COMMISSION FOR THE CONSERVATION OF ANTARCTIC MARINE LIVING RESOURCES
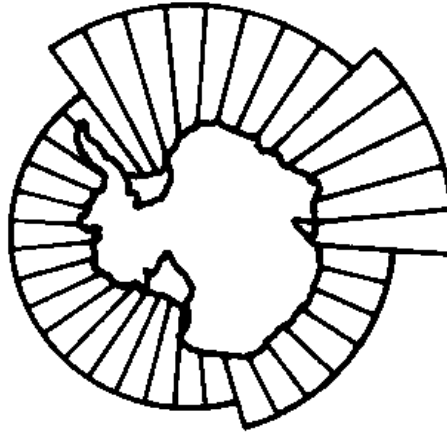
CCAMLR ECOSYSTEM MONITORING PROGRAM

STANDARD METHODS

CONTENTS

PART I:
STANDARD METHODS FOR MONITORING
PARAMETERS OF PREDATOR SPECIES

Section 1: Penguins

Section 2: Flying Birds

Section 3: Seals

Section 4: Monitoring Non Krill-dependent Species

PART II:
STANDARD METHODS FOR MONITORING
ENVIRONMENTAL PARAMETERS

PART III:
CEMP DATA REPORTING AND PROCESSING

PART IV:
OBSERVATION PROTOCOLS AND TECHNIQUES

INTRODUCTION

It was realised at the establishment of CCAMLR that in order to regulate harvesting of Antarctic living marine resources in accordance with the 'ecosystem approach' embodied in Article II, the effect of such harvesting on dependent species would have to be monitored. The animals primarily indicated by the phrase 'dependent species' in this context are those which are predators on the commercially harvested species (currently krill and fish), such as birds and seals.

CCAMLR started planning its CCAMLR Ecosystem Monitoring Program (CEMP) in 1984, with the following aims:

(i)   to detect and record significant changes in critical components of the ecosystem, to serve as a basis for the conservation of Antarctic marine living resources; and

(ii)   to distinguish between changes due to harvesting of commercial species and changes due to environmental variability, both physical and biological.

The Working Group on Ecosystem Monitoring and Management (WG-EMM), like its predecessor the Working Group on CEMP (WG-CEMP), is responsible for the design and coordination of the monitoring program and the analysis and interpretation of the data arising from it. The program's largest component is the monitoring of dependent species (predators), but in order to distinguish between changes due to harvesting and those due to environmental variability, the program also monitors harvested species, harvesting strategies and environmental parameters.

The program does not attempt to monitor all dependent species within the Antarctic ecosystem, but concentrates on a few which are likely to respond to changes in the availability of harvested species (these dependent species are sometimes termed 'indicator species'). They must be specialist predators on the prey items identified, have a wide geographical distribution and be important ecosystem components. The current list (Table 1) contains the crabeater and Antarctic fur seals, Adélie, chinstrap, gentoo and macaroni penguins, Antarctic and Cape petrels and black-browed albatross.

Two sets of sites were chosen for the monitoring program: a core set of sites within three defined integrated Study Regions (ISRs – regions for the intensive study of predators, prey and environmental interactions), and a network of additional sites which complement the research within these regions (Tables 2 and 3 and Maps 1 to 3). Within the ISRs sites may be adjacent to harvesting areas or isolated from them, contributing to a controlled experimental design.

Several parameters are monitored for each dependent species. The scales over which these parameters are expected to integrate changes in the status of the ecosystem varies from days–weeks in the vicinity of monitoring sites (e.g. breeding success, offspring growth rates) or region wide (e.g. weight of birds arriving to breed, adult survival).

Field work and data acquisition for the program are carried out voluntarily by CCAMLR Member States. The data they collect are submitted to the CCAMLR Secretariat which carries out specified standard analyses for consideration by WG-EMM. The Secretariat also collects and archives data used by the program which are acquired from other national and international environmental monitoring programs, for example, satellite-derived sea-ice and sea-surface temperature data.

Since the establishment of CEMP standard methods in 1987, CCAMLR has collected data from over 50 combinations of site, species and parameter. At least eight Members are currently involved in acquiring data. For some series, data are available from the late 1950s, but most data series start in the mid-1980s when CEMP was initiated.

WG-EMM carries out an analysis of these data to arrive at an annual ecosystem assessment. Trends and anomalous years in the monitored parameters of dependent (predator) species are identified for each species and site. Explanations for these phenomena are sought from examination of the monitored parameters of harvested species and the environment, so that changes due to natural environmental variation may be distinguished from those due to the effects of harvesting.

The methods described in this publication have been defined by CCAMLR expressly for use in CEMP. They include notes on data collection methods and instructions for data analysis which will yield standardised data series able to be compared between sites and species.

In August 1997, a new edition of the *CEMP Standard Methods* was produced following substantial revision of most methods and adoption of a number of new standard methods. It also included observation protocols and techniques, as well as a set of reference materials.

