ANNEX 6

REPORT OF THE WORKING GROUP FOR THE CCAMLR ECOSYSTEM MONITORING PROGRAM HAMBURG, FEDERAL REPUBLIC OF GERMANY 2–7 JULY, 1986

TABLE OF CONTENTS

REPORT OF THE WORKING GROUP FOR THE CCAMLR ECOSYSTEM MONITORING PROGRAM HAMBURG, FEDERAL REPUBLIC OF GERMANY

2 – 7 JULY, 1986

INTRODUCTION

The Working Group for the CCAMLR Ecosystem Monitoring Program was established at the Fourth Annual Meeting of the Scientific Committee of CCAMLR (SC-CAMLR) in September 1985. Dr K.R. Kerry (Australia) was elected as Convener of the Group. In order to expedite the operational implementation of a program, SC-CAMLR agreed that an intersessional meeting of the Working Group should be held during 1986 and a draft agenda was prepared for circulation.

2. The Scientific Committee accepted an invitation from the Federal Republic of Germany to hold the meeting at the Bundesforschungsanstalt fur Fischerei, Hamburg.

3. The meeting was held from 2 – 7 July, 1986.

4. Participants were welcomed by Dr D. Sahrhage, the Director of Institut für Seefischerei, Hamburg, and Chairman of SC-CAMLR. A list of participants is attached (Appendix 1).

5. The Convener opened the meeting and the agenda (Appendix 2) was adopted.

ORGANISATION OF THE MEETING

6. Mr D. Miller (South Africa) was appointed rapporteur for the Working Group.

7. A list of documents used as working papers and reference material is attached (Appendix 3).

REVIEW OF THE REPORT OF THE AD HOC WORKING GROUP ON ECOSYSTEM MONITORING, SEATTLE, 1985

8. To amplify the record of the Seattle Meeting, an outline was given of the background and rationale for the approach adopted. Two main considerations governed the initial approach: firstly, the requirement to maintain ecological relationships between harvested and dependent (and related) species, within the whole Convention area; secondly, the need to establish elements of a monitoring program as soon as possible. This automatically involved considering the extension of existing baseline data series as well as the creation of new baselines and the identification of necessary programs of directed research. In addition it was recognised that although the requirement covered the whole Southern Ocean system, it would be pointless to propose a comprehensive monitoring and research program for all species and their interactions, and therefore a selective approach would be needed. This would have to identify key predator and 'prey' species and important trophic links (with an emphasis on the practical aspects of monitoring). Thus a compromise program involving intensive local studies and broad coverage studies of harvested and dependent species would be required.

9. In selecting 'prey' species, discussion was focused primarily on how changes in availability would affect predators. The main attention was given to commercially harvested (or harvestable) species. *Euphausia superba* was identified as a priority target species. Discussion of related species identified *Pleuragramma antarcticum*, early life-history stages of fish, and in certain areas *Euphausia crystallorophias*, as potentially suitable indicators of system changes.

10. Predator species were selected primarily with respect to their dependence on *E. superba* (on the basis of quantitative dietary data). Criteria of subsidiary importance were geographical distribution, tractability of the monitoring programs and associated directed research, and the quality of existing baseline information.

11. Sites and areas for monitoring studies were chosen primarily on the basis of the presence of key species, and the existence and nature of current or perspective long-term scientific operations, and secondarily in order to achieve adequate geographical coverage.

Monitoring of Indicator Species

(a) Areas within which monitoring should be conducted

12. The Working Group agreed that the most important areas for the implementation of monitoring of predator-prey interactions in the Southern Ocean system were:

- the Prydz Bay region (58 – 68°S; 55 – 85°E; within CCAMLR Statistical Area 58.4.2) - representative of higher latitude Antarctic predator-prey interactions

- the Antarctic Peninsula region (60 – 68°S; 54 – 75°W; within CCAMLR Statistical Areas 48.1 and 88) representative of predator-prey interactions in dynamic intermediate latitude areas

- the South Georgia region (53 – 56°S, 35 – 40°W; within CCAMLR Statistical Area 48.3) - representative of lower latitude predator-prey interactions.

13. The Group also agreed upon a proposed network of sites for monitoring and directed research (see Table 1). The locations of the major study regions and the sites listed in Table 1 are shown in Figure 1.

(b) Species to be monitored

14. The Working Group endorsed the predator species chosen at the Seattle meeting as being the most useful potential indicators of change in food availability (especially of krill, *Euphausia superba*) in different geographical areas. It also acknowledged the criteria used in making the choice. After further consideration of the criteria and the selected sites for monitoring, the Group agreed to add the Antarctic petrel and the black-browed albatross to the list. The full list of species selected is:

(i) Crabeater seal
(ii) Antarctic fur seal
(iii) Adelie penguin
(iv) Chinstrap penguin
(v) Macaroni penguin
(vi) Minke whale

(vii) Antarctic petrel
(viii) Black-browed albatross.

15. At the Seattle meeting the Working Group had prepared a set of questions for referal to the Scientific Committee of the International Whaling Commission (IWC), concerning the suitability of the minke whale as a potential indicator of the effects of changes in krill availability (Appendix 4 of the report of the Seattle Meeting). The Working Group reviewed the response from the Scientific Committee of the IWC. It expressed its thanks to the IWC Scientific Committee for the work which it had done.

16. The Working Group noted that the IWC Scientific Committee is continuing to address problems associated with the first and third category of questions forwarded by SC-CAMLR concerning the nature and extent of the impact of krill fishing on trends in whale abundance. It was also noted that the Comprehensive Assessment of Whale Stocks being undertaken by the IWC could provide information relevant to these questions. The Comprehensive Assessment is expected to be completed by 1990. Because of its potential importance, the Working Group supported the rapid completion of the Comprehensive Assessment.

17. It was noted by the Working Group however, that the Comprehensive Assessment has as its major objective to improve current estimates of whale stocks. The Working Group therefore requested that high priority also be given to evaluating available data (and data collected during the Comprehensive Assessment) on physiological condition, stomach contents and feeding behaviour of minke whale in terms of their usefulness in indicating changes in the krill/whale system. It recommended that SC-CAMLR correspond with the IWC Scientific Committee in order to explore means by which this might be achieved.

18. The IWC representative drew the attention of the Working Group to preparations being undertaken by the IWC to hold a Workshop on the Feeding Ecology of Southern Baleen Whales. The possibility of CCAMLR jointly sponsoring such a workshop had been raised by the IWC in 1983. The IWC Scientific Committee has initiated steps to prepare an inventory of available data relevant to the above Workshop (to be reviewed at its 1987 meeting). The Working Group agreed that encouragement should be given to these developments. In this context the attention of the Working Group was drawn to national efforts in relation to the analysis and synthesis of available data as outlined in ECO/6 tabled at this meeting.

19. The Group noted that the proposed Feeding Workshop will be useful in evaluating further the potential of the minke whale as an indicator species. It therefore recommended that SC-CAMLR should support the Workshop.

