

KRILL RESOURCES

Fishery Status and Trends

2.1 The krill catch for the 1989/90 season was some 5% lower than in 1988/89 and totalled 374 793 tonnes (Table 2.1).

Table 2.1: National krill landings (in tonnes) since 1982/83.

Member	Split-Year*							
	1983	1984	1985	1986	1987	1988	1989	1990
Chile	3 752	1 649	2 598	3 264	4 063	5 938	5 329	4 527**
GDR	0	0	50	0	0	0	0	396
JAPAN	42 282	49 531	38 274	61 074	78 360	73 112	78 928	62 179**
Republic of Korea	1 959	5 314	0	0	1 527	1 525	1 779	4 040
Poland	360	0	0	2 065	1 726	5 215	6 997	1 275
Spain	0	0	0	0	379	0	0	0
USSR	180 290	74 381	150 538	379 270	290 401	284 873	301 498	302 376
TOTAL	228 643	130 875	191 460	445 673	376 456	370 663	394 531	374 793

* The Antarctic split-year begins on 1 July and ends on 30 June. The column 'split-year' refers to the calendar year in which the split-year ends (e.g. 1989 refers to the 1988/89 split-year).

** From catch data tabled during the Meeting

2.2 The total krill catch by subarea and year since 1973 is illustrated in Figure 2.1.

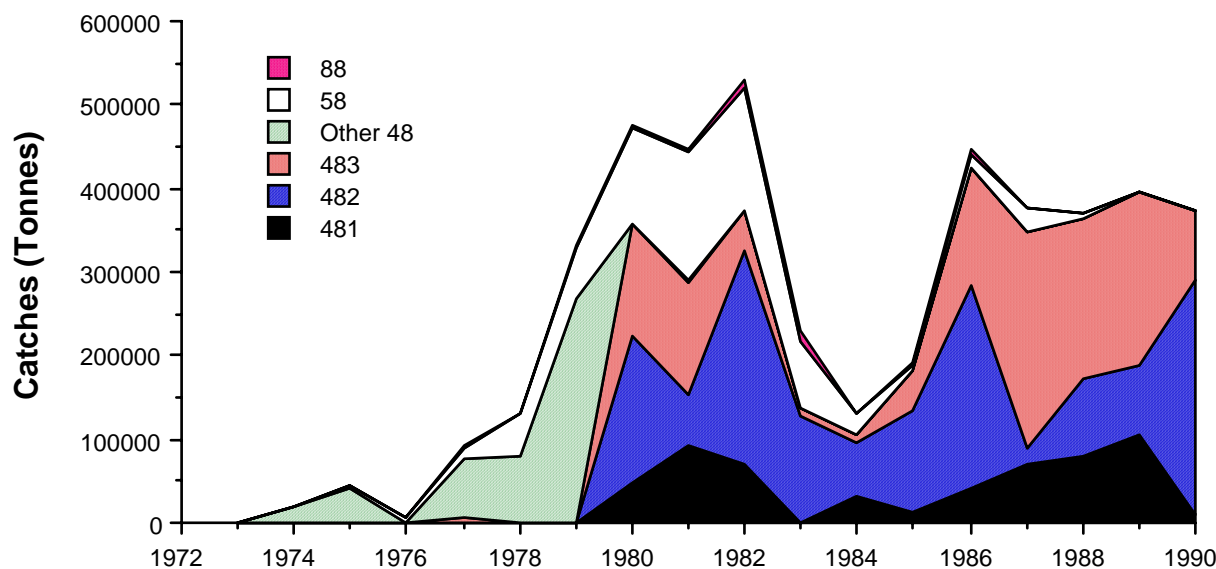


Figure 2.1: Total krill catches from 1973 to 1990. ('Other 48' refers to catches from Statistical Area 48 not allocated to Subareas 48.1, 48.2 or 48.3).