The manual is published in ring-binder format. The contents are divided, according to subject matter, into six parts which are further divided into sections. Revisions are issued periodically in the form of replacement or additional pages and will be accompanied by instructions for their insertion into the binder. All revisions should be inserted on receipt in accordance with the instructions in order to keep the manual up to date.

Table 1:   List of species.

Species Code	Species Name	English Name	French Name	Spanish Name	Russian Name
PYD	*Pygoscelis adeliae*	Adélie penguin	Manchot Adélie	Pingüino adelia	
PYN	*Pygoscelis antarctica*	Chinstrap penguin	Manchot à jugulaire	Pingüino de barbijo	
PYP	*Pygoscelis papua*	Gentoo penguin	Manchot papou	Pingüino papúa	
EUC	*Eudyptes chrysolophus*	Macaroni penguin	Gorfou macaroni	Pingüino macaroni	
SEA	*Arctocephalus gazella*	Antarctic fur seal	Otarie de Kerguelen	Lobo fino antártico	
SET	*Lobodon carcinophagus*	Crabeater seal	Phoque crabier	Foca cangrejera	
DIM	*Diomedea melanophrys*	Black-browed albatross	Albatros à sourcils noirs	Albatros de ceja negra	
TAA	*Thalassoica antarctica*	Antarctic petrel	Pétrel antarctique	Petrel antártico	
DAC	*Daption capense*	Cape petrel	Pétrel du Cap	Damero del cabo	

Table 2:   Sites within the Integrated Study Regions at which monitoring of predators has been or should be initiated now.

Site	Species	Critical Period
1. ANTARCTIC PENINSULA REGION		
Anvers Island (Palmer Archipelago)		
(south coast)	Adélie penguin	November–January
Livingston Island (S. Shetland Is)		
(north coast)	Chinstrap penguin	November–February
	Gentoo penguin	November–February
	Antarctic fur seal	December–March
King George Island (S. Shetland Is)		
(north ? and south coasts)	Adélie penguin	October–January
(north and south coasts)	Chinstrap penguin	November–February
	Gentoo penguin	November–February
(north coast)	Antarctic fur seal	December–March
Elephant Island (S. Shetland Is)		
(west coast)	Chinstrap penguin	November–February
	Gentoo penguin	November–February
	Macaroni penguin	December–February
	Cape petrel	December–February
Seal Island (S. Shetland Is)	Chinstrap penguin	November–February
	Macaroni penguin	December–February
	Antarctic fur seal	December–March
	Cape petrel	December–February
Sea-ice areas	Crabeater seal*	January–December
2. SOUTH GEORGIA REGION		
Bird Island	Fur seal	December–March
	Macaroni penguin	December–February
	Gentoo penguin	October–February
	Black–browed albatross	October–April
3. PRYDZ BAY REGION		
Mac. Robertson Land	Adélie penguin	October–January
	Antarctic petrel	November–February
Sea-ice areas	Crabeater seal*	January–December

   * Species for which standard methods have not yet been developed.

Table 3:   Network sites selected or suggested for monitoring studies to complement the programs in the three main Integrated Study Regions.

Species	Sites
Adélie penguin	Northwestern Ross Sea (Cape Hallett and Cape Adare)
	Budd Coast*
	Edmonson Point ?
	Ross Island ?
	Ongul Islands (near Syowa Station)
	Shepard Island*
	Signy Island, South Orkney Islands
	Laurie Island, South Orkney Islands
Chinstrap penguin	Signy Island, South Orkney Islands
	South Sandwich Islands*
	Bouvet Island
Gentoo penguin	Signy Island, South Orkney Islands
	Marion Island
Macaroni penguin	Bouvet Island
	Kerguelen Island*
	Marion Island
Antarctic petrel	Svarthamaren (Queen Maud Land)*
Cape petrel	Signy Island, South Orkney Islands
	Bouvet Island
	Rauer Islands (near Davis Station)
	Elephant Island (South Shetland Islands)
Antarctic fur seal	Bouvet Island
	Kerguelen Island
Crabeater seal	Weddell Sea*
	Amundsen and Bellingshausen Seas*