(c) Parameters to be monitored

20. The groundwork established at the Seattle meeting was reviewed. This information is summarised in Tables 3, 4 and 5 of SC-CAMLR-IV/7. Few additions and deletions were suggested. Additions to the list of parameters of potential immediate use (Table 3, SC-CAMLR-IV/7) were body condition in crabeater seal, and three parameters for minke whale (Table 2). Additions to the list of parameters which require directed research in order to assess their potential utility for monitoring programs comprised chick growth rates, fledging success and diet of Antarctic petrel, meal size in penguins, and several minke whale parameters (Table 3).

21. From the parameters listed in Table 2, specific parameters were selected for inclusion in monitoring programs to be established in the Prydz Bay, Antarctic Peninsula, and South Georgia regions (Table 4). Specific sites where land-based work should be carried out - at least at a minimum level - are listed in the footnotes to Table 4; further evaluation of some of these sites is still required.

22. It was especially noted that certain parameters of considerable potential importance for monitoring (e.g. frequency and duration of foraging trips; feeding rates and behaviour) and data critical to the interpretation of monitoring results (e.g. location of feeding areas; diet outside the breeding season), could not be evaluated or acquired without appropriate technological developments and the provision of dedicated shiptime.

23. The Working Group agreed on the sites where complementary monitoring work could be done, and reaffirmed the desirability of conducting work at these sites (SC-CAMLR-IV/7, pp.13–14). The species parameters to be measured at these sites would be the same as those specified in Table 2. The Group also reaffirmed the usefulness of conducting directed research at several sites identified in SC-CAMLR-IV/7, p.14. It noted that work on snow petrel at Cape Hallett (and elsewhere) and on Weddell seal in the Southern Ross and Weddell Seas could provide insight into predator interactions with *Pleuragramma antarcticum*.

24. With regard to monitoring important predator-krill interactions, the Group recommended that: the Scientific Committee request the SCAR Group of Specialists on Seals and the Subcommittee on Bird Biology to provide advice on the precise sampling protocols and sample sizes required for the effective monitoring of the identified parameters, including advice on the timing of investigations and the minimum time required to establish adequate base-lines.

25. Recognising that:

(a) the interpretation of many of the predator monitoring parameters requires quantitative information on diet outside the breeding season of most if not all predator species,

(b) to obtain the information needed for (a) requires dedicated time on research cruises and, for some species, dedicated research cruises *per se*, and

(c) scientific programs are being conducted by member nations within the framework of other international bodies could contribute to the acquisition of data,

the Working Group recommended that SC-CAMLR request SCAR to promote and coordinate, as a matter of urgency, the acquisition of pertinent data through the scientific research programs of member nations. The formation of the SCAR Group of Specialists on Southern Ocean Ecology was seen as an important development in the promotion of such coordinated research activities.

26. Recognising that the development of various devices permitting automated measurement and recording of data, especially involving at-sea distribution and behaviour of predators, was of paramount importance for the implementation of a successful long-term program, the Working Group recommended that the Scientific Committee approve the convening (by the Chairman of the Working Group in consultation with the Chairman of the SCAR Group of Specialists on Seals and the Subcommittee on Bird Biology) of a Workshop at which specialists currently involved in developing appropriate remote sensing equipment could discuss with members of the Working Group the requirements associated with the recommended monitoring programs. The workshop should also attempt to arrange for the preparation of detailed specifications for equipment to meet monitoring needs. The meeting should ideally be convened in conjunction with the next meeting of the Working Group.

27. In addition to data on krill abundance and hydrology, there will be a need to collect the supplementary data listed in Table 4 if some explanation of the expected variability in the various monitoring parameters is to be obtained.

28. It was recognised that there is a fundamental distinction between monitoring parameters for the assessment of important prey species in their own right (e.g. for resource appraisal purposes) and for the use of such parameters to evaluate predator-prey interactions.

It follows that the status of selected prey species and their interactions with other system components would be reflected in both the spatial and temporal variability of the prey species in the areas selected (Prydz Bay region, the Antarctic Peninsula region, and South Georgia regions). It also follows that monitoring interaction effects should provide data sufficient to distinguish between changes resulting from harvesting commercial species (of prey) and changes due to environmental variability, both physical and biological.

29. It was accepted that on a variety of temporal scales, it is necessary to monitor the following four categories of parameters with respect to assessing rates of change in abundance of the prey species selected:

(a) prey population variables over the region
(b) prey population variables associated with important predators
(c) prey population variables associated with prey fishery
(d) advection of prey.

30. A schema outlining the various parameters to be monitored to assess rates of change in krill abundance is given in Figure 2.

31. It was agreed that monitoring changes induced by the immigration and emigration of krill into and out of a particular area (i.e. fluxes across regional boundaries) would be critically important in the assessment of rates of change in krill abundance.

32. It was appreciated that the areal significance of this movement may vary and that some studies have attempted to determine to what extent advection of krill is important. The Group noted that the extensive USSR programs, the planning for SIBEX in the Western Atlantic, the British Antarctic Survey Offshore Biological Programme at South Georgia, and proposals for integrated monitoring of krill taking into account environmental variability in the Prydz Bay region (Krill WG/1985/Docs. 9 and 10), provide useful points of departure for the development of studies of this nature in the near future. Further development of such studies was encouraged. The Group noted that development of various techniques permitting automated recording of abundance and distribution data would greatly assist the monitoring of prey species, and agreed that research in this area should also be encouraged.

33. In relation to krill fisheries activities, the Group recognised two possible effects on krill abundance/distribution in the regions being considered. The first effect would be reflected in demographic parameters of krill actually taken by the fishery. The second would reflect effects of the fishery on the demography of the krill population(s) concerned.

34. Most of the parameters required for *Pleurogramma antarcticum* are the same as for krill (see Figure 2), except that the variables associated with the fishery are not applicable. Some allowance, however, has to be made for estimating the extent of the by-catch of *P. antarcticum* taken during krill fishing operations.

35. Similar allowance has to be made to assess the quantity of early life-history stages of other fish species taken as a by-catch of the krill fishery and to include an analysis of changes in species composition based on collections of early life-history stages. It was noted that work in this area was in progress and had been reported to the Scientific Committee (SC-CAMLR-IV, 4.26–4.29).

(d) Methods of monitoring selected parameters

36. Within the confines of the arguments outlined in the report of the Sub-group on Krill, Fish and Squid tabled in Seattle, various methods and parameters were identified as being useful for monitoring the variables summarised in Figure 2 (see Table 5).

37. The Group recognised that there is considerable overlap between the methods outlined in Table 5 and their use in monitoring changes in krill abundance. Most of the methods are applicable to the two other priority prey species identified, although it was appreciated that knowledge of these is not as great as it is for krill.

38. The Group recognised that assessment of recruitment and natural mortality are important parameters to be considered if adequate assessment of prey species dynamics and trophic relationships are to be made. However, the Group acknowledged the difficulty at present of monitoring these parameters. Directed research in this area was encouraged.

QUANTITATIVE RELATIONSHIPS BETWEEN CHANGES IN PARAMETERS OF SELECTED PREDATOR SPECIES, THEIR PREY AND THE ENVIRONMENT

39. Accepting the objectives of monitoring changes in the Southern Ocean system outlined in Paragraph 11 of the report of the Seattle Meeting, the Working Group acknowledged that effects of environmental variability on species to be monitored (both predator and prey species individually and their interactions) have to be examined critically.