2.3 An analysis of the 1989/90 landings by area and subarea indicated a decrease in total catches from Statistical Area 48 compared with the previous two years. In this regard, Soviet

catches in Subarea 48.3 decreased by approximately 125 000 tonnes in 1989/90 compared with 1988/89. In Subarea 48.2, on the other hand, Soviet catches increased by about 145 000 tonnes and no catch was reported from Subarea 48.1 (see paragraph 2.6).

2.4 In contrast to the above, there was an increase of catches (from 217 to 30 510 tonnes) taken in Subarea 58.4. Catches in Statistical Area 88 increased from 0 in 1988/89 to 658 tonnes.

2.5 While the total catch taken by the Soviet Union was essentially similar to that in 1988/89 (showing an increase of about 0.3%), catches by Chile, Japan and Poland decreased between 15 and 82%. The Korean catch was just over double that taken last year.

2.6 The total krill catch in 1989/90 by area and country is shown in Table 2.2.

Table 2.2: Total krill catch in 1989/90 by area and country. The catch for 1988/89 is indicated in brackets.

	Chile	Japan	Korea	Poland	USSR
Subarea 48.1	4527 (5329)	0 (75912)	4040 (1615)	0 (1823)	0 (20875)
Subarea 48.2	0 (0)	62179 (3016)	0 (164)	0 (2732)	220517 (76494)
Subarea 48.3	0 (0)	0 (0)	0 (0)	1275 (2442)	79698 (203912)
Subarea 58.4	0 (0)	0 (0)	0 (0)	0 (0)	1503 (217)
Statistical Area 88	0 (0)	0 (0)	0 (0)	0 (0)	658 (0)

2.7 Dr K. Shust (USSR) reported that Soviet catches in Subarea 48.2 came predominantly from north to northwest of Coronation Island and were taken between January and May 1990. Catch rates of between 40 and 110 tonnes per day were common during this time. At South Georgia (Subarea 48.3), on the other hand, catches were taken during the period October 1989 to May 1990 while rates of 65 to 87 tonnes per day were normal. Such catches were predominantly from the shelf-slope zone to the north and northwest of the island. Although available research data from Statistical Area 58 indicated an overall increase of krill in the region, unfavourable ice and weather conditions precluded any substantive increase in overall catch levels.

2.8 The bulk of the Soviet catches are used for the onboard production of tinned krill meat. For the first time representatives of the USSR krill fishing industry will be attending the Commission Meeting. The Scientific Committee expressed the hope that these representatives will be able to provide additional information on possible future developments by the Soviet krill fishery.

2.9 Dr M. Naganobu (Japan) reported that the Japanese krill fishery was strongly market related and as such, the decreases in catches during the past year can be attributed to a reduction in demand for krill products by the Japanese domestic market.

2.10 Mr J. Park (Republic of Korea) indicated that Korean catches were taken in the vicinity of Elephant and King George Islands (Subarea 48.1) between early December 1989 and early February 1990. Mr A. Mazzei (Chile) stated that Chilean catches were taken in the Antarctic Peninsula region (Subarea 48.2) and were used for the production of meal and frozen tail meat products.

2.11 Mr Miller suggested that in view of the ongoing need to monitor trends in krill fishing operations and to assess the possible impact of such activity in the Convention Area, the Scientific Committee may find some utility in having information on the number of vessels fishing for krill in any one year available during its annual review of the fishery. The Scientific Committee agreed that such information would be useful and requested the Secretariat to provide the Scientific Committee with summaries of the information supplied by Members on intended vessel operations under the auspices of the Standing Committee on Observation and Inspection (SCOI).

2.12 Papers distributed at the Meeting dealt with the results of a net sampling survey in Subarea 48.1 (SC-CAMLR-IX/BG/9), and catch-per-unit effort and body length composition of Japanese catches north of Livingston Island in the 1988/89 season (SC-CAMLR-IX/BG/10). In this connection, the Scientific Committee reiterated its 1989 decision (SC-CAMLR-VIII, paragraph 2.11) and referred these papers to WG-Krill for detailed consideration.