* Suggested sites
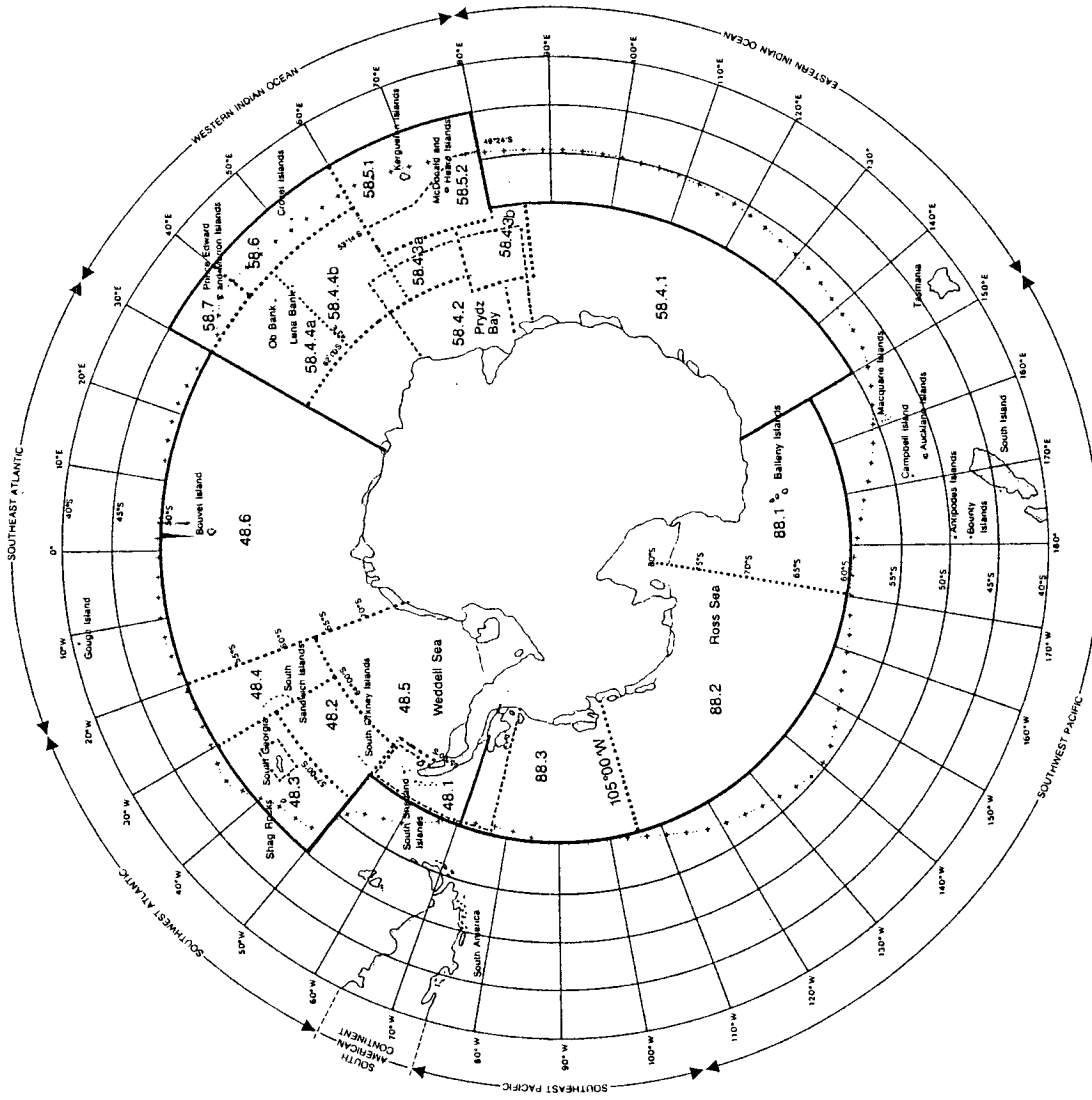
Map 1: Boundaries of the reporting areas in the CCAMLR Convention Area.
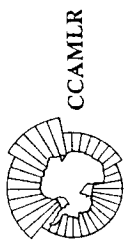