas outside Subarea 48.3. Suggestions for research on biological parameters and data collection expressed in this report largely apply to both species although only *P. spinosissima* is considered here.

2.4 The genus *Paralomis* is in the family Lithodidae, anomuran crabs closely allied to the hermit crabs. The family includes the genera *Lithodes* and *Paralithodes* which are commonly known as king or stone crabs and contain species that provide important commercial fisheries world wide. The genus *Paralomis* is known from all the World's oceans except the Arctic and is usually found at extreme depths. In the Southern Oceans members of the genus are, however, found in continental shelf and slope waters. *Paralomis granulosa*, for example, is harvested in Chile and to a lesser extent in Argentina as well as the Falkland Islands.

2.5 Anomurans differ from the true crabs (Brachyura) in that females lack spermathecae and cannot store sperm during mating and fertilize eggs at a later time. Female anomuran crabs mate and extrude eggs immediately after moulting with fertilization occurring during or immediately after extrusion. The abundance and size of mature males relative to that of females may be more important in fishery management of anomuran crabs than it is in the management of brachyurans. This is especially true if the moulting-mating season is relatively short. The correlation between moulting and mating times may also influence the timing of fishing seasons.

2.6 The Workshop considered available information on reproduction in *P. spinosissima* in Subarea 48.3 and noted the following:

(i) Size at maturity is probably lower at Shag Rocks than at South Georgia Island. Chela allometry indicates that males mature at about 66 mm carapace length at Shag Rocks and 75 mm at South Georgia Island. Differences in female size at maturity (based on the frequency of ovigerous specimens by size group) were less apparent; 50% of the females were carrying eggs at a size of 62 mm carapace length (data combined from both locations). The minimum and average sizes of ovigerous females were, however, smaller at Shag Rocks than at South Georgia Island. Determination of size at maturity was difficult due to the high frequency of rhizocephalan parasites. The size of ovigerous females is directly proportional to functional maturity. There was some discussion of the possibility that morphometric maturity as determined for males may not be directly equatable to the size at which males actually participate in mating and are hence functionally mature.

(ii) Field and subsequent microscopic observations of embryos being brooded by females during July 1992 suggest that mating probably occurs over substantial portions of the year. Developmental stages ranged from external eggs showing only the formation of blastodiscs, to those that had completed development and were in the process of hatching. Females carrying only the remnants of hatched eggs were also commonly encountered. While these observations are indicative of a protracted spawning period, in the absence of seasonal monitoring it is not clear whether spawning within the population occurs throughout the year . If there is a seasonal component to the frequency of spawning, its timing may influence spatial distribution of males relative to females and the frequency of moulting.

(iii) The number of newly fertilized eggs in *P. spinosissima* ranged from approximately 2 000 to 14 000 and increased exponentially with carapace length. The relationship between fecundity and size was compared to that for *Lithodes aequispina* from the Aleutian Islands. While fecundity in *P. spinosissima* is an order of magnitude lower than many other crab species, at any given size average fecundity in *P. spinosissima* is higher than that for *L. aequispina*. Participants noted that recruitment in other crab and crustacean populations is highly variable and not necessarily well related to population egg production. However, the importance of fecundity observations and their application to understanding stock/recruitment relationships should not be ruled out for *Paralomis* spp. Also, participants noted that it would be desirable to describe the relationship between numbers of brooded embryos and body size at later stages of embryologic development in order to estimate the number of larvae hatched.

(iv) Data on the diameter of oocytes relative to the developmental stage of brooded embryos indicated that spawning does not immediately follow hatching in *P. spinosissima*. If it is assumed that embryologic development lasts for one year and that vitellogenesis occurs at a roughly constant rate, then the spawning cycle may approach two years. This would be similar to spawning cycle of *L. aequispina* which has a similar depth range in the North Pacific, an embryologic period of one year, similar egg size and is capable of lecithotrophic larval development. The possibility that *P. spinosissima* has lecithotrophic, benthic larvae was discussed as this sort of life history may influence stock/recruitment relationships.

2.7 Apart from the above reproductive data and limited information on size frequency, participants noted that there was very little life history, ecological or demographic information available. Due to the limited area that has been fished and from which biological data has been collected, considerable attention should be given to areal differences in all parameters.

Distribution and Stock Identity

2.8 The Workshop considered data presented in documents WS-Crab-93/17, 19, 24 and 25 as well as WG-FSA-92/29. It was noted that the Spanish trawl survey of continental shelf and slope waters of the Scotia Arc encountered crabs only at South Georgia Island and Shag Rocks. It was agreed that CCAMLR Members should attempt to assemble existing, unpublished, information on the geographic distribution of crabs in the Southern Oceans.

2.9 Differences in mean size and the size at maturity between Shag Rocks and South Georgia Island suggest that discrete stocks may exist. Discussions indicated that comparative morphology and demographic studies were most generally used to identify stocks of crabs and that recent studies were proving the utility of genetic techniques in stock identification. Tagging studies have also been used to delineate stocks for the purposes of fishery management. It was generally agreed that differences in demographic characteristics were frequently sufficient to warrant separate treatment of populations inhabiting various grounds even if populations could be considered as parts of the same interbreeding unit (deme) genetically.

2.10 The Workshop suggested that in addition to biological and fishery data collection, oceanographic data also be collected. If this is available from other sources it should be interfaced with the biological data. Most crab populations show significant changes in size over time, which may be related to environmental factors. Data on seasonal water temperatures and probably current patterns are desirable. These data could be best obtained by established hydroacoustically released gear. Expendable Bathy Thermographs (XBTs) give a snap shot of conditions at a given time, but given the limited commercial effort, would probably be insufficient in quantity to provide a useful time series of data.

Demographic Characteristics

2.11 Participants agreed that information on size-specific growth, mortality and stock abundance was most important at the moment. At present these elements can most easily be estimated by analogy with other species and stocks. The interaction of reproductive and life history parameters with stock/recruitment relationships was discussed as was the importance of parasitism. Participants agreed that the acquisition of demographic information would be influenced by the selectivity of pots in the fishery. Comparative fishing experiments between pots with small and large mesh size and between pots and trawls were suggested.

Parasitism

2.12 Investigations during the experimental crab fishing study had indicated that in some areas a very high proportion of the *P. spinosissima* were parasitised by rhizocephalan*. Microsporidian infections were also found but at much lower incidence. The incidence of infection was greatest in small individuals of both sexes and was more prevalent at South Georgia than at Shag Rocks. These parasites were not found in *P. formosa* (WG-FSA-92/29). Incidence of rhizocephalans and microsporidians is probably underestimated as early stages of infection are cryptic.

2.13 The implications on the *P. spinosissima* population of this rhizocephalan infestation were considered in the study described in WS-Crab-93/7 and supported by more general models in WS-Crab-93/9. The following conclusions had been drawn in this study:

(i) the spawning stock of a population with a high prevalence of rhizocephalan infestation is likely to be below the spawning stock of an uninfected population;

(ii) the spawning stock ratio (exploited SSN**/unexploited SSN) decreases as fishing mortality increases when only healthy animals are harvested. This is also true in the absence of parasitism but the 'starting point' or the unexploited level of spawning stock is lower when there is any infestation; and

(iii) when healthy and parasitised animals are harvested the spawning stock ratio decreases less rapidly than is the case when only healthy animals are harvested and in some cases there may be an increase in the spawning stock for relatively low levels of fishing mortality.

* genus Briarosaccus class Cirripedia, phylum Crustacea

** SSN = Spawning Stock Number

2.14 It was noted that in modelling the situation it was important to take account of the recruitment dynamics of the parasite and host. This in turn meant it was important to determine the larval distribution and be able to determine stock identity.