Report of the Working Group on Krill

2.13 The Second Meeting of WG-Krill was held in Leningrad, USSR from 27 August to 3 September 1990. This meeting was attended by 41 participants from 12 Member countries.

2.14 Having briefly outlined the objectives of this meeting as agreed at last year's meeting of the Scientific Committee (SC-CAMLR-VIII, paragraphs 2.35 and 5.21), the Convener of WG-Krill, Mr D. Miller (South Africa), presented the Report of the Meeting (SC-CAMLR-IX/4) as well as his own summary of its conclusions and recommendations (SC-CAMLR-IX/5).

2.15 The Report of WG-Krill is attached in Annex 4.

2.16 In reviewing the report, the Scientific Committee thanked the Convener of WG-Krill and all the participants for their input. There were some 40 background papers presented to the Working Group and the list of documents considered is given in Annex 4, Appendix C.

2.17 The Scientific Committee endorsed WG-Krill's report and in accepting the report, made use of its findings as a basis for discussion. To avoid unnecessary duplication, only a brief summary of WG-Krill's deliberations is given below. Wherever paragraphs of the Working Group's report were accepted with only little or minor revision, the reader is referred to the relevant paragraphs of the Working Group report (Annex 4). Consequently, the following summary should be read in conjunction with that report.

Development of Approaches to Managing the Krill Fishery

2.18 The Scientific Committee noted that in dealing with the question of developing approaches to management of the krill fishery (CCAMLR-VIII, paragraph 50), WG-Krill had agreed to focus discussion on Subarea 48.3 (the target of the Commission's questions). The Scientific Committee agreed with the Working Group's conclusion that management approaches and considerations developed with respect to that specific subarea would also be pertinent to the krill fishery in other subareas (Annex 4, paragraph 11).

2.19 The Scientific Committee supported the approach adopted by the Working Group (Annex 4, paragraphs 55 and 61 to 62), taking particular note of the Working Group's suggestions concerning four general concepts on which to base operational definitions of Article II with respect to krill (Annex 4, paragraph 61). These:

- (i) aim to keep the krill biomass at a level higher than might be the case if only single-species harvesting considerations were of concern;
- (ii) given that krill dynamics have a stochastic component, focus on the lowest biomass that might occur over a future period, rather than the mean biomass at the end of that period as might be the case in a single-species context;
- (iii) ensure that any reduction of food to predators which may arise because of krill harvesting is not such that land-breeding predators with restricted foraging ranges are disproportionately affected in comparison with predators present in pelagic habitats; and

- (iv) examine what level of krill escapement would be sufficient to meet the reasonable requirements of krill predators. It was agreed that WG-CEMP be asked to consider this aspect.

The Scientific Committee supported the Working Group's request that Members provide suggested operational definitions of Article II to the Working Group's next meeting.

2.20 In keeping with the approach adopted by the Working Group, the Scientific Committee agreed that estimation of the potential yield of krill is fundamental to the development of an appropriate operational definition of Article II and the formulation of suitable approaches to management of the resource.

Estimation of Potential Yield

2.21 The Scientific Committee noted that WG-Krill had attempted to estimate the potential yield of krill from Subarea 48.3 in response to the Commission's question on this matter (CCAMLR-VIII, paragraph 50) and as an example to be used to improve definition of the types of data required to carry out such a calculation (Annex 4, paragraphs 63 to 80).

2.22 WG-Krill used the classical and simplified formula applicable to the calculation of potential yield:

$$Y = \lambda MB_0 \quad (1)$$

where **Y** is the annual yield,

M is the natural mortality,

B₀ is an estimate of the effective total biomass of the population prior to exploitation, and

λ is a numerical factor which depends on age-at-first capture, growth curve parameters, and the extent of recruitment variability.

2.23 The Scientific Committee recognised that in applying the formula to krill, there are likely to be a number of major problems and took note of specific reservations expressed by Members of the Working Group as to the formula's applicability (Annex 4, paragraphs 78 to 80). There was, however, general agreement that the example provided by the Working Group represented a useful first step to addressing the problems associated with the estimation of krill yield.