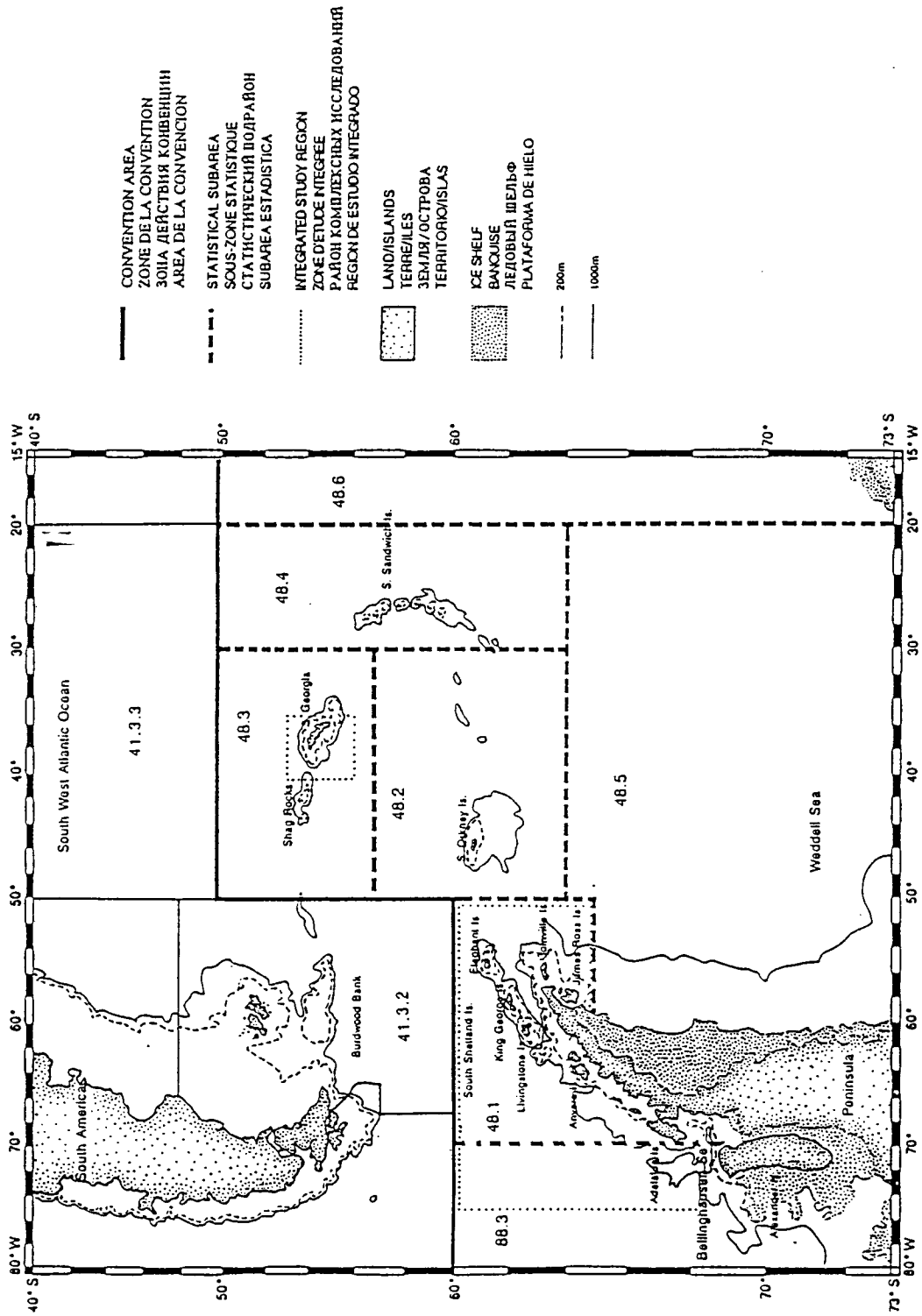
Map 2: Southwestern Atlantic sector.
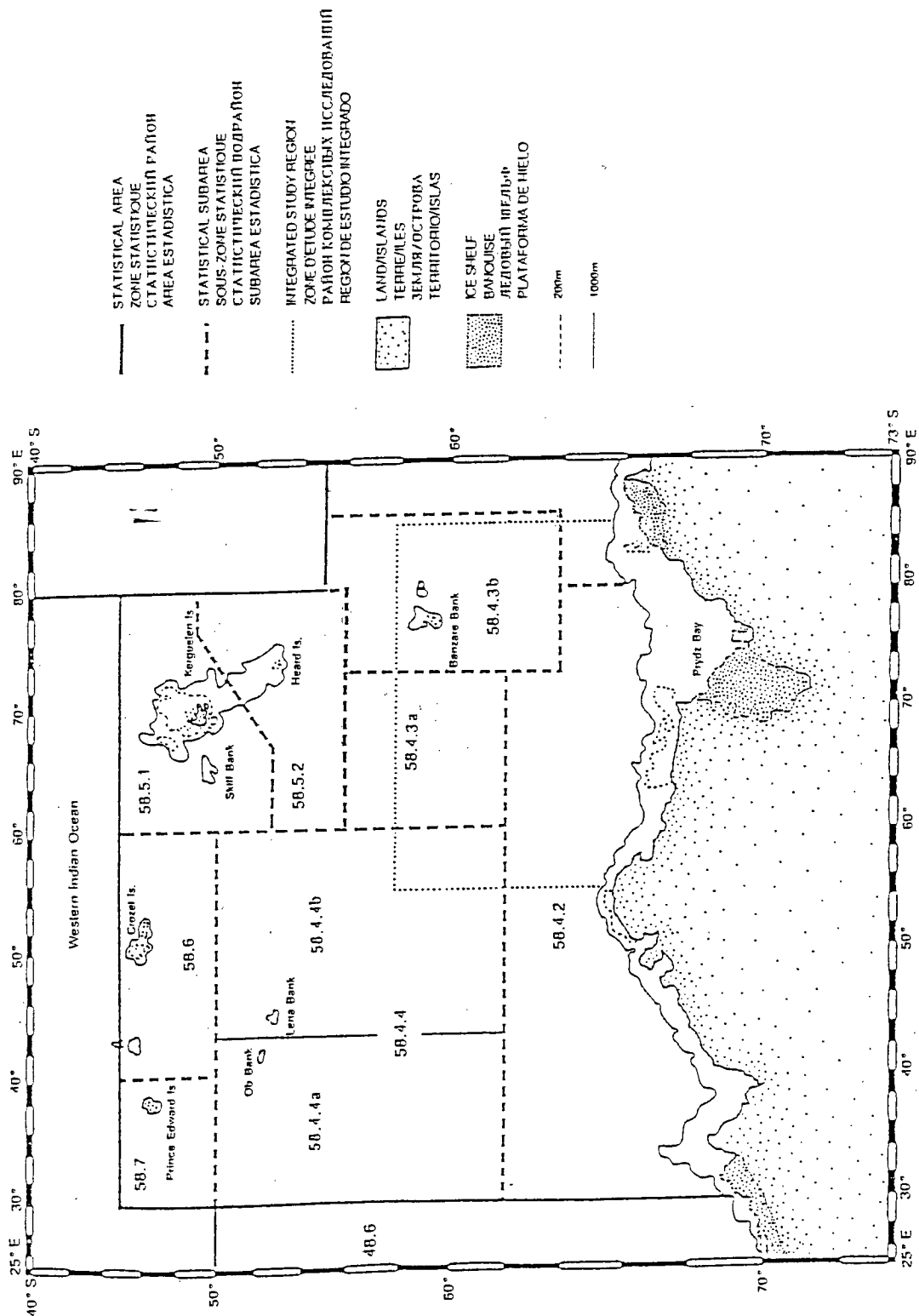
Map 3: Western Indian Ocean sector.