2.15 Even though the rhizocephalan tends to cause feminisation in *P. spinosissima*, it was noted that there was a higher prevalence of parasitisation in males than females. During the field study presence of pleopods had been taken as diagnostic that the crab was female.

2.16 A significant proportion of the rhizocephalans were themselves infected by an undescribed species of isopod. The dynamics of this hyperparasitisation were unknown and merit analysis through extension of models in WS-Crab-93/7 and 9.

2.17 Even though the majority of the rhizocephalan infected *P. spinosissima* were smaller than the minimum size adopted in WG-FSA-92/29, it was agreed that destroying infected individuals is more likely to have an overall benefit to the crab population. It was considered that there was no chance of further infection if such crabs were crushed and returned directly to the sea.

2.18 Infection by the rhizocephalan is thought to occur during the immediate post-moult period. The externa, the external manifestation of the parasite, becomes visible some months later.

2.19 No information was available to indicate whether high levels of parasitisation were a localised or widespread phenomenon. Information on this topic could be obtained by analysis of data on infestation rates on a haul-by-haul basis taking account of the location of the catches.

2.20 The prevalence of rhizocephalan parasitism undoubtedly influences demographic characteristics and stock recruitment relationships in any stock that may be defined. This host-parasite interaction should be more extensively modelled to predict its influence on demographic characteristics and yield.

ASSESSMENT METHODS

3.1 Various assessment methods that have been used in other crustacean fisheries and that may be applicable to the *P. spinosissima* and *P. formosa* fishery in Subarea 48.3 were identified. The methods can be grouped as follows:

depletion methods;
change-in-ratio and index-removal methods;
size/length-based assessment analyses;
calibration of abundance indices;
production models; and
yield-per-recruit.

These methods, with the exception of yield-per-recruit, are discussed in turn and their main assumptions, data requirements and outputs are summarised in Table 2. For all of the assessment methods described below estimates of uncertainty of current stock status should be made and sensitivity to underlying assumptions and data quality should be explored.

3.2 These methods can be divided into two groups. The first group (depletion, change-in-ratio, index-removal, size/length-based assessment, and production model methods) require that the fishery substantially reduces the population from the study area since it is the change in the population due to known removals that is the basis of the estimation. The second group does not require that the fishery reduce the population size.

Depletion Methods

3.3 Depletion methods (also referred to as Leslie-De Lury methods) can, in theory, be applied to aggregated data over a whole fishing season or several years to obtain estimates of total population size. In the context of the crab fishery at South Georgia, it is at this stage more appropriate and feasible to consider local depletion models applied to data at a finer temporal and spatial scale.

3.4 Local depletion models use commercial catch-per-unit-effort (CPUE) and cumulative catch data to estimate local population densities in relatively small areas. These density estimates can then be used to extrapolate to a population size over a larger area if data on distribution of the stock are available. The main assumptions are that CPUE is proportional to the density and that the population is closed over the period considered in the analysis. The second assumption can often be relaxed though additional information may be required.

3.5 It is important that an appropriate measure of effort is used when constructing CPUE. Soak time of pots may, for example, have to be taken into account if there is any relationship between catch per pot and soak time or if there is any sign of saturation. The aggregated data on catch per pot and average soak time presented in WS-Crab-93/24 seem to show some form of saturation in catch rate at a soak time of around 30 hours. Saturation can be due to many effects, for example, degradation of bait, and is usually determined from field studies.

3.6 Ideally, catch/effort data should be on as fine a spatial and temporal scale as possible. This is particularly relevant in this case because the level of effort is currently relatively low. Data at a coarse scale of, for example, 10-day periods by gridsquare (1° longitude by 0.5° latitude) may disguise any depletion occurring at a finer scale.

3.7 Some participants felt sceptical about the possibility of detecting any depletion effects, even on a local scale. Firstly, this is because there is a possibility that spawning and moulting are protracted for this species. Secondly, there is a single vessel in the fishery and it would tend to avoid depletion. The first issue can be addressed by developing a variation of the standard depletion method to take growth and recruitment into account, though this would clearly require additional information.

3.8 The second issue could be addressed by using an experimental approach. One possibility may be to request the fishing vessel(s) to do repeated sampling by settings of many strings in a relatively small area over a short period of time. Catch/effort data from this type of 'fishing experiment' may be very valuable for estimation of local density from depletion methods. From the point of view of a fishing vessel, this may be feasible over a period of one week or less since it is not in a vessel's interest to continue fishing once catch rates have dropped to very low levels. However, repeated sampling may generate emigration from the area.

3.9 It was noted that the assumption of constant catchability may not be realistic in this new fishery where fishermen are still in a process of learning. As long as the analysis is applied to data over a short time-period (one or two weeks rather than the entire season, for example) this should not be a problem.

3.10 Extrapolation from estimates of local density to larger areas should be done with great care as topology, substratum characteristics, depth, etc. may vary considerably between areas containing crab. Only areas of similar physical characteristics should be included in extrapolation, perhaps creating a need for more study areas. In some cases it may not be appropriate to extrapolate at all because of factors such as movement or migration of crabs and changes in size of animals by area (and/or depth).

Change-In-Ratio (CIR) and Index-Removal (IR) Methods

3.11 Descriptions of the CIR and IR methods and their application to snow crab are given in WS-Crab-93/10. Both these methods require some form of survey, either by appropriate trawl gear or pots, to randomly sample animals before and after the fishery. Total removals (i.e., total catch) is also required.

3.12 The CIR method uses the random samples to obtain estimates of the proportions of legal and sub-legal sized crabs before and after fishing. These proportions and the total removals are then used to estimate the population size and the number of legal-sized crabs before fishing, as well as catchability coefficients. The IR method uses estimates of catch rates before and after fishing from the random samples and the total removals to estimate the same parameters as the CIR method. It is also possible to combine estimates from the two methods as indicated in WS-Crab-93/10.

3.13 Both these methods are based on the assumption that the population is closed. The CIR method further assumes that all legal sized animals have the same probability of being caught. The IR method assumes that the probability of capture does not vary within or between surveys. As in the case of the depletion method, there are ways of relaxing these assumptions.

3.14 Most of the comments made with respect to the depletion method also apply to these two methods. The main difference is, however, that additional information from fishing at random locations is required for CIR and IR whereas the commercial fishery may not be prosecuted at random locations. There may be some advantage in looking at the feasibility of requesting the commercial vessel(s) to carry out fishing at random locations.

3.15 It would be particularly useful if estimates of population size from both the CIR/IR and depletion methods could be obtained. These estimates could also be combined with appropriate weighting (by, for example, inverse variance) to possibly improve the precision of the estimates.

Size/Length-based Methods

3.16 There are various methods that fall within this category. Length-based cohort analysis (or Jones method) is basically a deterministic model that uses catch in numbers by size class with estimates of growth rate, natural mortality and terminal fishing mortality to estimate population size. The main assumption which generally limits the use of this method is that the population is in equilibrium. The deterministic nature of this method means that it can, in theory, be applied to a single year's data though results would obviously be interpreted with great caution.

3.17 Length-converted catch curves are used to estimate total mortality. They require data and assumptions similar to those required for length-based cohort calculations. With a virgin population, length-converted catch curves can potentially be used to estimate natural mortality.

3.18 The length-based De Lury method (Conser, 1992) uses time series of indices of population numbers, by at least two size classes, and total catches together with some description of growth and mortality to estimate population sizes and fishing mortalities by size class. This method estimates parameters using a likelihood criterion.

3.19 Catch-at-size analysis (CASA) is similar to the length-based De Lury method but requires further information as indicated in Table 2.

3.20 All the size-based methods of assessment require relatively large amounts of detailed data and cannot really be applied to the crab fishery around South Georgia at this early stage.