40. In terms of Article II of the Convention on the Conservation of Antarctic Marine Living Resources, monitoring of environmental variables should be so designed as to provide the information necessary to distinguish between changes in the system induced by the harvesting of particular species (especially krill) and changes resulting from environmental variability, both physical and biological.

41. The Working Group identified a number of specific environmental variables thought to affect predator-prey interactions, as well as predator and prey dynamics separately. An attempt was made to define the spatial and temporal scales at which such variables should be monitored for both predators and prey, and the methods that could be used (Table 6). Their short and long-term suitability for monitoring purposes was also assessed.

42. The Working Group noted that certain environmental variables identified in Table 6 are also likely to affect the scope of fisheries activities directly. This in turn would be expected to exert some second-order effect on predator species dependent on the harvested resource, especially krill.

43. The Working Group further considered that in the future it may be both desirable and expedient to consult with appropriate specialist groups having intimate knowledge of the theoretical background of, and methods for, monitoring important environmental variables (e.g. hydrological and meteorological variables), particularly the Program Group for the Southern Oceans of the IOC and Working Group 74 of SCOR.

FRAMEWORK FOR THE DEVELOPMENT OF AN INTERNATIONAL MONITORING PROGRAM

44. The Working Group agreed that a wide variety of data needs would be identified and that these would be dependent on the specific site being considered. Similarly logistic, technological and economic considerations need to be taken into account when formulating the development of an internationally-coordinated monitoring program.

45. The operational requirements of monitoring activities themselves will be dependent on a variety of empirical, iterative and interpretative activities. The Working Group attempted to integrate a range of such activities using directed monitoring of Adelie and chinstrap penguins as examples (Figure 3). It became apparent that the requirements for the institution of an effective monitoring framework to study environmentally/ecologically induced changed in the target penguin species used in Figure 3 could be divided as follows:

- interpretative requirements;
- requirements for technological developments;
- requirements for directed research; and
- the actual parameters to be monitored.

46. For the areas discussed below, the Group recognised that in terms of obtaining adequate assessments of both temporal and spatial variability of the key prey species to be monitored, as much of the area as practicable should be surveyed at various times of the year. In terms of assessing the availability of krill to key predators, monitoring surveys need to cover as much as possible of the total distributional area of the krill population(s) concerned. In addition, it was felt that no matter how precise the estimates of changes in krill abundance might be, such estimates would be of little application to monitoring systematic changes unless results were corroborated by synoptic data on krill predators.

47. Bearing such considerations in mind, the following initial monitoring framework was proposed for the three regions:

Antarctic Peninsula Region

48. This region was defined as: west of 54°W, east of 75°W (or the western ice edge, whichever is further), south to the Antarctic Peninsula and north to latitude 60°S. This represents an area of approximately 9×10^5 km^2.

(a) Land-based monitoring

49. The following land-based monitoring sites for birds, and possibly fur seals, were identified:

(i) Palmer Station
(ii) King George Island (at Admiralty and Maxwell Bays and one site on the north coast)
(iii) Elephant Island.

The species and parameters to be monitored at each site are listed in Table 7. Sampling should be undertaken on a yearly basis.

(b) Ship-based monitoring

(i) Predators

50. Two features of crabeater seal biology were identified as suitable for monitoring. These are:

Condition Index: It was suggested that Condition Index should be measured during October (breeding haul-out) and might also be measured during late summer if the population is accessible. The former would reflect winter feeding conditions, the latter, summer feeding. Measurements of Condition Index during summer require ship-based food surveys within 100 km of the monitoring sites. Sampling should be on a yearly basis.

Demographic Variables: Sampling should be undertaken in the pack-ice zone during the period October–December, wherever suitable concentrations of seals are found. The sampling interval should be in the order of 3 – 5 years.

Detailed protocols will await advice from the SCAR Group of Specialists on Seals.

(ii) Prey

51. Krill abundance and distribution should be monitored over the whole region. Intensive monitoring should be focused within critical period predator foraging ranges of the land-based monitoring sites, particularly at King George Island and Elephant Island.

52. The critical period foraging ranges of Adelie and chinstrap penguins and fur seal were estimated to be within about 100 km radius of their respective breeding sites. It was therefore agreed that within that range, sampling of prey should be highly concentrated and within the critical periods identified in Table 7.

53. Monitoring operations should comprise a standard survey of transects aligned at right angles to the main direction of water movement over the whole region (e.g. as in the extensive programs of the USSR and SIBEX).

54. An alternative approach which was discussed would be to estimate the flux of krill in the region by repeated sampling throughout a particular season of transects situated at the geographical boundaries of the region. Although attractive in that it would allow trends

during the season to be identified, strong reservations were expressed concerning the scientific basis of the approach.

55. No specific requirements for monitoring early life-history stages of fish or *P. antarcticum* could be identified. It is expected that some data will become available incidentally in catches of krill. These data would provide some information for future monitoring directed specifically at these groups.

(iii) Environment

56. Closely spaced stations should be monitored within the critical period foraging ranges of monitored species from the land-based sites. Sampling strategies to be employed should encompass hydrological and meteorological measurements. In particular, the Group considered it was essential that standardised hydrological sections should be taken along the regional boundaries at least once each season.

(iv) Logistics

57. As a first approximation, the following estimates of shiptime per year were made:

(i)	Regional krill survey and environmental monitoring	40 shipdays
(ii)	Intensive (i.e. associated with land-based sites) krill surveys at each site (Dec to Jan)	60 shipdays
(iii)	Seal monitoring	30 shipdays
	Total:	130 shipdays

(c) Data requirements from fisheries activities

58. Detailed catch and effort data will be required on appropriate scales to provide suitable information on the impact of fisheries activities (especially the krill fishery) within

the region. The Group agreed that detailed requirements would be assessed at its next meeting.

(d) Onset of monitoring activities

59. In view of the potential of monitoring as a tool for providing data on which to base management advice, the Working Group agreed that monitoring activities must be implemented as soon as possible. Refinement of particular techniques will occur as an on-going process as results from directed research programs become available.

South Georgia Region

60. This was defined as the region enclosed by latitudes 53 to 56°S and longitudes 35 to 40°W. This represents a total area of approximately 8×10^4 km^2.

(a) Land-based monitoring

61. Bird Island was identified as the primary site for land-based predator monitoring.

62. The species, parameters, and the extent to which they should be monitored, are summarised in Table 7. A foraging range of about 100 km was agreed to be a reasonable estimate for the most important predator species, fur seal and macaroni penguin. The range was considered to be about 250 km for the black-browed albatross.

(b) Ship-based monitoring

(i) Predators

63. No ship-based predator monitoring studies were identified for the region.

(ii) Prey

64. Three sets of survey activities were considered necessary. These are the estimation of the abundance and distribution of krill (a) for the whole region, (b) within the foraging range of the predator species and (c) studies of flux of krill across regional boundaries. In terms of monitoring krill within foraging range of the primary land-based monitoring site chosen (Bird Island), the critical radius was agreed to be about 100 km and the optimal time for the conduct of the surveys was during February.

65. Bearing in mind the depleted state of certain South Georgia fish stocks, effective monitoring of the early life-history stages of fish was considered to be of high priority.