PART I

**STANDARD METHODS FOR MONITORING
PARAMETERS OF PREDATOR SPECIES**

SECTION 1

PENGUINS: METHODS A1 – A9

SPECIES: Penguins: Adélie, chinstrap, macaroni
(*Pygoscelis adeliae*, *Pygoscelis antarctica*, *Eudyptes chrysolophus*)

PARAMETERS: Adult weight on arrival at breeding colony

ASSOCIATED PARAMETERS:

Over-winter survival; length of the first incubation shift; size of breeding population; breeding success; adult weight at chick fledging; chick weight at fledging; adult weight before moult (macaroni penguin only).

AIMS:

To determine the mean weight of breeding birds of both sexes at first return to the colony.

DATA COLLECTION:

GENERAL PROCEDURE:

Procedure A:

Procedure A requires sampling throughout the arrival period. This attempts to allow for biases in arrival date and weight due to age and/or experience, particularly for Adélie and chinstrap penguins where there is considerable overlap in the arrival dates of the two sexes:

1. Capture a random sample of adult birds on the beach as they leave the sea- or pack-ice; do not capture those already occupying territories in the colony.

2. Weigh each bird to the nearest 10 to 50 g (depending on conditions and accuracy of scale used). Specify the type and accuracy of scales used. Test the scales against a known weight at periodic intervals.

3. Determine the sex of birds by measuring bill length and depth and applying appropriate discriminant function analyses (see Part IV, Section 1).

4. Starting with the first available complete five-day period after adults are first observed in the colony, record the weight of at least 75 unsexed birds or 25 birds of each sex from a random sample of at least 50 birds in each of at least two and up to four consecutive five-day periods (or until the counts from the chronology colony (Method A9) indicate that most breeding adults have arrived).

Procedure B:

Procedure B involves sampling each sex on a single day near the peak of the arrival influx. This method is likely to be mainly appropriate for macaroni penguins where there is little overlap in the arrival dates of each sex:

CCAMLR Standard Method A1 (v3)

1. Steps 1 to 3 for Procedure A also apply to Procedure B.

2. Around the time of peak rate arrival for each sex, as determined by regular direct observation of the study colony, record the weight of 100 birds of each sex on one day each.

MANDATORY DATA:

Procedure A:

1. Individual weights of birds in each five-day period.
2. Sex of each bird which has its sex estimated.
3. The bill length and depth of each bird that has its sex estimated.
4. Dates upon which birds were weighed.
5. Type and accuracy of scales used.

Procedure B:

1. Individual weights of birds of known sex.
2. Sex of each bird.
3. Dates upon which birds were weighed.
4. Type and accuracy of scales used.

HIGHLY DESIRABLE DATA:

Procedure A:

Determine the sex of all birds.

Procedure B:

Arrival data from chronology study (Method A9).

Procedures A and B:

Records of any anomalous and/or extreme environmental conditions observed during the study (e.g. snow and ice cover, wind and temperature).

PROBLEMS TO BE CONSIDERED:

COMMENTS:

Automatic data loggers capable of recording most of the data required for this parameter would be helpful. Equipment (camera) to record species, date and weight of each individual would considerably reduce the manual input to data collection and increase the accuracy of data.

DATA PROCESSING AND ANALYSIS:

ANALYTICAL METHODS:

1. Data on males and females should be analysed separately.

2. Mean arrival weight, standard deviation and range should be calculated for each five-day period. If Procedure B is used these values will only be available for one date, and should be checked against the results of the chronology study (Method A9).

3. With Procedure A the percentage of animals arriving in the five-day periods must also be calculated. For 'total population' and 'unsexed population' the correct percentages are those for the numbers of adults arriving in the colony during the five-day period, a figure easily obtained from the chronology study (Method A9) if this is being undertaken. Without a chronology study these percentages should be estimated.

4. Calculation of correct percentages for males and females involves the following for each five-day period:

    (a) multiply the total number of adults arriving in the five-day period (from Method A9, or estimated from another source) by the proportion of males or females observed in the random sample taken for penguin arrival weight; and

    (b) from the resultant numbers of males and females arriving during the five-day period and the totals over all periods calculate percentages arriving during the period.