2.24 In discussion, the Scientific Committee highlighted the following problems.

2.25 The first problem is directly associated with obtaining accurate estimates of krill biomass, in particular \mathbf{B}_0 .

2.26 The structure of the model underlying formula (1) assumes that the krill stock being considered is 'static' and therefore confined within the area of concern. There are, however, likely to be large scale immigration and emigration (i.e., fluxes) of krill through the area. In addition, the estimate of biomass is assumed to pertain to a single unit stock.

2.27 The second problem is associated with obtaining accurate estimates of λ , which depend on demographic parameters (i.e., age-at-first capture, growth and recruitment variability) and natural mortality (\mathbf{M}).

2.28 Finally, the formula does not take into consideration the requirement of krill-dependent predators – an important underlying concept identified in the operational definitions of Article II (Annex 4, paragraph 61(iii) and (iv) and paragraph 2.19 above), developed by WG-Krill.

Biomass Estimation

2.29 The Scientific Committee noted that two primary methods are currently used to assess krill spatial distribution and biomass – acoustics and direct net sampling. Acoustics has the principal advantage that a much larger portion of potential krill habitat is sampled per-unit-survey-time. Principal disadvantages include undersampling in the upper 10 or so metres of the water column and possible undersampling of non-aggregated krill (Annex 4, paragraph 18).

2.30 The Scientific Committee noted that the Working Group had expanded and updated the table of the characteristics of nets used to sample krill which was developed at the Working Group's First Meeting (Annex 4, paragraph 24 and Table 1).

2.31 Given the importance of acoustic techniques and in the overall interest of improving krill abundance estimation, the Scientific Committee endorsed the Working Group's conclusions that further development is required to standardise procedures for the conduct of acoustic surveys, including specification of:

- krill acoustic target strength to size relationships used to scale echo integration data in order to obtain biomass estimates;
- statistical procedures to summarise data, prepare distribution maps and estimate total abundance along with its associated variance; and
- guidelines for acoustic survey design and direct sampling requirements.

2.32 The Scientific Committee noted that considerable progress has been made in the last two years to improve available krill target strength information and consequently endorsed paragraphs 20 to 23 of the Working Group's report (Annex 4). In particular, the Scientific Committee emphasised that (in order of priority):

- (i) additional experiments should be undertaken to measure krill target strength under controlled conditions; and
- (ii) suggestions for appropriate acoustic survey designs, methods for summarising survey data and procedures for estimating biomass and associated variance should be developed and submitted to next meeting of WG-Krill.

2.33 Most present estimates of krill biomass are 'instantaneous' estimates of biomass which, because of immigration and emigration of animals from a region, differ from the 'effective total' biomass. The Scientific Committee noted that estimation of effective total biomass is required for assessment of the potential harvest which can be removed from a particular region (Annex 4, paragraph 34).

2.34 In principal, the Scientific Committee agreed that this problem can be dealt with either by:

- changing the underlying model (or formula) in order to specifically incorporate immigration and emigration rates; or
- adjust estimates of 'instantaneous biomass' obtained from biomass surveys (e.g., via acoustics) to allow for residence times of krill in a particular area.

2.35 In both the above cases, estimates of both immigration and emigration rates as well as possible residence times of krill in a particular area will be required.

2.36 The Scientific Committee noted that WG-Krill had throughout its meeting, attempted to provide suggestions as to how to improve current understanding of krill flux rates in different areas. Such suggestions include further hydrographic studies (Annex 4, paragraphs 109 and 129), the use of satellites to detect gross hydrographic features (Annex 4, paragraphs 107 to 109) and further analyses of commercial fisheries data (particularly haul-by-haul data) to improve definition of areas of possible krill concentration (Annex 4, paragraphs 113 to 115 and 118 to 120).