3.21 These size-based methods also focus on the need to estimate growth parameters. Estimates of growth rates are also required for estimating other quantities such as yield. Since it is not possible to directly age crabs, other methods, for example, length frequency analyses have to be used. There are many problems associated with length frequency analyses although they have been applied to data from other crab fisheries. The first problem is that commercial data from pots are unlikely to be representative of the whole population. Ideally random samples from trawl catches or, possibly, from fine-meshed pots should be used. It may be feasible to use some fine-meshed pots on strings of commercial pots.

3.22 The second problem is that there is often a large degree of variability in the relationship between size and age because not all animals moult every year. A given cohort may exhibit a bi-modal or multi-modal distribution of sizes. As in the case of many other crustacean and fish species, the size distributions at older age classes overlap thus obscuring any modes at larger size in length frequency distributions.

3.23 Two of the most promising methods for obtaining good growth data are tagging studies and holding of pre-moult animals. These methods generally provide information on moult increments by size. Information on moult frequency by size is far more difficult to obtain.

3.24 There are clear advantages in starting tagging experiments at this early stage of the fishery. It is important to note that the design and extent of such an experiment would depend on its main purpose. If the main purpose of a tagging experiment is to obtain information on growth (rather than estimating the population size, for example) then it would be appropriate to do intense tagging in a small area and return at a later stage to try and recover tagged animals. Such data would be useful even if the percentage of returned tags is low. Concern was expressed as to the feasibility of using tagging methods given the current low levels of effort in the fishery.

3.25 It was pointed out that tagging can produce reduced moult increments and high incidental mortality. Holding tank experiments are also advisable.

Calibration of Abundance Indices

3.26 The calibration of abundance indices include the following two methods. The first consists of using the catch rates (catch-per-pot) and some estimate of the effective area fished by a pot to calculate the population density and then extrapolate over a 'fishable' area. The main problem with this method is estimating the effective area fished by a pot. Since pots are baited, crabs are effectively attracted and the gear is therefore not passive. Furthermore, the area of attraction may well depend on the orientation of the string relative to currents and migration 'routes' of crabs. This method is not generally recommended for assessment unless the effective area fished can be estimated in a direct way by, for example, using radio-tagged crabs.

3.27 The second method consists of using a trawl to estimate density by the swept-area method and then doing comparative fishing trials to relate catch rates of traps to the density estimated by the trawl. For this purpose, it is best to estimate the gear efficiency of the trawl (e.g., by mounting a camera on the trawl). However, in some cases it may be acceptable to use the trawl density estimates uncorrected for gear efficiency (i.e., minimum trawlable biomass) as has been used for other crustacean fisheries.

3.28 There are various types of appropriate gear for crab surveys, including 'Nephrops' trawls and beam trawls. A type of 'snow plough' gear (Maynard and Conan, 1985) which employs a camera to photograph crabs lifted off the bottom and pushed up against a grid, for easy counting and measuring, has also been employed with success. The use of camera sleds in conjunction with line transect type survey methods could also be investigated.

3.29 Research surveys, independent of the commercial fishery, are of great value for comparison with other assessment methods based on the commercial data. Even if the likelihood of surveys for this fishery seems remote at this stage, it should be borne in mind as an assessment and monitoring method for the future.

Production Models

3.30 Production models, like depletion models, use changes in indices of abundance such as CPUE to estimate population size. This method has been applied to Dungeness crabs (Stocker and Butler, 1990[1]). These methods work best where there is some contrast in the data and therefore many of the comments regarding the depletion methods and the relatively low current level of effort would also apply to production models.

Other *Ad Hoc* Methods

3.31 One of the *ad hoc* methods used in WG-FSA-92/29 for estimating appropriate catch levels (rather than population size) was to consider comparable species. This method is fraught with difficulties, as recognised by the WG-FSA, and is not recommended now that more information has been obtained.

MANAGEMENT APPROACHES

Harvesting Regimes

4.1 The goal of management of the Antarctic crab resource is preventing the reduction of the stock below the level at which the stock will be able to produce the maximum sustainable yield on a continuing basis. Working paper WS-Crab-93/5 reviews the management methods applied to crab stocks in other areas. In general, there are two primary categories of regulations controlling harvesting: (i) indirect controls on mortality through regulated minimum legal size, seasonal closures and prohibitions on harvesting females; and (ii) direct mortality controls through catch or effort limits.

4.2 The Workshop noted that controls on the size of the animals landed, prohibition on retaining female crabs and seasonal closures during peak spawning or moulting periods are very widely used for regulating crab fisheries. These measures have the advantage of being applicable even when information on the population dynamics of the resource is quite limited. For example, with the data available from the first year of fishing around South Georgia, minimum legal sizes have been determined which are expected to allow male crabs at least one mating year before they are vulnerable to the fishery. The justification for the prohibition of retaining females can be based on the basic biology of the animal, though further work is needed in the future to ensure that reproductive

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1 Stocker and Butler. 1990. *Fish. Res*., 9: 231-254.

success is not impaired due to the reduction of the adult male population. Determining the appropriate timing of seasonal closures will require additional information on the life history of these crabs, in particular the seasonal patterns in moulting and spawning.

4.3 The Workshop participants also noted that size, sex and seasonal regulations would not restrict the expansion of the fishery and hence are termed 'indirect controls'. In order for the development of the fishery to be geared to the collection of information necessary for conserving the resource, further controls on fishery expansion are required. The experience in Alaskan crab fisheries is that in those areas where direct controls on the mortality, through catch limits, have not been imposed, fishing mortality appears relatively high. Therefore, the Workshop recommends that both indirect and direct control measures be applied to the Antarctic crab fishery.

4.4 It was noted that the combination of direct and indirect controls can mean that catch limits need not be set precisely or conservatively, since the indirect controls should protect the stock from reproductive failure in the short-term even if the catch is too high to be sustainable in the longterm. However, if the catches exceed the longterm sustainable level, the fishery will be affected by having greater sensitivity to variations in recruitment, lower average catch rates, and greater proportion of the catch with new shells and thus low meat quality.

4.5 More specifically, a minimum legal landing size for both *P. spinosissima* and *P. formosa* should be applied. Only legal sized male crabs should be retained in the catch, except if an experimental strategy for reducing parasite infestation is attempted (paragraph 4.8). No seasonal closure can be recommended at present until more biological data become available. Investigation of yield/recruitment and maturation processes may influence the setting of minimum sizes in the future.

4.6 In the future, a catch limit should be calculated based on analysis of the available data to determine both an assessment of biomass (virgin and current) and the maximum proportion of the exploitable stock that can be harvested on a sustainable basis. There is no reliable assessment of stock biomass currently available (see Section 3 above).

Approaches to Management

4.7 The Workshop discussed additional approaches to management which should yield substantial new information as well as improve conservation of the crab resource. To reduce the number of crabs below the minimum legal size which are caught, a minimum mesh size or the requirement for an escape port in the pots should be considered. In addition, to prevent lost pots from continuing to kill crabs, a biodegradable or galvanic time release device which opens the traps should be required. Reducing the number of crabs caught and then discarded should improve conservation. There is some evidence that crabs caught and then discarded may not die immediately after capture and so mortality due to handling can be substantially underestimated. Additional studies on handling mortality are desirable.

4.8 The Workshop discussed the management implications of modelling studies of the parasite infestation of *P. spinosissima* (WS-Crab-93/7 and 9). Harvesting of the infected crabs may reduce the prevalence of the parasite in the population and so improve the reproductive potential of the stock (the parasite renders an infected crab sterile). One possibility discussed was the destruction of any infected crabs caught, irrespective of crab size. The Workshop recommended that the feasibility of this be investigated.