5. The results should be first analysed for seasonal variation and interseasonal variation using (weighted) nested analysis of variance or similar methods. Depending on the results of these analyses, a useful annual index could be the weighted mean arrival weights over a particular period in the season.

INTERPRETATION OF RESULTS:

The mean timing of arrival and weight at arrival after the winter period at sea may provide an index of general condition (fat reserves) and reflect the availability and quality of food through the early spring. Weight on arrival may be affected by the following:

1. Food availability, quality and access.
2. Individual variation – age, social status, health and fitness of each bird.
3. Distance between open water and colony.

PROBLEMS TO BE CONSIDERED:

COMMENTS:

Research to determine the relative values of Procedures A and B for the three species is required.

DATA REPORTING:

Data should be reported using the latest version of CCAMLR data submission form E/A1 (see Part III, Section 1). Data from different areas, species, sexes and procedures (A or B) should be reported on separate forms.

DATES OF OBSERVATION:

Reported mean dates and ranges of first arrival at nominated breeding areas:

	Adélie	Chinstrap	Macaroni	Refs
Prydz Bay	12 Oct (4–17 Oct)	NA	NA	1
South Orkneys	2 Oct (21 Sept–8 Oct)	31 Oct (16 Oct–12 Nov)	X	2
South Georgia	NA	X	17 Oct (14–23 Oct)	4
South Shetlands	20 Oct	2 Nov	X	3

X   data not available
NA   not applicable, species absent in specified area

REFERENCES:

(1)   Johnstone G.W., D.J. Lugg and D.A. Brown.   1973.   The biology of the Vestfold Hills, Antarctica. *ANARE Sci. Rep. Ser. B*, 1.

(2)   Lishman, G.S.   1985.   The comparative breeding biology of Adélie and chinstrap penguins, *Pygoscelis adeliae* and *P. antarctica*, at Signy Island, South Orkney Islands. *Ibis*, 127: 84–99.

(3)   Trivelpiece, W.Z. and N.J. Volkman. 1979.   Nest site competition between Adélie and chinstrap penguins: an ecological interpretation. *Auk*, 96: 675–681.

(4)   Williams, T.D. and J.P. Croxall. 1991. Annual variation in breeding biology of the macaroni penguins, *Eudyptes chrysolophus,* at Bird Island, South Georgia. *J. Zool. Lond*., 223: 189–202.

BACKGROUND PAPERS:

Ainley, D.G. and W.B. Emison. 1972. Sexual size dimorphism in Adélie penguins. *Ibis,* 114: 267–271.

Ainley, D.G., R.E. Leresche and W.J.L. Sladen.   1983.   *Breeding Biology of the Adélie Penguin.* University of California Press.

Croxall, J.P. 1984. Seabirds. In: Laws, R.M. (Ed.). *Antarctic Ecology*, 2. Academic Press: 533–619.

Croxall, J.P. and P.A. Prince.   1980.   Food, feeding ecology and ecological segregation of seabirds at South Georgia. *Biol. J. Linn. Soc.*, 14: 103–131.

BIOMASS. 1983. Meeting of BIOMASS Working Party on Bird Ecology. *BIOMASS Report*, 34.

SC-CAMLR. 1985. Report of the Ad Hoc Working Group on Ecosystem Monitoring. In: *Report of the Fourth Meeting of the Scientific Committee (SC-CAMLR-IV)*, Annex 7. CCAMLR, Hobart, Australia: 81–137.

SPECIES: Penguins: Adélie, chinstrap
(*Pygoscelis adeliae*, *Pygoscelis antarctica*)

PARAMETERS: Duration of the first incubation shift

ASSOCIATED PARAMETERS:

Weight on arrival at breeding colony; breeding success; adult weight at chick fledging; adult weight before moult (macaroni penguin only).

AIMS:

To measure the mean duration of the first incubation shift for each member of the pair.

DATA COLLECTION:

GENERAL PROCEDURE:

1. Select 100 pairs prior to the beginning of the egg-laying period. Note: these can be the same birds as used to determine breeding success by Procedure B.

2. Band or mark (with dye) both pair members, capturing (marking) them close to egg laying to minimise the possibility of the birds deserting.

3. Check nests daily, note dates of relief. When both birds are present at the nest during a nest check, each receives a half-day credit for that day.

4. Continue monitoring nests daily until the chicks hatch <u>and</u> both members of the pair are seen, indicating they are both still alive.

MANDATORY DATA:

1. Date when the first mate to incubate the eggs is first observed incubating eggs alone at nest and is first marked with dye.

2. Date when the second mate to incubate the eggs is first seen incubating eggs after returning from its first post-laying trip to sea.

3. Date when the first mate to incubate the eggs is again seen incubating eggs after returning from its first post-laying trip to sea.

4. Date and cause of nest failure (non-return of mate or other cause – specify).

HIGHLY DESIRABLE DATA:

1. If an incubating bird is not relieved, continue the daily observation of the nest and record the date of nest desertion.

2. When one of the pair returns from the sea but does not immediately relieve its mate and start incubating, the presence of this individual at the nest site should be noted.