2.37 It was therefore recommended that a program of work be established whereby additional information on krill movements be collected. Both existing and this new data should be analysed to estimate immigration and emigration rates as well as krill residence times in a particular area.

2.38 The Scientific Committee noted that the effective separation of krill 'stocks' by genetic and other means is yet to yield unequivocal results (Annex 4, paragraphs 13 to 15).

Estimation of Demographic Parameters and Other Problems

2.39 With respect to improving estimates of M and λ in formula (1), the Scientific Committee agreed that available estimates should be refined by further analyses of existing and newly provided data (Annex 4, paragraphs 44 to 50).

2.40 The Scientific Committee recommended that WG-Krill consider methods for taking account of the needs of krill predators in calculations of the potential yield of krill. It was also noted that local predator needs could require additional consideration in cases where krill catches are predominantly taken in important foraging areas for land-based predators.

2.41 Finally, the Scientific Committee recommended that the approach aimed at estimating the potential yield of krill in Subarea 48.3 (as set out in Annex 4, paragraphs 67 to 80) should also be applied in other subareas (e.g., Subareas 48.1 and 48.2) as far as is possible.

Monitoring of Krill as Prey and the Working Group for the CCAMLR Ecosystem Monitoring Program

2.42 The Scientific Committee noted the Working Group's deliberations on this particular topic in response to the former's request for pertinent information (SC-CAMLR-VIII, paragraph 5.21) (Annex 4, paragraphs 87 to 115).

2.43 The Scientific Committee agreed with WG-Krill's conclusion that initially it will be most practical to develop a krill (i.e., prey) survey strategy to be implemented during a period (the 'integration period') of two to two-and-a-half months (particularly during mid-December to late February) within a radius of approximately 100 km of land-based monitoring sites and to a water depth of 150 m. It was also agreed that acoustic surveys offer the most practical approach to assessing krill variability at the spatial and temporal scales described (Annex 4, paragraph 91).

2.44 The Scientific Committee endorsed the Working Group's view that although absolute estimates of krill biomass are preferred for prey monitoring purposes, relative biomass estimates were still considered valuable. However, the Working Group felt that further consideration in this regard must be given to:

- the degree of precision required in the estimation of krill biomass related to the predator parameters being studied with, and in association with, the integration period identified;
- the compilation of areal data on krill distribution; and
- methods of calculating relationships between survey design, associated survey effort and the expected precision of estimates.

2.45 The Scientific Committee endorsed WG-Krill's recommendation that a small subgroup be tasked with considering matters related to the design of surveys for monitoring krill biomass in relation to predator requirements. The subgroup would also consider the statistical combination of line transect measurements of krill density to estimate biomass over a region in combination with provision of associated estimates of variance (Annex 4, paragraphs 96 to 98).

2.46 In this context, the Scientific Committee felt that many of the tasks being undertaken by the subgroup were also relevant to the estimation of krill biomass over broader spatial and

temporal scales (see discussion in paragraphs 2.29 and 2.38) than those considered in terms of predator requirements.

2.47 The Scientific Committee endorsed the Working Group's suggestions for interim guidelines for implementing krill (prey) surveys (Annex 4, paragraph 100).

2.48 The Scientific Committee recognised that additional data are required to improve linkages between prey surveys and key predator parameters being monitored by WG-CEMP (Annex 4, paragraph 104), as well as between krill availability and key environmental processes (Annex 4, paragraphs 106 to 113). The collection of haul-by-haul data from commercial fishing operations was also seen as being an important source of information in this regard (Annex 4, paragraphs 112 to 115).

2.49 The Scientific Committee duly noted that the continued close liaison and exchange of information between WG-Krill and WG-CEMP will be crucial to the future development of prey monitoring.

Effects of Krill Catches for Young and Larval Fish

2.50 The Scientific Committee noted that the Commission has sought WG-Krill's advice on possible measures for the krill fishery in Subarea 48.3 (SC-CAMLR-VIII, paragraph 50) which would contribute to the protection of young and larval fish.