4.9 In order to obtain more information on the dynamics of the parasite infection as well as on the response of the crab stock to different levels of harvest, the Workshop recommended that the fishing area might be divided into differential fishing zones. In one zone, the catch would be much smaller than in the other. Each zone would be further partitioned so that in one part, sub-legal size parasite infected *P. spinosissima* would be destroyed and in the other part they would not. Pots in an experimental management regime should enable capture of parasitised crabs.

4.10 The Workshop recognised that such an experimental management regime would not be an ideal statistical experiment since replicate treatments would not be possible. However, it was the consensus of the participants that substantial information could be obtained in this way, even if a formal statistical test would not be feasible, particularly if the system was operated over several fishing seasons.

4.11 Finally, the Workshop discussed multispecies implications of the developing crab fishery. There are two concerns: (i) that crabs may be important prey items for other species in the area of the fishery; and (ii) that there is a by-catch in the crab fishery which is likely to impact other stocks. There is, at this stage, no real evidence to suggest that either of these concerns warrant additional restrictions with respect to the development of the fishery or its subsequent management.

DATA AND REPORTING REQUIREMENTS

5.1 Table 1 summarises basic biological, demographic and distributional data required for a more complete understanding of *Paralomis* spp. and to enable more sophisticated use of the methods discussed under Agenda Item 3. These data may not necessarily be obtainable from the commercial fishery but if they can be obtained this will usually require the presence of observers.

WS-Crab-93/6 describes some biological and catch/effort data that may be obtained from the fishery without the use of observers.

5.2 The logbook issued by the US to the vessel engaged in fishing in 1992 and 1993 for recording haul-by-haul catch and effort details (WS-Crab-93/16) currently contains the following:

Cruise Descriptions:
 cruise code, vessel code, permit number, year.
Pot Descriptions:
 pot shape, dimensions, mesh size, funnel attitude,
 number of chambers, presence of an escape port.
Effort descriptions
 date, time, latitude and longitude of the start of the set;
 number of pots set, number of pots lost, depth, soak time;
 bait type.
Catch Descriptions
 retained catch in numbers;
 catch of regulated fish, if present.

5.3 To these, the Workshop suggested that the following should be added:

number of pots on the line;
spacing of pots on the line;
by-catch of all species, irrespective of regulated status; and
incremental record number, for linking with sample information.

5.4 If a management strategy involving the destruction or utilisation of parasitised undersized males and parasitised females were to be imposed it would be important that the numbers of crabs in these categories were recorded on the catch and effort logbook.

5.5 Currently, commercial vessels are required to measure a subsample of 35 crabs (all species combined) each day, although there is no specific guidance about the way the catch should be sampled. A random sampling strategy is extremely important if the resultant data are to be a representative, statistically robust sample of the catch.

5.6 Crabs could be sampled by (i) taking 35 crabs from the whole catch over the day, (ii) taking 35 crabs randomly from the total catch of a single line, or (iii) taking 35 crabs from a number of pots on a line. The former two methods suffer from the likelihood of bias by selection by fishermen, and the latter produces imprecise estimates due to aggregation by the pots - (crabs might aggregate by sex, size or parasitic infection, for instance).

5.7 As long as the likelihood of aggregations is recognised and considered in statistical analyses (cluster sampling, analysis of inter-pot variance) the latter method is likely to prove most reliable in this fishery. It has the additional advantage that it is likely to be the least disruptive of fishing activities. Pots typically contain less than 35 crabs, so a number of pots may have to be sampled.

5.8 Accordingly, the Workshop recommends that crabs are sampled from the line hauled just prior to noon, by collecting the entire contents of a number of pots spaced at intervals along the line so that at least 35 specimens are represented in the subsample.

5.9 The logbook for recording biological data (WS-Crab-93/14) currently contains the following:

Cruise Descriptions:
cruise code, vessel code, permit number
Sample Descriptions
date, position
Data
species, sex, length for 35 individuals.

5.10 The Workshop suggested that the subsample should be linked to the line information by including:

line number; and
position of the start of the set,

and that the following additional information should be collected:

presence/absence of rhizocephalan parasites;
a record of the destination of the crab: kept, discarded, destroyed; and
a record of the pot number from which the crab comes.

5.11 Paragraphs 5.2 to 5.10 above discuss the data which should be collected by commercial vessels fishing for crab. Paragraph 7 of Conservation Measure 60/XI requests that the Workshop decide which of these detailed data should be reported to CCAMLR and in what form. The conservation measure sets minimum guidelines for this in its paragraph 5: (i) fine-scale data with a resolution of at least 1° longitude by 0.5° latitude by 10 day period; and (ii) species, size and sex composition of a subsample.

5.12 The Workshop agreed that data at the finest scale possible would be desirable for good assessment and management of the fishery according to the methods outlined under Agenda Items 3 and 4. However, the Workshop did not agree on the precise format of data to be submitted to CCAMLR.

5.13 Dr Holt expressed the opinion that since a single vessel was engaged in the fishery, haul-by-haul data containing precise positional and depth information would be considered confidential and could not be submitted to CCAMLR except in summary form.

5.14 It was pointed out that since the fishery was in its early stage, there were certain management measures that could be taken which would not demand data of as fine a resolution as the haul-by-haul data for the current year. As the fishery proceeded an increase in precision might be necessary as management and assessment methods became more sophisticated.

5.15 It might also be possible to report data using methods which retained a sufficient degree of detail to be used in the assessment and management, but which did not reveal the commercially confidential details. Translocation/transformation of position, categorisation of depth and aggregation of data by areas smaller than 1° longitude by 0.5° latitude were examples of these.

5.16 Prof. J. Beddington (UK) expressed the view that since the highest resolution of these data was haul-by-haul and many of the assessment and management methods were most efficient when the finest scale data are available for use, haul-by-haul data should be reported. Although the types of categorisation suggested in paragraph 5.15 could perhaps eventually be used in management, it would not be possible to decide on the appropriateness of these scales until haul-by-haul data had been examined.

5.17 Examples from other crab fisheries indicated that on the east and west coast of the US some haul-by-haul data are provided for management analyses. However, such data is kept confidential to protect commercial operators. In other cases only aggregated data are reported.

5.18 In view of these differences, the Workshop was unable to provide a unanimous recommendation for the data reporting requirements of Conservation Measure 60/XI, paragraph 7.

ADVICE TO THE SCIENTIFIC COMMITTEE

Management Measures

6.1 Following the management approaches adopted at CCAMLR-XI, the fishery should continue to be managed by both indirect and direct controls on harvesting:

Indirect: limits on retention of crab by size, sex (males only) and in the future possibly season (the 3S approach).

Direct: catch limits for each season, initially set as a precautionary measure and refined as data become available.

6.2 The use of galvanic time releasers or biodegradable devices, which effectively destroy the pot long before normal decay processes would, will reduce the effects of ghost fishing should pots be lost from a line and should be considered.

6.3 Adoption of a minimum mesh size and/or the inclusion of an escape port (usually a metal ring set into the side of the pot) in pots should be considered following research on mesh or port selectivity, to better select only crabs of harvestable size and reduce the number of discards (paragraph 4.7).

6.4 Harvesting or destruction of parasitised crabs of all ages and sexes may reduce the prevalence of parasitism in the population, and should be considered (paragraph 4.8). In this regard, use of pots with smaller mesh or escape port sizes would catch more parasitised crabs, but would expose small unparasitised crabs to the high wind chill factors on deck, with a consequent possibility of discard mortality.

6.5 The Workshop recommended the use of depletion methods, the change-in-ratio and index-removal methods and the analysis of length frequency distribution methods for assessment purposes at this stage (paragraphs 3.3, 3.11 and 3.21).

6.6 The Workshop recommended that the possibility of designing an experimental approach to harvest strategies should be considered, for instance, one in which local depletion of the population is encouraged over a short period of time or a survey is conducted before and after the fishing season (paragraphs 3.8 and 3.11).