(iii) Environment

66. As noted for the Antarctic Peninsula region (paragraph 56).

(iv) Logistics

67. As a first approximation the following rough estimates of shiptime per year were made:

(i)	Regional krill survey and environmental monitoring	60 shipdays
(ii)	Intensive krill surveys	30 shipdays
	Total:	90 shipdays

(c) Data requirements from fisheries activities

68. As noted for the Antarctic Peninsula region (paragraph 58).

(d) Onset of monitoring activities

69. As noted for the Antarctic Peninsula region (paragraph 59).

Prydz Bay Region

70. This was defined as the region enclosed by 55°E and 85°E, extending from the mainland north to 58°S. This represents an area of approximately 900 x 600 nautical miles (approximately 2 x 10^6 km^2).

(a) Land-based monitoring

71. For Adelie penguins, three monitoring sites are to be selected, including one at Davis, and another possibly at Scullin Monolith. The foraging range is about 100 km from each site.

72. For Antarctic petrel, colonies at Scullen Monolith and the Rauer Islands are being investigated as potential monitoring sites. The foraging range may extend to 300 km.

(b) Ship-based monitoring

(i) Predators

73. As for the Antarctic Peninsula region, two features of crabeater seal biology were identified as suitable for monitoring. Sampling protocols of Condition Index and Demographic Variables are the same as those described in paragraph 50.

(ii) Prey

74. Distribution and abundance of krill need to be monitored over the whole region, with concurrent monitoring of the environment as noted for the Antarctic Peninsula region. Variations in abundance and distribution have to be recorded during the summer period, as well as from year to year. At the regional level, a series of standardised meridional transects (a minimum of 3 for the region) should be followed by intensive surveys in areas of high krill concentration identified during regional surveys. Intensive monitoring of krill abundance and distribution within critical range of land-based predator monitoring sites also needs to be carried out.

75. No specific requirements for monitoring *P. antarcticum* or early life-history stages of fish were formulated.

(iii) Environment

76. As for the South Georgia and the Antarctic Peninsula regions (Paragraph 56).

(iv) Logistics

77. As a first approximation the following estimates of shiptime per year were made:

1. Regional krill surveys and environment

wide-scale	20 shipdays	
intensive	30 shipdays	
2 x summer surveys		100 shipdays

2. Intensive surveys in association with land-based predator monitoring sites

Adelie penguin (3 sites x 10 days)	30 shipdays
Antarctic petrel (2 sites x 10 days)	20 shipdays

3. Crabeater seal monitoring

2 surveys x 15 days	30 shipdays
Total:	180 shipdays

(c) Data requirements from fisheries activities

78. As noted for the Antarctic Peninsula and South Georgia regions (paragraph 58).

(d) Onset of monitoring activities

79. As noted for the Antarctic Peninsula and South Georgia regions (paragraph 59).

PRACTICAL NEEDS FOR THE IMPLEMENTATION OF AN ECOSYSTEM MONITORING PROGRAM

80. The monitoring programs outlined in this report are mainly based upon those species and parameters considered to be most suitable for immediate monitoring. The Working Group emphasised that for a number of species and parameters, as well as for some environmental features, considerable research and development are required before it will be possible to assess whether parameters being considered are the most suitable for monitoring purposes and can in fact be monitored both routinely and practicably. In addition, steps have to be taken to assess whether meaningful data on important system interactions will be obtained.

81. The initial program framework outlined here thus requires selected pilot studies during its initial years in order to determine, as far as possible, the level of sampling precision desired and ultimately the sampling intensity necessary in the future. The Group therefore agreed that in this context directed studies should be carried out on the key elements identified as requiring further research in the Report of the Seattle Meeting.

82. The Working Group noted the overall importance of ensuring standardisation of the methods and procedures to be used in monitoring. In particular, the acquisition and handling of data should be agreed upon at an early stage in the implementation of any future monitoring program framework. Many nations are already carrying out research which is likely to contribute to such a monitoring framework and, as has already been mentioned, there are a lot of baseline data which could be used. Data from these sources will have to be compatible with those collected in the program envisaged in this Report. It was noted that there is an urgent need to reach agreement on the various methodologies to be used so that the implementation of the program can be commenced as soon as practicable.

83. Despite the urgent need for the standardisation of methods to be used, the Working Group acknowledged that there was insufficient time available at the present meeting to discuss this problem adequately. In addition, many of the associated matters of substance are likely to necessitate the input of expert opinion which was unavailable within the Group. The Working Group therefore recommended that practical needs for the timely implementation and phasing of the monitoring program framework discussed at the meeting should be referred to the next meeting of the Group as a major agenda item.

84. Specific topics to be addressed at the next meeting should include:

- data needs, data acquisition and data handling in respect of predator, prey, environment and the fishery;
- standardisation of monitoring methods;
- identification and elaboration of new methods;
- remote sensing;
- theoretical aspects and pilot studies as related to monitoring needs and methodologies;
- scheduling of various program elements.

85. It was noted that various SCAR Groups, especially the Sub-Committee on Bird Biology and the Group of Specialists on Seals, are in a position to provide the necessary expert advice to the Working Group.

86. While noting that the objectives of the monitoring program differ from those of the BIOMASS program, the Group recognised that many of the techniques/methods developed through BIOMASS are directly applicable to the present program. It was agreed that the Working Group should investigate the potential utilisation of these methods, including those for data handling, within the context of the monitoring program.

87. The Working Group noted that having elaborated the framework for a Monitoring Program it was now important to determine the degree to which existing national programs could contribute to such a Monitoring Program and to consider the practical contributions each country might make.

88. In this connection the Group acknowledged the papers tabled as ECO/6, ECO/7, ECO/12, ECO/13. It noted a preliminary announcement inviting cooperation during a forthcoming research cruise of the R.V. *Kaiyo Maru* to the Antarctic Peninsula Region in 1987/88.

89. It was agreed that there would be an advantage in holding the next meeting of the Working Group soon after the CCAMLR/IOC jointly sponsored Scientific Seminar on Ocean

Variability and its Influence on Marine Living Resources Particularly Krill to be held in Paris from 2–6 June 1987. In the meantime it was suggested that some progress might be made by arranging an informal discussion at a suitable time during the forthcoming meeting of SC-CAMLR.

CLOSE OF MEETING

90. The Report was adopted and the meeting concluded at 1700 hours on 7 July 1986.

91. The Convenor thanked the Chairmen of the Sub-Groups and especially the Rapporteur for their efforts, and expressed the Group's appreciation to Dr Sahrhage for hosting the meeting and to the staff of the Institute für Seefischerei for its assistance.

RECOMMENDATIONS TO THE SCIENTIFIC COMMITTEE

1. The Scientific Committee in recognising the importance of the Comprehensive Assessment of Whale Stocks to the Ecosystem Monitoring Program request the IWC to complete the study as a matter of urgency (paragraph 16).

2. The Scientific Committee correspond with the IWC to explore means by which available data relating to parameters associated with the physiological condition and feeding behaviour of minke whales might be analysed (paragraph 17).

3. The Scientific Committee support the IWC proposal for a jointly sponsored Workshop on the Feeding Ecology of Southern Baleen Whales (paragraph 19).