3. Records of any anomalous and/or extreme environmental conditions observed during the study (e.g. snow and ice cover, wind and temperature).

PROBLEMS TO BE CONSIDERED:

1. Disturbance by visits can induce desertion of the nest. Do not handle any of the birds (e.g. do not lift birds off the nest to check for eggs).

2. For Adélies and chinstraps, the male normally takes the first incubation shift. However, a small percentage of females will incubate the egg first, usually for only a few days ('reverse role' incubation) (Ref. 1). The sample size, however, should be sufficient to identify the 'outlying' data points resulting from these nests.

3. It is sometimes difficult to identify which member of the pair is occupying the nest at the beginning of the first incubation shift. Care should be taken to check the nest one to two days after the sitting bird has been marked with dye. A clean-breasted bird at this stage would mean that the female has been marked rather than the male. Special care should then be taken in recording the dates of subsequent changes in incubation.

COMMENTS:

DATA PROCESSING AND ANALYSIS:

ANALYTICAL METHODS:

1. For analysis purposes, use only pairs which laid two eggs and successfully hatched both chicks (note: this will minimise differences in age/experience among the sample nests between years).

2. For each nest, day 0 equals the date of clutch completion.

3. Calculate the duration of the first incubation shift for males and females.

4. Calculate total number of days spent by males and females on the nest throughout the incubation period.

5. Determine the total number of reliefs at the nest during the incubation period.

6. Note the dates and causes of nest failures.

INTERPRETATION OF RESULTS:

1. The duration of the first incubation shift indicates the quality and accessibility of food during the pre-laying period and to the bird taking second shift. It is influenced by breeding experience of the birds incubating and the fat reserves of the individuals.

2.   Analysis of incubation shift durations within and among sites indicates that incubation shifts at specific sites are fairly constant year-to-year while significant differences exist between different sites (Ref. 3).   Adélie penguins may be returning to areas of known productivity during their first long incubation shifts (Ref. 4), hence the fairly consistent, year-to-year, duration of shifts at each site.   Differences between sites may reflect differences in travel time needed to reach productive areas in the early spring from different breeding locations.

PROBLEMS TO BE CONSIDERED:

COMMENTS:

DATA REPORTING:

Data should be reported using the latest version of CCAMLR data submission form E/A2 (see Part III, Section 1).   Data for different colonies and species should be reported on separate forms.

DATES OF OBSERVATION:

Duration of first and second incubation shifts (mean ± standard error, range) and sex of incubating bird:

	Incubation Shift	Adélie	Chinstrap	Refs
Prydz Bay	First Second	X X	NA NA	
South Orkneys	First Second	M: 13.7 ± 0.2 (9–18) F: 12.7 ± 0.2 (8–18)	F: 6.0 ± 0.2 (1–14) M: 9. 8 ± 0.3 (5–18)	2

M   male
F   female
X   data not available
NA   not applicable, species absent in specified area

REFERENCES:

(1) Ainley, D.G., R.E. Leresche and W.J.L. Sladen. 1983. *Breeding Biology of the Adélie Penguin.* University of California Press.

(2) Lishman, G.S. 1985. The comparative breeding biology of Adélie and chinstrap penguins, *Pygoscelis adeliae* and *P. antarctica*, at Signy Island, South Orkney Islands. *Ibis*, 127: 84–99.

(3) Trivelpiece, W.Z. In prep. The significance of variations in the incubation shifts of Adélie penguin populations.

(4) Trivelpiece, W.Z. and W.R. Fraser. 1996. The breeding biology and distribution of Adélie penguins: adaptations to environmental variability. In: Ross, R., E. Hofmann and L. Quetin (Eds). *Foundations for Ecological Research West of the Antarctic Peninsula.* American Geophysical Union, *Antarctic Research Series*, 70: 273–285.

BACKGROUND PAPERS:

BIOMASS. 1983. Meeting of BIOMASS Working Party on Bird Ecology. *BIOMASS Report*, 34.

BIOMASS. 1982. Penguin census methods. *BIOMASS Handbook*, 20.

Croxall, J.P. 1984. Seabirds. In: Laws, R.M. (Ed.). *Antarctic Ecology*, 2. Academic Press: 533–619.

Davis, L.S. 1988. Coordination of incubation routines and mate choice in Adélie penguins, *Pygoscelis adeliae. Auk*, 105: 428–482.

Sladen, W.J.L. 1978. Sexing penguins by cloacascope. *International Zoo Yearbook*, 18: 77–80.

Taylor, R.H. 1962. The Adélie penguin at Cape Royds. *Ibis*, 104: 176–204.

Trivelpiece, W.Z., S.G. Trivelpiece and N.J. Volkman. 1987. Ecological segregation of Adélie, gentoo and chinstrap penguins at King George Island, Antarctica. *Ecology*, 68: 351–361.

SPECIES: Penguins: Adélie, chinstrap, gentoo, macaroni (*Pygoscelis adeliae*, *Pygoscelis antarctica*, *Pygoscelis papua*, *Eudyptes chrysolophus*)

PARAMETERS: Breeding population size

ASSOCIATED PARAMETERS:

Over-winter survival; weight on arrival, breeding success.