6.7 A further experimental approach would be to divide Subarea 48.3 into several crab management areas. Different levels of fishing effort would then be applied to the different areas (by imposition of area-specific catch limits), and/or they could receive different parasite management strategies or mesh size strategies as discussed in paragraph 4.9.

Data Requirements

6.8 There are a number of biological phenomena which require investigation (Table 1). Much of the biological data required, by Table 1, could be obtained by observers on commercial vessels. In this case, the Workshop suggested that pots with finer mesh or escape ports should be added to lines of commercial pots to collect crabs of all sizes (paragraph 3.21).

6.9 Fine-meshed pots or small escape port pots will also provide data on the overall length frequency of the population. Despite the difficulties in interpreting these length frequencies to estimate growth and natural mortality (paragraph 3.17) the Workshop recognised that a large dataset collected at the start of the fishery (when the population is still in a virgin state) would have the potential to be extremely valuable in the future when other factors required for its interpretation (such as moult frequency and size increments) are better understood.

6.10 Additional information which observers could collect includes data on discard mortality. However, in crabs, discard mortality may not be evident until some months after the catching incident, because damage may result in an inability to moult rather than immediate death, and consequently discard mortality studies should be of long duration.

6.11 The Workshop agreed on the data that should be collected by commercial vessels fishing for crab. These are given in Section 5. The Workshop was unable to provide a unanimous recommendation for the data reporting requirements of Conservation Measure 60/XI, paragraph 7.

OTHER BUSINESS

7.1 Recognising that very little information concerning Antarctic crabs is available, Dr A. Paul (USA) suggested that it would be useful for CCAMLR to maintain an ongoing bibliography for these species.

ADOPTION OF THE REPORT

8.1 The report was adopted.

CLOSE OF THE MEETING

9.1 In closing the meeting, the Convener thanked all participants for their hard work and cooperation during the meeting. He congratulated the participants for producing critical information requested by CCAMLR.

9.2 He also thanked the Secretariat for their high standards of professionalism and hard work in making sure the meeting ran smoothly and efficiently.

9.3 Finally, he expressed appreciation to the staff of the Southwest Fisheries Science Center for their support during the meeting.

9.4 The Convener then closed the meeting.

Table 1: Research needs for *P. spinosissima* and *P. formosa*.

Knowledge Required	Sources	Priority
Reproductive Dynamics		
Number of eggs extruded by size of crab	Lab analyses	High[a]
Number of eggs hatched by size of crab	Lab analyses	High
Incubation period by season and duration [estimated: 1year]	Tank holdings, tagging, seasonal monitoring	High
Female mating frequency by season [estimated:1-2 years]	Tank holdings, tagging, seasonal monitoring	High
Percent carrying fertilized eggs by season and size of crab	Catch sampling	High
Egg hatching location by season and depth	Research survey, catch sampling	Low
Larvae location by season and depth	Research survey	Low
Duration of larval stage	Research survey, lab holdings	Low
Proportion maturity by size	Catch sampling	High[a]
Growth Dynamics and Mortality		
Growth rate	Catch data, length frequency	High
Moult increment by season and size	Tank holdings, tagging	High
Duration of intermoult period by season and size	Lab studies, tagging, radioisotope studies	High
Allometry of chela (estimation of size at maturity)	Commercial observer, research survey	High[a]
Mortality (by size)	Catch monitoring, length frequency analysis, tagging	Med
Host-Parasite Interaction		
Reproductive output of rhizocephalan	Tank holdings	Med
Brooding period of rhizocephalan	Tank holdings	Med

[a] Some data are already available for this item (WS-Crab-93/24 and WG-FSA-92/29)

Table 1 (continued)

Knowledge Required	Sources	Priority
Fine-scale prevalence of rhizocephalan	Catch sampling	High
Host susceptibility characteristics	Lab experiments	Med
Effect of parasite on growth	Lab experiments	Low
Incidence of hyperparasitisation	Catch sampling	Med
Effect of hyperparasitisation	Catch sampling, lab experiments	Med
Parasite larval duration	Lab experiments	High
Intensity of symbiotic egg predators	Catch sampling	Med
<u>Distribution and Stock Identity</u>		
Depth range by sex, size, reproductive condition, parasitic infestation, substratum type	Commercial observer, research survey	High
Geographic distribution	Exploratory survey	High
Larval dispersion	Plankton survey (old plankton records)	Low
Stock identity	Morphometrics genetics (mitochondrial DNA)	Low

Table 2: Assumptions and data requirements of assessment methods.

Method	Data Requirements	Main Assumptions	Outputs
Depletion methods	• Catch • And appropriate measure of effort to construct CPUE; or • Some other INDEX of abundance	• Closed* population • CPUE is proportional to population size	• Population size (or local abundance) • Catchability coefficient • Exploitable rate (fishing mortality) • Fishing power of gear • Possible estimate of recruitment
Change-in-ratio (CIR) and Index-removal (IR)	• Random samples before and after fishing • Total catches	• Closed population • CIR: all animals have same probability of being captured • IR: probability of capture does not vary within or between surveys	• Population size • Catchability coefficient • Exploitable rate (fishing mortality) • Fishing power of gear • Possible estimate of recruitment
Length-based cohort analysis	• Catch in numbers by size class • Growth rate • Natural mortality • Terminal fishing mortality	• Closed population • Equilibrium population	• Population numbers by size class • Fishing mortality by size class
Length-converted catch curves	• Abundance in numbers by size class • Growth rate • Age at full recruitment	• Equilibrium population • Closed population	• Total mortality Z = F + M
Length-based De Lury (Conser, 1992)	• Index of population size in numbers by size class over time • Total catch over time • Growth (parameters or description) • Natural mortality	• Closed population	• Population numbers by size class • Fishing mortality by size class • Catchability coefficient(s)
Catch-at-size analysis	• Index of population size in numbers by size class over time • Total catch over time • Growth (parameters or description) • Natural mortality • Probability distribution for length-at-age • Selectivity coefficient	• Closed population	• Population numbers by size class • Fishing mortality by size class • Catchability coefficient(s)
Calibrating index of abundance	• Index of abundance • Estimate of calibration factor • Catchability coefficient	• Various - depends on the type of index	• Population size • Exploitation rate
Production models	• Catch and effort data	• Various - depends on model used	• Population size • Parameters relating to growth/ recruitment and "carrying capacity"

* Closed to known immigration and emigration.

ATTACHMENT A

LIST OF PARTICIPANTS

Workshop on the Management of the Antarctic Crab Fishery
(La Jolla, California, USA - 26 to 28 April, 1993)

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ATTACHMENT B

LIST OF DOCUMENTS

Workshop on the Management of the Antarctic Crab Fishery
(La Jolla, California, USA - 26 to 28 April 1993)