4. The Scientific Committee request the SCAR Group of Specialists on Seals and the Subcommittee on Bird Biology to provide advice on the precise sampling protocols and sample sizes required for the effective monitoring of the identified parameters, including information on the timing of investigations and the minimum time required to establish adequate base-lines (paragraph 24).

5. The Scientific Committee request SCAR to promote and coordinate, as a matter of urgency, the acquisition of data on the diets of predator species outside the breeding season (paragraph 25).

6. The Scientific Committee approve the convening by the Chairman of the Working Group of a Workshop to discuss the development of remote sensing equipment for use in the proposed monitoring program and include the necessary funds in the Scientific Committee budget for 1987 (paragraph 26).

Table 1: Sites selected and suggested for monitoring studies to complement the programs in the three main integrated study regions.

(for the locations of sites see Figure 1)

Species	Sites
Adelie penguin	NW Ross Sea (Cape Hallett and Cape Adare) Pointe Geologie Davis Casey Syowa Shepard Island* Signy Island, South Orkney Islands
Chinstrap penguin	Signy Island, South Orkney Islands South Sandwich Islands* Bouvet Island*
Macaroni penguin	Bouvet Island* Marion Island* Kerguelen Island* Heard Island*
Antarctic fur seal	Bouvet Island*
Crabeater seal	Weddell Sea* Amundsen and Bellingshausen Seas*

Suggested sites

Table 2: Parameters of potential immediate use for monitoring programs (revision of SC-CAMLR-IV/7 Table 3).

Species	Parameters	Sampling Interval*	Time-series required**	Integration time***
Antarctic fur seal	Foraging/attendance cycles	W	Short-medium	D
	Pup growth and weaning weight	Y	Short-medium	M
Crabeater seal	Reproductive rate	P	Long	Y
	Age at sexual maturity	P	Long	Y
	Cohort strength	P	Long	YY
	Body condition	Y	Short-medium	M
Penguins (Adelie, chinstrap, macaroni)	Arrival weight	Y	Medium	MM
	Population size	P	Medium-long	M-Y
	Survival	P	Long	M-Y
	Incubation shift duration	W	Medium-long	D
	Breeding success	Y	Medium-long	M
	Foraging trips	W	Short-medium	D
	Fledging weights	Y	Medium	M
	Adult weight at fledging	Y	Medium	M
	Macaroni weight before moult	Y	Medium	D
Minke whale	Reproductive rate	P	Long	Y
	Age at sexual maturity	P	Long	Y
	Cohort strength	P	Long	YY

* W = within season
Y = year-to-year
P = periodic (3 to 10 years)

** Short = 3 - 5 years
Medium = 5 - 10 years
Long = more than 10 years

*** Integration time = time over which parameter will reflect environmental variability
D = days
M = months
Y = years

Table 3 Directed research programs required to assess the utility of potential monitoring parameters (revision of SC-CAMLR-IV/7 Table 4).

Species	Program	Time-series required**	Integration time***
Antarctic fur seal	Indices of body condition (blood, blubber)	Unknown; prob. medium	MM
	Juvenile tooth size	Medium-long	Y
	Fine structure of teeth	Short-medium	M
Crabeater seal	Collection of material for further analyses of demographic variables	Long	Y
	Instantaneous growth rates	Unknown; prob. Medium	M?
	Juvenile tooth size	Medium-long	Y
	Indices of body condition (blood, blubber)	Unknown; prob. medium	MM
	Feeding areas and behaviour, using satellite technology	Unknown	D-M
Antarctic petrel	Growth rate, fledging success, diet	Short-medium	M
Penguins	Feeding areas, behaviour and frequency, using-satellite technology	Unknown	D-M
	Meal size		
Minke whale	Surveys of abundance using sightings (as by IDCR)	Long	Y
	Diving behaviour	Short-medium	D-M
	Analysis of existing data:		
	- Stomach contents	Short	D-M
	- Blubber thickness	Short-medium	M-Y
	- Density and patchiness	Short-medium	M-Y
	- School size	Short-medium	M-Y

**}
***} - see footnotes to Table 2

Table 4: Recommended minimum effort to detect and monitor possible predator responses to changes in food availability.

Area and Species	Monitoring Parameters	Assessment Requirements	Supplementary Data; Interpretative Requirements
I	II	III	IV
Prydz Bay Region			
Crabeater seal	Body condition (blubber thickness) Age at sexual maturity Age structure and cohort strength Reproductive rates	Develop and validate standard, non-destructive measurement techniques Determine stock discreteness Determine optimal frequency, size and timing of samples	Ice condition; winter and summer distribution; diet; foraging range and behaviour
Adelie penguin	Breeding success[3] Fledging weight Next most desirable: arrival weight; as many other parameters as possible from Table 2	Determine and standardize sampling methods[4]	Ice onditions; summer diet; foraging areas and range Winter distribution; diet; foraging range and foraging behaviour[5]
Antarctic petrel		Determine krill dependence; identify potential monitoring parameters	Snow, depth at wave and ice conditions
Antarctic Peninsula Region			
Crabeater seal	Same as for Prydz Bay region	Collect independent samples from one or more adjacent areas for comparison, and determine stock discreteness	Same as for Prydz Bay region
Adelie penguin[6]	Same as for Prydz Bay region	Same as for Prydz Bay region	Same as for Prydz Bay region
Chinstrp penguin[7]	Same as for Adelie penguin	Same as for Adelie penguin	Same as for Adelie penguin; wave height
Antarctic fur seal	Foraging/attendance cycle Pup growth and weaning weight	Survey to determine if feasible monitoring sites exist	Same as for crabeater seal
South Georgia Region			
Antarctic fur seal	Foraging/attendance cycle Pup growth and weaning weight	Determime optional frequency, size timing of samples	Same as for crabeater seal
Macaroni penguin	Same as for Adelie penguin; adult weight before moult	Seasonal diet; foraging area and behaviour; winter distribution; ice condition	
Black-browed albatross	Reproduction success Duration of foraging trips Population size	Same as for Macaroni penguin	

Table 4 (continued)

Footnotes:

1. The SCAR Group of Specialists on Seals should be asked to consider and provide advice on the optimum sampling protocol.

2. Davis, Mawson and third area yet to be specified.

3. As a minimum, this should be mean number of chicks per pair fledged by successful pairs and proportion of fledged two-chick broods among all fledged broods; otherwise it could be mean number of chicks fledged per breeding pair.

4. The SCAR Subcommittee on Bird Biology should be asked to consider and provide advice on the optimum sampling protocol.

5. Obtaining needed information on winter distribution and movements will probably require development and use of satellite-linked tracking capability.

6. Palmer Station area, King George Is. (at least Admiralty and Maxwell Bays and, if possible, an additional site on the north coast), Elephant Is. and Signy Is.

7. Same sites as for Adelie penguin except Palmer Station area.

Table 5 Methods to be utilised in monitoring rates of changes in abundance in selected prey species. Krill is used as an illustrative example and parameters to be measured should be cross-referenced with the schema illustrated in Figure 2.