2.51 The Scientific Committee noted that the WG-Krill had considered the problem of quantifying the incidental catch of young fish in krill trawls.

2.52 This problem had also been referred to WG-FSA where it had been considered in some depth (Annex 4, paragraphs 21 to 29) and the results of such discussion are reflected in Annex 5, paragraphs 16 to 29 and 3.16 below.

2.53 In addition to improving information on the incidental by-catch of young fish by the krill fishery, having suitably trained personnel as observers on commercial krill trawlers would substantially improve the flow of information aimed at quantifying krill demographic parameters from the fishery (Annex 4, paragraph 121). The improved supply of data likely to be forthcoming as a result of the deployment of observers aboard commercial fishing vessels was also considered by the Scientific Committee to be an important factor in improving the

flow of information from the Antarctic commercial finfish fishery (see paragraphs 3.16 to 3.17).

WG-Krill's Answers to Questions Posed by the Commission

2.54 The Scientific Committee noted that WG-Krill had attempted to answer the three questions conveyed to it from the Commission (SC-CAMLR-VIII, paragraph 50).

2.55 Specifically, these three questions requested advice on:

- (i) What is the biomass and potential yield of krill in Subarea 48.3?
- (ii) What are the possible management measures, including limits, that might be necessary on krill catches in the subarea which would maintain ecological relationships with dependent and related populations, including:
 - (a) the protection of dependent predators; and
 - (b) the protection of young and larval fish?
- (iii) If these questions cannot be answered, what new information is required and how soon could it be obtained?

2.56 WG-Krill's answers to these questions were set out in Annex 4, paragraph 139 and are as follows:

- (i) some Members considered that a crude range of biomass and potential yield estimates of krill in Subarea 48.3 could be provided. Others expressed reservations concerning such estimates and the formula used to calculate annual yield (Annex 4, paragraphs 63 to 80);
- (ii) specific concepts with respect to approaches to the management of krill were developed along with suggestions for operational definitions of Article II of the Convention:

- (a) a number of suggestions were made concerning the improvement of information on, and consequently, the protection of krill dependent predators (Annex 4, paragraph 59);
- (b) suggestions were made on gear developments to alleviate the potential problem of incidental by-catch of young and larval fish by commercial krill trawling operations (Annex 4, paragraph 81). It was recommended that experiments be carried out on such gear modifications with a view to reducing possible mortality of young fish in trawls and that field data on the extent of the problem should be collected (Annex 4, paragraph 122); and
- (iii) requirements for new information were outlined (Annex 4, paragraphs 80, 118 to 120, 122 to 124 and 128 to 129), but it was felt that the determination of the time required to obtain sufficient data to provide satisfactory answers to the questions being posed would be a substantial exercise and one which the Working Group was unable to carry out in the time available to it.

2.57 The Scientific Committee also noted that many of the key issues crucial to answering questions of the type posed by the Commission have been considered by WG-Krill and will constitute a major part of the Working Group's ongoing work.

Future Work of the Working Group on Krill

2.58 The Scientific Committee agreed that discussion at WG-Krill's meeting had identified many areas important to the ongoing assessment of the impact of fishing on krill stocks and krill availability to both the fishery and dependent predators.

2.59 In addition to the ongoing requirement to monitor fisheries activities, review the status of the krill resource and liaise with WG-CEMP, the Scientific Committee agreed that WG-Krill should focus its attention on refining estimates of potential yield. In this connection, further work on estimation of biomass, determination of krill acoustic target strength, estimation of krill advection and the separation of stocks are essential.

2.60 In the interest of improving management advice on krill, the Scientific Committee agreed that WG-Krill should continue to develop approaches to management.

2.61 In order to address these issues which are fundamental to the development of advice on krill, the Scientific Committee recommended the WG-Krill should meet during the intersessional period for approximately one week during 1991.

2.62 Attention was also drawn to the fact that the above meeting will be immediately preceded by a three-day workshop to review results forthcoming from the various tasks assigned to the subgroup on survey design (see Annex 4, paragraph 97).