WS-CRAB-93/1	AGENDA
WS-CRAB-93/2	LIST OF PARTICIPANTS
WS-CRAB-93/3	LIST OF DOCUMENTS
WS-CRAB-93/4	THE ANTARCTIC CRAB FISHERY: EXTRACTS FROM CCAMLR-XI AND SC-CAMLR-XI Secretariat
WS-CRAB-93/5	MANAGEMENT AND ASSESSMENT OPTIONS FOR THE CRAB FISHERY AROUND SOUTH GEORGIA M. Basson and D.D. Hoggarth (UK)
WS-CRAB-93/6	DATA REQUIRED FOR IMPLEMENTATION OF MANAGEMENT OPTIONS M. Basson and J.R. Beddington (UK)
WS-CRAB-93/7	A PRELIMINARY INVESTIGATION OF THE POSSIBLE EFFECTS OF RHIZOCEPHALAN PARASITISM ON THE MANAGEMENT OF THE CRAB FISHERY AROUND SOUTH GEORGIA M. Basson (UK)
WS-CRAB-93/8	UNCERTAINTY, RESOURCE EXPLOITATION, AND CONSERVATION: LESSONS FROM HISTORY Donald Ludwig, Ray Hilborn and Carl Walters (USA)
WS-CRAB-93/9	MODELLING CRUSTACEAN FISHERIES: EFFECTS OF PARASITES ON MANAGEMENT STRATEGIES Armand M. Kuris and Kevin D. Lafferty (USA)
WS-CRAB-93/10	CHANGE-IN-RATIO AND INDEX-REMOVAL METHODS FOR POPULATION ASSESSMENT AND THEIR APPLICATION TO SNOW CRAB (*CHIONOECETES OPILIO*) Xucai Xu, Earl G. Dawe and John M. Hoenig (USA)
WS-CRAB-93/11	RELATIVE SELECTIVITY OF FOUR SAMPLING METHODS USING TRAPS AND TRAWLS FOR MALE SNOW CRABS (*CHIONOECETES OPILIO*) John M. Hoenig and Earl G. Dawe (USA)

WS-CRAB-93/12	GROWTH PER MOLT OF MALE SNOW CRAB *CHIONOECETES OPILIO* FROM CONCEPTION AND BONAVISTA BAYS, NEWFOUNDLAND David M. Taylor and John M. Hoenig (USA)
WS-CRAB-93/13	LESLIE ANALYSES OF COMMERCIAL SNOW CRAB TRAP DATA: A COMPARATIVE STUDY OF CATCHABILITY COEFFICIENTS John M. Hoenig, Earl G. Dawe, David M. Taylor, Michael Eagles and John Tremblay (USA)
WS-CRAB-93/14	COMMERCIAL VESSEL CCAMLR SUBSAMPLE LOGBOOK (USA)
WS-CRAB-93/15	COMMERCIAL VESSEL DAILY ACTIVITY LOGBOOK (USA)
WS-CRAB-93/16	COMMERCIAL VESSEL FISHING EFFORT LOGBOOK (USA)
WS-CRAB-93/17	GRAPHICAL PRESENTATIONS OF PRELIMINARY DATA COLLECTED ABOARD THE F/V *PRO SURVEYOR* IN 1992 (USA)
WS-CRAB-93/18	BIOLOGY OF BLUE CRAB, *PORTUNUS TRITUBERCULATUS* IN THE YELLOW SEA AND THE EAST CHINA SEA Lee Jang-Uk and An Doo-Hae (Republic of Korea)
WS-CRAB-93/19	NOTA SOBRE LA PRESENCIA DE *PARALOMIS SPINOSISSIMA* Y *PARALOMIS FORMOSA* EN LAS CAPTURAS DE LA CAMPAÑA "ANTARTIDA 8611" L.J. López Abellán and E. Balguerías (Spain)
WS-CRAB-93/20	DEMOGRAPHY OF THE KOREAN BLUE CRAB, *PORTUNUS TRITUBERCULATUS* FISHERY EXPLOITED IN THE WEST COAST OF KOREA AND THE EAST CHINA SEA Lee Jang-Uk and An Doo-Hae (Republic of Korea)
WS-CRAB-93/21	A BRIEF EXPLOITATION OF THE STONE CRAB *LITHODES MURRAYI* (HENDERSON) OFF SOUTH WEST AFRICA, 1979/80 R. Melville-Smith (South Africa)
WS-CRAB-93/22	QUANTITATIVE STOCK SURVEY AND SOME BIOLOGICAL AND MORPHOMETRIC CHARACTERISTICS OF THE DEEP-SEA RED CRAB *GERYON QUINQUEDENS* OFF SOUTH WEST AFRICA C.J. De B. Beyers and C.G. Wilke (South Africa)

WS-CRAB-93/23	A SYSTEM-OF-EQUATIONS APPROACH TO MODELING AGE-STRUCTURED FISH POPULATIONS: THE CASE OF ALASKAN RED KING CRAB, *PARALITHODES CAMTSCHATICUS* Joshua A. Greenberg, Scott C. Matulich and Ron C. Mittelhammer (USA)
WS-CRAB-93/24	PLOTS OF SOUTH GEORGIA ISLAND CRAB DATA R.S. Otto (USA)
WS-CRAB-93/25	EXTRACT FROM: MACPHERSON, E. 1988. REVISION OF THE FAMILY LITHODIDAE SAMOUELLE, 1819 (CRUSTACEA, DECAPODA, ANOMURA) IN THE ATLANTIC OCEAN. *MONOGRAFÍAS DE ZOOLOGÍA MARINA* VOL. 2: 9-153

OTHER DOCUMENTS

WG-FSA-92/29	A PRELIMINARY REPORT ON RESEARCH CONDUCTED DURING EXPERIMENTAL CRAB FISHING IN THE ANTARCTIC DURING 1992 (CCAMLR AREA 48) Robert S. Otto and Richard A. MacIntosh (USA)

ATTACHMENT C

AGENDA

Workshop on the Management of the Antarctic Crab Fishery
(La Jolla, California, USA - 26 to 28 April 1993)

1. Opening of the Meeting
   (i) Review of the Meeting Objectives
   (ii) Adoption of the Agenda

2. Information on the *Paralomis spinosissima* stock
   (i) Biological Characteristics
   (ii) Distribution, Stock Identity
   (iii) Demographic Characteristics
   (iv) Parasitism

3. Assessment Methods

4. Management Approaches
   (i) Harvesting Regimes
   (ii) Approaches to Management

5. Data and Reporting Requirements

6. Advice to the Scientific Committee
   (i) Longterm Management Plan for the Crab Fishery
   (ii) Data Reporting Requirements

7. Other Business

8. Adoption of the Report

9. Close of the Meeting.

APPENDIX F

1993 ASSESSMENT SUMMARIES

Assessment Summary: *Notothenia rossii*, Subarea 48.3

Source of Information: This Report

Year:	1988	1989	1990	1991	1992	1993	Max[2]	Min[2]
Recommended TAC			0					
Agreed TAC			300	300	0			
Landings	197	152	2	1	1	0		
Survey Biomass	1699	2439	1481[a] 3915[b] 3900[b]	4295[c] 10022[d]	7309[c]			
Surveyed by	USA/POL	UK/POL	UK/POL[a] USSR[b]	UK[c] USSR[d]	UK[c]			
Sp. Stock Biomass[3]			No information					
Recruitment (age...)			available					
Mean F (.....)[1]			since 1985/86					

Weights in tonnes, recruits in ....

1 ... weighted mean over ages (...)

2 Over period 1982 to 1992

3 From VPA using (..........)

Conservation Measures in Force: 2/III and 3/IV

Catches:

Data and Assessment: No new assessment was performed for this species.

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1993/94:

Option Basis	1993 F	1993 SSB	1993 Catch	1994 F	1994 SSB	1994 Catch	Implications/ Consequences

Weights in tonnes

Assessment Summary: *Champsocephalus gunnari*, Subarea 48.3

Source of Information: This Report

Year:	1988	1989	1990	1991	1992	1993	Max[2]	Min[2]
Recommended TAC	31500	10200	12000		8400-61900	9200-15200		
Agreed TAC	35000	-[4]	8000	26000	0	9200		
Landings	34619	21359	8027	92	5	0		
Survey Biomass	15716	24241	72090[a]	27111[a]	43763[a]			
			442168[b]	192144[b]				
Surveyed by	USA/POL	UK/POL	UK/POL[a]	UK[a]	UK[a]			
			USSR[b]	USSR[b]				
Stock Biomass[3]	70	50	50	50.5				
Recruitment (age 1)	500	500	(millions)					
Mean F (.....)[1]					0			

Weights in '000 tonnes

1 ... weighted mean over ages (...)