Parameters	Scale			Points of Cross Reference With Figure 2
	Macro 100–1000 km	Meso 1–100 km	Micro 1–100 m	
Abundance Absolute Changes in	A N (S) C	A N C	A N P	(ai); (bi); (ci) (bii); (cii); (ciii); (di)
Emigration/Immigration	A N H	A N H		(di)
Aggregation patterns	A N	A N V	A N P	(bii) (cii) (aii)
Demography Sex Size/Age Reproductive/ Development Stage	N B	N B	N B	(aii) (bii) (cii) (dii)

Key :

A - Acoustics
N - Net sampling
(S) - Satellite imagery (future development?)
C - Fisheries catch dependent methods
P - Photography
V - Visual observation of
B - Biochemical/genetic traces
H - Hydrographic measurements

Table 6: Environmental Data Requirements

Feature	Scale		Outline of Proposed Methods	Status	Comments
	Spatial	Temporal			
1. WATER					
1.a. Water Movements	Macro & Meso Within Season	Year to Year	1. Hydrographic grid of stations leading to determination of currents 2. Direct measurement of currents 3. Satellite imagery (position of fronts etc)	M	Affects prey flux in region. Location of frontal systems and water bodies affects prey distribution
1.b. Physical/Chemical Properties	Meso & Micro	Year to Year Within Season	1. Nutrient estimation e.g. Silicate, Phosphate, Nitrate 2. Temperature, Salinity leading density estimation	R	Affects ability of prey to live and survive in the region
1.c. Biological Properties	Meso & Micro	Year to Year Within Season	1. Determination of primary and Secondary production	R	Affects ability of prey to live and survive in the region
2. ICE					
2.a. Sea Ice Movement and Characteristics: Ice Edge Position % Cover Ice Type&Thickness Floe Size Snow Cover	Macro & Meso	Year to Year Within Season	1. Satellite observation 2. Field observation	M	Affects primary production, vulnerability of krill to natural predators and fishing mortality. Accessibility of krill to predators, size of sampling area and ability to sample. Affects vulnerability of krill predators to higher order predators
2.b. Ice Shelf Extent	Meso & Micro	Year to Year	1. Satellite observations 2. Field observations	U	Affects spawning grounds

Table 6 (continued)

Feature	Scale		Outline of Proposed Methods	Status	Comments
	Spatial	Temporal			
3. WEATHER & CLIMATE					
3.a. Wind and/or Wave Height	Meso & Micro	Within Season	1. Field Observations 2. Satellite tracked buoys 3. Satellite observations	M&D	Surface turbulance affects primary production and thus indirectly krill production. Also affects predator energy requirements and commercial fishing success
3.b. Atomspheric Circulation	Macro & Meso	Year to Year	1. Analysis of weather maps	M	Cyclones affect water movement and thus krill distribution
3.c. Air Temperature at Land Stations	Macro & Meso	Year to Year	1. Field observations	M	Mean air temperature gives indication of trends in mesoscale and macroscale environments

Key to Status Indicators: M - Suitable to monitor now
R - Topic currently under research that my ultimately provide a parameter suitable for monitoring
D - New techniques need to be developed to enable research leading to monitoring
V - Relatively unimportant in the context of this Group's studies

Table 7: Sites within regions at which land based monitoring of predators should be undertaken. Important parameters to be monitored (or already monitored) and the critical period when monitoring activities should take place are indicated.

Site	Species	Parameter to be Monitored	Critical Period	Areal Priority for Prey Monitoring
I	II	III	IV	V
		Antarctic Peninsular Region		
Palmer Station	Adelie penguin	Breeding success Fledging weight	Nov-Jan Jan	3
Admiralty and Maxwell Bays	Adelie penguin	Breeding success Fledging weight	Oct-Jan Jan	1
	Chinstrap penguin	Breeding success Fledging weight	Nov-Feb Feb	
King George Is.	Adelie penguin (North coast)	Breeding success Fledging weight	Oct-Jan Jan	1
	Chinstrap penguin (precise site to be selected)	Breeding success Fledging weight	Nov-Feb Feb	
	Fur seal	Foraging/Attendance cycle Pup growth/Weaning weight	Jan-March March	
Elephant Is.	Adelie penguin	Breeding success Fledging weight	Oct-Jan Jan	2
	Chinstrap penguin (site to be selected)		Nov-Feb Feb	
		South Georgia Region		
Bird Is.	Fur seal	Foraging/Attendance cycle	Dec-March (Dec-Jan)	1
		Pup Growth/Weaning weight	Jan-March (March)	
	Macaroni penguin	Breeding success Fledging weight	Dec-Feb Feb	1
	Black-browed albatross	Breeding success Foraging trip duration Population size	Oct-April Jan-April Oct	1
		Prydz Bay Region		
Davis and 2 others	Adelie penguin	Breeding success Fledging weight	Oct-Jan Jan.	1 (at Davis)
	Antarctic petrel	Breeding success Fledging weight	Oct-Jan Jan	(1 or 2)