Data Requirements

2.63 In view of a continued need to monitor fishery activities, the Scientific Committee endorsed WG-Krill's recommendation (Annex 4, paragraph 113) that, if possible, haul-by-haul data should be reported from areas within 10 km of land-based predator colonies. The potential utility of deploying suitably qualified observers aboard commercial vessels to facilitate the collection of such data was recognised.

2.64 The Scientific Committee endorsed WG-Krill's action with respect to developing a form to be used by scientific observers and aimed at collecting data on krill demographic parameters from the krill fishery (Annex 4, paragraph 121).

2.65 Analyses of fine-scale fisheries data should continue (as per SC-CAMLR-VIII, paragraph 2.41) with a view to monitoring fishery activities specifically (Annex 4, paragraph 115). Such data should be reported for Subareas 48.1, 48.2 and 48.3 as well as the Antarctic Peninsula Integrated Study Region.

2.66 As recommended last year (SC-CAMLR-VIII, paragraphs 2.37 and 2.38), Members should report results of analyses of both past and currently available acoustic data on krill as well as on the examination of available echo-charts. Submissions on procedures to access such data should also be provided (Annex 4, paragraph 120).

2.67 The interim measure requiring collection of at least 50 krill per single haul, per vessel, per fishing day for length frequency analyses, should remain until the level of precision to be achieved by such analyses can be properly evaluated. In this regard, the improved definition of the specific use(s) to which krill length frequency data from commercial catches can be put, is required before modification of the interim measure is recommended (Annex 4, paragraph 123).

2.68 Length frequency data from commercial catches already collected should be analysed (either nationally or by the Secretariat) to estimate the level of precision to be expected from implementation of the current sampling regime (Annex 4, paragraph 124).

2.69 Under the current arrangement, data from the krill fishery must be submitted by 30 September. The Scientific Committee considered the deadline in view of WG-Krill's requirement to consider such data from the most recent split-year and the fact that meetings of the Working Group are likely to be scheduled prior to this deadline. The Scientific Committee felt that at this stage, however, there was no need to modify the current deadline of 30 September.

Advice to the Commission

2.70 WG-Krill should hold an intersessional meeting and workshop during 1991 in order to review commercial fishing activities, attempt estimates of potential yield and sustain momentum in the development of approaches to structuring advice on krill resources. The WG-Krill should also develop advice on survey design for, and continue liaison with, WG-CEMP.

2.71 The continued collection of haul-by-haul catch and effort data (including relevant operational details) should continue.

2.72 The interim guidelines for the conduct of krill (prey) surveys in the vicinity of land-breeding colonies should be adhered to until such time as suitable prey survey designs have been developed.

2.73 The Commission had posed a number of questions concerning krill resources in Subarea 48.3. The first question concerned the estimation of the total biomass and the potential yield of krill. WG-Krill indicated that they were unable to estimate biomass reliably because of uncertainty in estimates of acoustic target strength (estimates differed by an order of 10) and uncertainty about the residence times of krill in the area.

2.74 Because of the uncertainty in estimating biomass, WG-Krill was unable to estimate potential yield.

2.75 Regarding the second question posed by the Commission, WG-Krill indicated that it is not possible to provide detailed advice on measures aimed at protecting krill dependent predators or young and larval fish, due to a lack of data.

2.76 Finally, WG-Krill was unable to provide any indication of how soon sufficient information to resolve these particular problems could be collected. In the light of the uncertainties outlined above, and in the absence of any reliable estimate of potential yield of krill in Subarea 48.3, the Scientific Committee recommended that the Commission consider imposing precautionary measures for limiting krill fishing in Subarea 48.3.

2.77 At the time the Report of the Scientific Committee was being adopted, the Delegations of Japan and USSR expressed the view that the introduction of precautionary limits on krill fishing in Subarea 48.3 was not yet justified because of the lack of estimates of the total biomass and the potential yield.