2 Over period 1982 to 1992

3 From VPA (2+)

4 Prohibition from 4 November 1988

Conservation Measures in Force: 19/IX and 33/X

Catches:

Data and Assessment: Extensive re-analysis of VPA and survey estimates of biomass produced a more consistent past series of *C. gunnari* biomass. However, for stock projections the 1992 survey was used to estimate 1993/94 biomass between 51 and 396 '000 tonnes

Fishing Mortality:

Recruitment:

State of Stock: Unknown pending a proposed 1993/94 survey by the UK.

Forecast for 1993/94:

Option Basis	1993			1994			Implications/ Consequences
	F	Stock	Catch	F	Stock	Catch	
$F_{0.1}$							
Projection 1	95% confidence limits					20850	
Projection 2	95% confidence limits					13209	

Weights in '000 tonnes

Note: Age 2+, assumes recruitment at lower 95% confidence limit

Assessment Summary: *Patagonotothen guntheri*, Subarea 48.3

Source of Information: This Report

Year:	1988	1989	1990	1991	1992	1993	Max[2]	Min[2]
Recommended TAC		-	-	20-36000	0			
Agreed TAC		13000	12000	0	0			
Landings	13424	13016	145	0	0	0		
Survey Biomass				584[a] 16365[b]	12746			
Surveyed by				UK[a] USSR[b]	UK			
Sp. Stock Biomass[3]			na					
Recruitment (age 1)			na					
Mean **F** (3 - 5)[1]			na					

Weights in tonnes

1 ... weighted mean over ages (...)

2 Over period 1982 to 1992

3 From VPA using (..........)

4 Maximum catch in 1989

Conservation Measures in Force: 34/X

Catches:

Data and Assessment: No new assessment was performed for this species.

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1993/94:

Option Basis	1993 F	1993 SSB	1993 Catch	1994 F	1994 SSB	1994 Catch	Implications/ Consequences

Weights in tonnes

Assessment Summary: *Dissostichus eleginoides*, Subarea 48.3

Source of Information: This Report

Year:	1988	1989	1990	1991	1992	1993	Max[2]	Min[2]
Recommended TAC			-					
Agreed TAC			-	2500[5]	3500	3350		
Landings	1809	4138	8311	3843	3703	2990		
Survey Biomass	674	326	9631*[a] 335+[a] 1693*[b] 3020+[b]	19315* 885+	3353* 2460+			
Surveyed by	USA/ POL[4]	UK/ POL[4]	POL/UK[a] USSR[b]	UK	UK			
Stock Biomass[3]			20745 - 435817			11000-17000		
Recruitment (age...)			na					
Mean F (.....)[1]			na					

Weights in tonnes

1 ... weighted mean over ages (...)
2 Over period 1982 to 1992
3 Estimated from cohort projections
4 Survey excluding Shag Rocks
5 TAC from 1 November 1990 to 2 November 1991
6 Estimated from various methods
* Shag Rocks
\+ South Georgia

Conservation Measures in Force: 35/X, 36/X, 37/X

Catches: TAC of 3 350 tonnes, 2 990 tonnes taken due to problems with projecting date of closure of the fishery.

Data and Assessment: Haul-by-haul data enabled estimates of local density based on CPUE analysis for individual vessels. Exploitable biomass estimated to be 10 700 tonnes to 17 400 tonnes at beginning of 1992/93 season.

Fishing Mortality: Exceeds $F_{0.1}$.

Recruitment: No new information.

State of Stock: Model projections indicate exploitable biomass may have been depleted to around 30% of the unexploited level. Suggested catch levels: 900 to 1 700 tonnes.

Forecast for 1993/94:

Option Basis	1993			1994			Implications/ Consequences
	F	SSB	Catch	F	SSB	Catch	

Weights in tonnes

Assessment Summary: *Notothenia gibberifrons*, Subarea 48.3

Source of Information: This Report

Year:	1988	1989	1990	1991	1992	1993	Max[2]	Min[2]
Recommended TAC					500-1500			
Agreed TAC					0			
Landings	5222	838	11	3	4	0		
Survey Biomass	7800	8500	17000	25000	29600			
Surveyed by	USA	UK	UK USSR	UK USSR	UK			
Sp. Stock Biomass[3]	4300	3300	4300	6200				
Recruitment (age 2)	24000	21000	27000	25000				
Mean F (.....)[1]	0.86	0.54	0.014	0.0002				

Weights in tonnes

1 Weighted mean over ages 2 to 16

2 Over period 1975/76 to 1991/92

3 From VPA using survey q = 1 model

Conservation Measures in Force: 34/X

Catches:

Data and Assessment: No new assessment was performed for this species.

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1993/94:

Option Basis	1993			1994			Implications/ Consequences
	F	Stock	Catch	F	Stock	Catch	

Weights in tonnes

Assessment Summary: *Chaenocephalus aceratus*, Subarea 48.3

Source of Information: This Report

Year	1988	1989	1990	1991	1992	1993	Max[2]	Min[2]
Recommended TAC		1100	0	300	300-500			
Agreed TAC		0	300	300	0			
Landings	313	1	2	2	2	0	1272	1
Survey Biomass	6209	5770	14226[a]	13474[c]	12500			
			14424[b]	18022[d]				
			17800[b]					
Surveyed by	USA/POL	UK/POL	UK/POL[a]	UK[c]	UK			
			USSR[b]	USSR[d]				
Sp. Stock Biomass[3]	4156	4404	5098[4]					
Recruitment (age 2)	8648	6717	4047[4]					
Mean F (.....)[1]	0.13	0.002						

Weights in tonnes, recruits in ‘000s

1 ... weighted mean over ages 3 to 11
2 Over period 1982 to 1992
3 From VPA using revised VPA from WG-FSA-90/6
4 Predicted

Conservation Measures in Force: 34/X

Catches:

Data and Assessment: No new assessment was performed for this species.

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1993/94:

Option Basis	1993 F	1993 Biomass	1993 Catch	1994 F	1994 SSB	1994 Catch	Implications/ Consequences

Weights in tonnes

Assessment Summary: *Pseudochaenichthys georgianus*, Subarea 48.3

Source of Information: This Report

Year	1988	1989	1990	1991	1992	1993	Max[2]	Min[2]
Recommended TAC		1800	0	300	300-500			
Agreed TAC			300	300	0			
Landings	401	1	1	2	2	0	1661	1
Survey Biomass	9461	8278	5761[a] 12200[b] 10500[b]	13948[c] 9959[d]	13469			
Surveyed by	USA/POL	UK/POL	UK/POL[a] USSR[b]	UK[c] USSR[d]	UK			
Sp. Stock Biomass[3]	8090	8889[4]						
Recruitment (age 1)	1372							
Mean F (.....)[1]	0.15							

Weights in tonnes, recruits in '000s

1 ... weighted mean over ages 3 to 6

2 Over period 1982 to 1992

3 From VPA described in WG-FSA-90/6

4 Predicted

Conservation Measures in Force: 34/X

Catches:

Data and Assessment: No new assessment was performed for this species.

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1993/94:

Option Basis	1993 F	1993 Biomass	1993 Catch	1994 F	1994 SSB	1994 Catch	Implications/ Consequences

Weights in tonnes

Assessment Summary: *Notothenia squamifrons*, Subarea 48.3

Source of Information:

Year	1988	1989	1990	1991	1992	1993	Max[2]	Min[2]	Mean[2]
Recommended TAC			0	300	300				
Agreed TAC			300	300	0				
Landings	1553	927	0	0	0	0	1553	0	563
Survey Biomass	409	131	1359[a] 534[b]	1374	1232				
Surveyed by	USA/POL	UK/POL	UK/POL[a] USSR[b]	UK	UK				
Sp. Stock Biomass[3]									
Recruitment (age...)									
Mean **F** (.....)[1]									

Weights in tonnes, recruits in ....