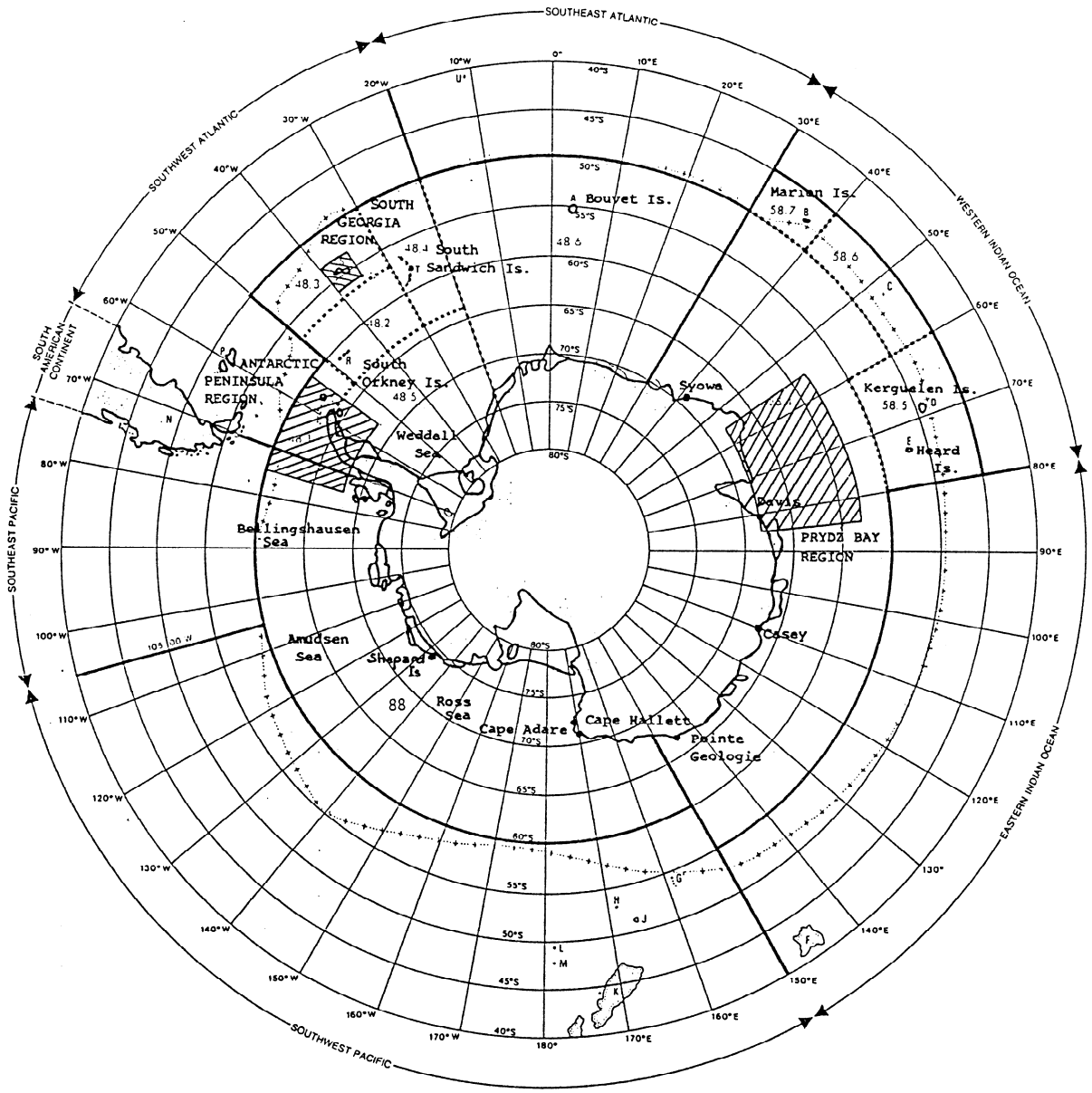

Figure 1: Location of the major study regions and the sites listen in Table 1.

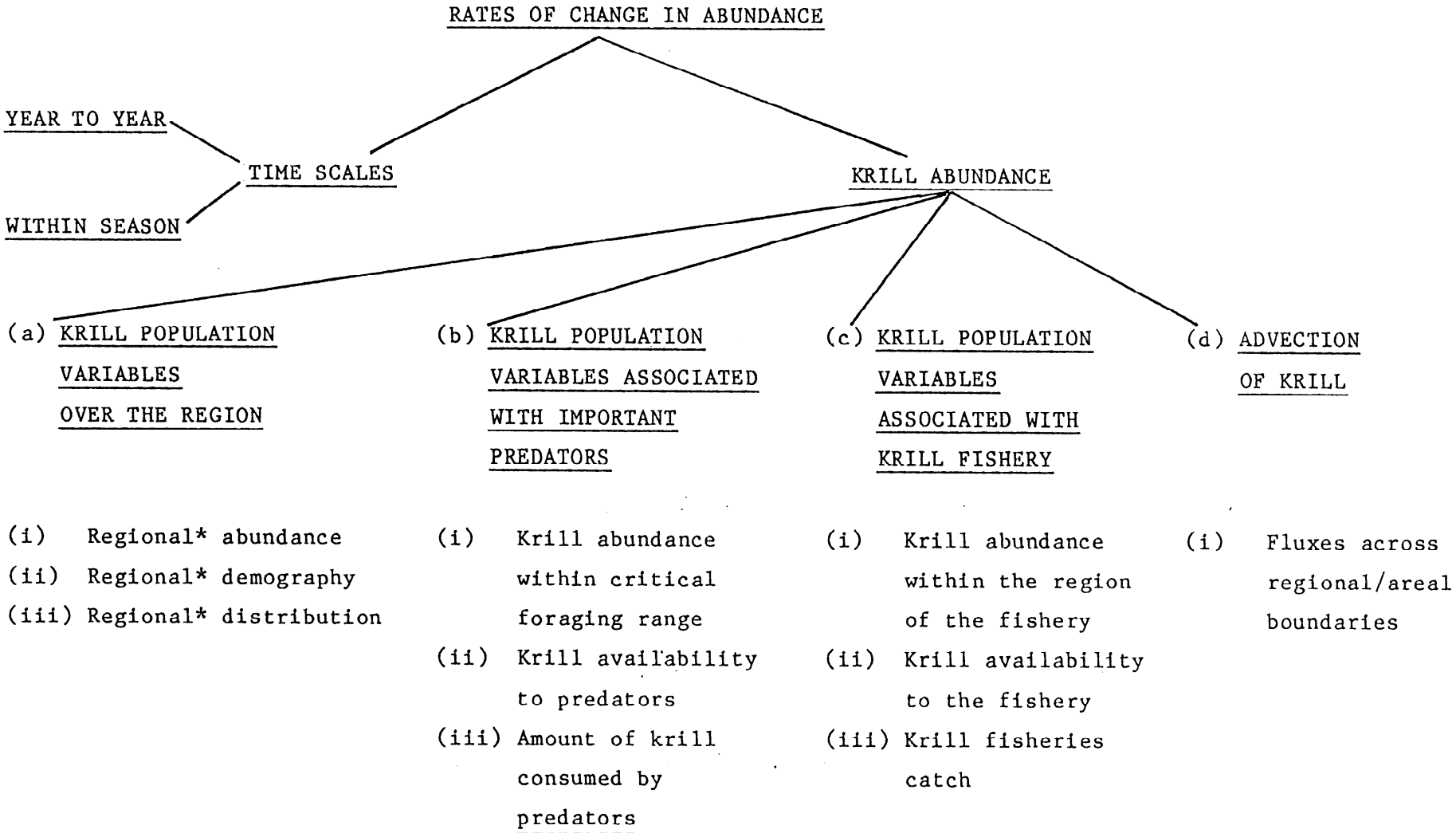

Figure 2: Schematic representation of parameters to be monitored with respect to assessing rates of change in abundance of selected prey species. Krill is used as an illustrative example.

* 'Regional' refers to the areas identified for monitoring in paragraph 12.