1 ... weighted mean over ages (...)

2 Over period 1982 to 1992

3 From VPA using (..........)

Conservation Measures in Force: 34/X

Catches:

Data and Assessment: No new assessment was performed for this species.

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1993/94:

Option Basis	1993 F	1993 SSB	1993 Catch	1994 F	1994 SSB	1994 Catch	Implications/ Consequences

Weights in tonnes

Assessment Summary: *Electrona carlsbergi*, Subarea 48.3

Source of Information:

Year	1988	1989	1990	1991	1992	1993	Max[2]	Min[2]	Mean[2]
Recommended TAC	-	-	-	-	-				
Agreed TAC	-	-	-	-	245000				
Landings	14868	29673	23623	78488	46960	0			
Survey Biomass	1200 kt	USSR[4]							
Surveyed by	160 kt	USSR[5]							
Sp. Stock Biomass[3]									
Recruitment (age...)									
Mean **F** (.....)[1]									

Weights in tonnes, recruits in ....

1 ... weighted mean over ages (...)

2 Over period 1982 to 1992

3 From VPA using (..........)

4 WG-FSA-90/21 large portion of Subarea 48.3

5 WG-FSA-90/21 Shag Rocks region

Conservation Measures in Force: 38/X; TAC 245 000 tonnes. 39/X, 40/X.

Catches:

Data and Assessment: No new assessment was performed for this species.

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1993/94:

Option Basis	1993 F	1993 Exploitable Biomass	1993 Catch	1994 F	1994 Exploitable Biomass	1994 Catch	Implications/ Consequences

Weights in '000 tonnes

Assessment Summary: *Notothenia rossii*, Division 58.5.1

Source of Information: This Report

Year	1988	1989	1990	1991	1992	1993	Max[2]	Min[2]	Mean[2]
Recommended TAC									
Agreed TAC									
Landings	21	245	155	287	0	0			
Survey Biomass									
Surveyed by									
Sp. Stock Biomass[3]									
Recruitment (age...)									
Mean F (.....)[1]									

Weights in tonnes, recruits in ....

1 ... weighted mean over ages (...)

2 Over period 1982 to 1992

3 From VPA using (..........)

Conservation Measures in Force: Conservation Measure 2/III. Resolution 3/IV. Limitation of trawlers allowed on fishing grounds each year. Arrêté Nº: 18, 20, 32 (for details see SC-CAMLR-VIII, Annex 6, Appendix 10, page 290).

Catches:

Data and Assessment: No new assessment was performed for this species.

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1993/94:

Option Basis	1993 F	1993 SSB	1993 Catch	1994 F	1994 SSB	1994 Catch	Implications/ Consequences

Weights in tonnes

Assessment Summary: *Notothenia squamifrons*, Division 58.5.1

Source of Information: This Report

Year	1988	1989	1990	1991	1992	1993	Max[2]	Min[2]	Mean[2]
Recommended TAC									
Agreed TAC	2000	2000[4]							
Landings	39	1553	1262	98	1	0			
Survey Biomass									
Surveyed by									
Sp. Stock Biomass[3]									
Recruitment (age...)									
Mean F (.....)[1]									

Weights in tonnes, recruits in ....

1 ... weighted mean over ages (...)

2 Over period 1982 to 1992

3 From VPA using (..........)

Conservation Measures in Force:

Catches:

Data and Assessment: No new assessment was performed for this species.

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1993/94:

Option Basis	1993			1994			Implications/ Consequences
	F	SSB	Catch	**F**	SSB	Catch	

Weights in tonnes

Assessment Summary: *Champsocephalus gunnari*, Division 58.5.1

Source of Information: This Report

Year	1988	1989	1990	1991	1992	1993	Max[2]	Min[2]	Mean[2]
Recommended TAC									
Agreed TAC									
Landings (Kerguelen)	157	23628		12644	44	0			
Landings (Combined)									
Survey Biomass									
Surveyed by									
Sp. Stock Biomass[3]									
Recruitment (age...)									
Mean F (.....)[1]									

Weights in tonnes, recruits in ....

1 ... weighted mean over ages (...)

2 Over period 1982 to 1992

3 From VPA using (..........)

Conservation Measures in Force:

Catches:

Data and Assessment: No new assessment was performed for this species.

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1993/94:

Option Basis	1993 F	1993 SSB	1993 Catch	1994 F	1994 SSB	1994 Catch	Implications/ Consequences

Weights in tonnes

Assessment Summary: *Dissostichus eleginoides*, Division 58.5.1

Source of Information: This Report

Year	1988	1989	1990	1991	1992	1993	Max[2]	Min[2]	Mean[2]
Recommended TAC									
Agreed TAC									
Landings	554	1630	1062	1848	7492	2722	7492	121	
Survey Biomass		27200							
Surveyed by									
Sp. Stock Biomass[3]									
Recruitment (age...)									
Mean F (.....)[1]									

Weights in tonnes, recruits in ....

1 ... weighted mean over ages (...)

2 Over period 1982 to 1992

3 From VPA using (..........)

Conservation Measures in Force: Catch limit in 1992/93.

Catches: Western grounds: 92 tonnes trawl } France 941 tonnes
Northern grounds: 2 630 tonnes trawl } Ukraine 1 781 tonnes

Data and Assessment: 1988 survey estimate of 27 200 tonnes divided between western stock (19 000 tonnes) and other areas. Northern grounds not inlcuded in survey area however.

Fishing Mortality: $F_{0.1}$=0.151 (13.3% catch/biomass ratio)
$F_{50\%SSB}$=0.08 (7.3% catch/biomass ratio)

Recruitment: No information.

State of Stock: Northern stock - unknown.
Western stock - likely to be above 50% unexploited spawning stock size.

Forecast for 1993/94:

Option Basis	1993 F	1993 SSB	1993 Catch	1994 F	1994 SSB	1994 Catch	Implications/ Consequences

Weights in tonnes

Western stock: $F_{0.1}$ gives 1 820 tonnes yield but recommend use of $F_{50\%SSB}$
$F_{50\%SSB}$ gives 1 400 tonnes longterm yield

Northern stock: Precautionary TAC needed. Recent catches likely to be too high.

Assessment Summary: *Notothenia squamifrons*, Division 58.4.4

Source of Information: This Report

Year	1988	1989	1990	1991	1992	1993	Max[2]	Min[2]	Mean[3]
Recommended TAC (Lena Bank)									
Agreed TAC									
Landings (Ob Bank[a])	2989	850	867	?	0		4999	0	1151
Landings (Lena Bank[a])	2013	3166	596	?	0		6284	0	1335
Landings (Combined[b])	5002	4016	1463	575	0	0	11283	027	2487
Survey Biomass (Ob Bank)		12700							
Survey Biomass (Lena Bank)									
Surveyed by		USSR							
Sp. Stock Biomass[4]			na						
Recruitment (age...)			na						
Mean F (.....)[1]									

Weights in tonnes, recruits in ....

1 ... weighted mean over ages (...)

2 Over period 1982 to 1992

3 Assumes TAC of 267 tonnes for Ob Bank and 305 tonnes for Lena Bank was taken in 1991

4 From VPA using (..........)

a From WG-FSA-92/5

b From SC-CAMLR-IX/BG/2 Part 2 (Statistical Bulletin)

Conservation Measures in Force: 2/III and 4/V

Catches:

Data and Assessment: No new assessment was performed for this species.

Fishing Mortality:

Recruitment:

State of Stock:

Forecast for 1993/94:

Option Basis	1993 F	1993 SSB	1993 Catch	1994 F	1994 Biomass	1994 Catch	Implications/ Consequences

Weights in tonnes