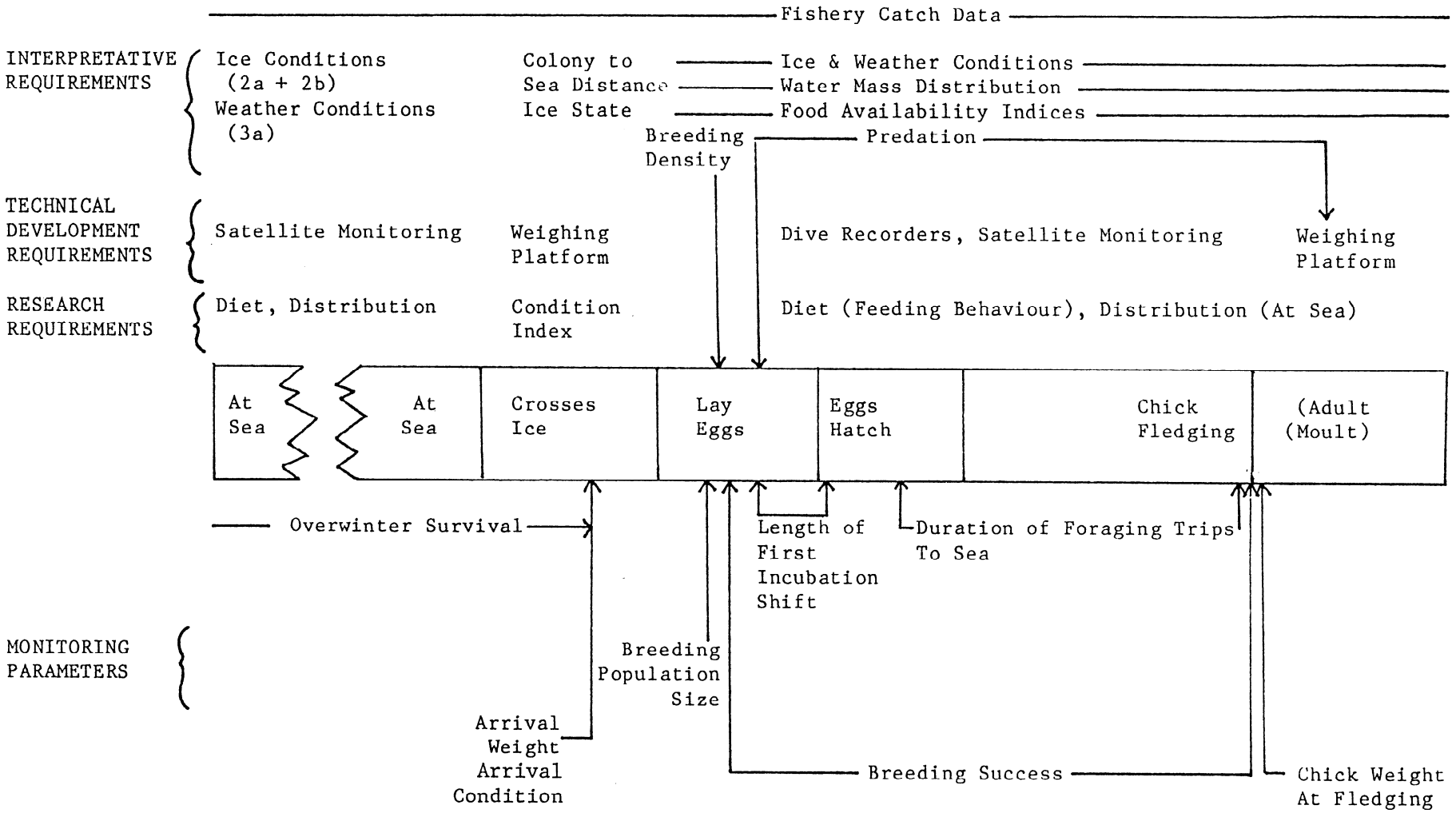

Figure 3: Operational requirements of a monitoring program for Adelie and chinstrap penguins.

APPENDIX 1
CCAMLR/86/ECO/9

WORKING GROUP FOR THE CCAMLR ECOSYSTEM MONITORING PROGRAM

(FRG, Hamburg, 2–7 July, 1986)

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APPENDIX 2
CCAMLR/86/ECO/8

WORKING GROUP FOR THE CCAMLR ECOSYSTEM MONITORING PROGRAM
(FRG, Hamburg, 2–7 July, 1986)

AGENDA

1. Opening remarks

2. Adoption of Agenda

3. Monitoring of Indicator Species

   - parameters to be monitored
   - establishment of baselines
   - theoretical studies

4. Monitoring of Prey Species

   - parameters to be monitored and their variability
   - establishment of baselines
   - theoretical studies

5. Quantitative Relationships between Changes in Parameters of Indicator Species, Their Prey and the Physical Environment

   - theoretical aspects with regard to predator-prey linkage status
   - case history studies with regard to predator-prey relationships
   - other

6. Priority Areas Within Which Monitoring Should Be Conducted

7. Review of Current National Programs in Relation to Monitoring

8. Review of CCAMLR Ecosystem Monitoring Needs

9. Framework of the Development of an International Monitoring Program: Contributions Your Country May Make

10. Practical Needs for the Implementation of an Ecosystem Monitoring Program

- data
- standardisation of methods
- remote sensing
- theoretical studies
- other (requirements for the obligatory collection of data)

11. Implementation and Coordination of Ecosystem Monitoring and Associated Research Activities.

12. Adoption of the Report

APPENDIX 3
SC-CAMLR/86/ECO/10

WORKING GROUP FOR THE CCAMLR ECOSYSTEM MONITORING PROGRAM
(FRG, Hamburg, 2-7 July, 1986)

LIST OF DOCUMENTS

1.	Draft Agenda	SC-CAMLR/86/ECO/1
2.	Members' Comments on Draft Agenda	SC-CAMLR/86/ECO/2
3.	Adopted Agenda	SC-CAMLR/86/ECO/8
4.	List of Participants	SC-CAMLR/86/ECO/9
5.	List of Documents	SC-CAMLR/86/ECO/10
6.	Report of the Fourth Meeting of the Scientific Committee (Item 7: Ecosystem Monitoring and Management)	SC-CAMLR/86/ECO/3
7.	Response of the IWC Scientific Committee to the Questions of the CCAMLR Scientific Committee on Ecosystem Monitoring	SC-CAMLR/86/ECO/4
8.	Krill Sampling and the CCAMLR Ecosystem Monitoring Program (D. Miller, SA)	SC-CAMLR/86/ECO/5
9.	A Preliminary Program of Japanese Activities on Ecosystem Monitoring (Y. Shimadzu, T. Hoshiai, Japan)	SC-CAMLR/86/ECO/6
10.	The Soviet Proposals on the Program of the Ecosystem Monitoring of the Commonwealth Sea and Prydz Bay. (T. Lubimova, USSR)	SC-CAMLR/86/ECO/7
11.	Members' Research Activities in 1984/1985 and 1985/1986 Seasons Related to Ecosystem Monitoring	SC-CAMLR/86/ECO/11

12.	International CCAMLR Applied Research and Monitoring Program. Prydz Bay Priority Area (Australian contribution to the First Five Year Program)	SC-CAMLR/86/ECO/12
13.	Directed Research. Antarctic Marine Living Resources (AMLR). A Program Development Plan (USA)	SC-CAMLR/86/13
14.	Establishment of a Group of Specialists on Southern Ocean Ecology (Annex 3 to the XIX SCAR Report)	SC-CAMLR/86/14
15.	CCAMLR Ecosystem Monitoring Early Life Stages of Fish (Comments on the Agenda Item 5 of the 1986 Meeting). W. Slosarczyk (Poland)	SC-CAMLR/86/15

RELATED PAPERS

1.	Report of the Meeting of the *Ad Hoc* Working Group on Ecosystem Monitoring	SC-CAMLR-IV/7
2.	Comments on the Report of the *Ad Hoc* Working Group on Ecosystem Monitoring (Submitted by the Delegation of the USSR)	SC-CAMLR-IV/13
3.	Report of the Subcommittee on Bird Ecology (SCAR Working Group on Biology) (USA, San Diego, 9–10 June, 1986)	
4.	Report of the Meeting of the SCAR Group of Specialists on Seals SCAR XIX, San Diego, California, USA, 11–13 June, 1986	

5. Attempts at a Quantificative Estimate by Trawl Sampling of Distribution and Juvenile Notothenioids (Pisces, Perciformes) in Relation to Environmental Conditions in the Antarctic Peninsula Region during SIBEX 1983–84
(Mem. Nat. Inst. Polar. Res., Spec. issue, 40, 299–315, 1986).