AIMS:

To determine interannual trends in the size of breeding populations.

DATA COLLECTION:

This method pertains only to ground counts of nests in entire colonies.

GENERAL PROCEDURE:

1. Select one or more colonies that are discrete, can each be counted as a whole unit, and which will not be affected by other studies or station activities. These sites should be well defined and distributed in various parts of the study area – some in the centre, some far or near to the beach, etc. Ideally, the total number of nests being counted annually at a study area should be around 1 000 to 2 000 nests; the minimum total for an area would be 100 nests. The same colonies are to be censused for this parameter each year.

2. The colonies should be the same as those used to assess chick numbers (see Method A6, Procedure A), and must have the same criteria for selection, especially no disturbance by human activities (station, research or other). Colonies must be clearly marked and mapped. Number each colony and permanently mark them using metal stakes or other means. Map these sites showing position in the study area (perhaps with an aerial photo), and provide this map to the CCAMLR Secretariat; refer to it in all reports.

3. One week after the peak of egg-laying (determined by Method A9 or see 'Dates of Observation' below) count the number of occupied nests in each of the colonies as well as the number of nests on which eggs are being incubated. The date should be as close as possible to the same date each year. Assume that all birds lying down inside the periphery of the colony are incubating eggs; do not physically lift birds to check underneath them.

4. Three separate counts should be made of each of the selected colonies on the same day. If one of the three counts differs more than 10% from the others, a fourth count should be made on the same day as the other three counts. Record each count separately.

CCAMLR Standard Method A3A (v4)

MANDATORY DATA:

1. For each count, record the total number of occupied nests and the total number of incubated nests (record three to four counts separately).

2. Date each count.

HIGHLY DESIRABLE DATA:

Records of any anomalous and/or extreme environmental conditions observed during the study (e.g. snow and ice cover, wind and temperature).

PROBLEMS TO BE CONSIDERED:

It is important that the same colonies be counted annually and that the counts are made one week after peak egg-laying. If data from a chronological study colony (Method A9) are available, these should be used to determine the optimal time to make the counts.

COMMENTS:

The use of transects to subsample large colonies or aerial surveys is not yet considered part of Procedure A3 (see Ref. 4, paragraphs 36 and 37).

DATA PROCESSING AND ANALYSIS:

ANALYTICAL METHODS:

1. Calculate the number of nests occupied and the number of nests incubating eggs as means of the three (or four) independent counts at the colony.

2. Means of the number of occupied and the number of incubating nests for several colonies combined may provide a yearly index of breeding population size. Comparisons between years should probably include variance analysis.

INTERPRETATION OF RESULTS:

The total number of birds engaged in breeding activity can be influenced by:

1. Cohort size at fledging and rate of recruitment of each cohort to the breeding population.

2. Food supply during pre-laying and incubation periods.

3. Ages of individual birds (and consequently the age structure of colony).

4. Previous breeding experience of the individuals.

5. Length of mate-bond.

6. Presence of mate.

7. Size and location of colony.

8. Ice conditions prior to colony occupation.

PROBLEMS TO BE CONSIDERED:

It is important that counting methods are fixed over successive years to maintain consistent levels of disturbance. It is also important that the colonies selected for this method are repeatedly used in successive years.

COMMENTS:

DATA REPORTING:

Data should be reported using the latest version of CCAMLR data submission form E/A3 (see Part III, Section 1). Data from different species should be reported on separate forms.

DATES OF OBSERVATION:

Mean laying date ± standard error (range of dates) (a); together with mean incubation period ± standard error (range of incubation period) (b):

		Adélie	Chinstrap	Gentoo	Macaroni*	Refs
Prydz Bay	a	10 Nov ± 1 (5–15 Nov)	NA	NA	NA	3
	b	34 days ± 0.3 (32–25)				
South Orkneys	a	3 Nov ± 0.3 (27 Oct–9 Nov)	4 Dec ± 0.3 (28 Nov–10 Dec)	X	X	1
	b	35 days ± 0.2 (33–39)	36 days ± 0.2 (33–39)			
South Georgia	a	NA	X	28 Oct ± 0.4 (8 Oct–18 Nov)	24 Nov ± 0.2 (22–24 Nov)	5, 6
	b			35 days ± 0.1 (32–38)	35 days ± 0.4 (31–37)	
South Shetlands	a	3 Nov	27 Nov	X	X	2
	b	X	X			

* second egg data (first egg is usually lost before second is laid)
X data not available
NA not applicable, species absent in specified area

REFERENCES:

(1)   Lishman, G.S.   1985.   The comparative breeding biology of Adélie and chinstrap penguins, *Pygoscelis adeliae* and *P. antarctica* at Signy Island, South Orkney Islands. *Ibis*, 127: 84–99.

(2)   Trivelpiece, W.Z. and N.J. Volkman. 1979.   Nest site competition between Adélie and chinstrap penguins: an ecological interpretation. *Auk*, 96: 675–681.

(3)   Johnstone, G.W., D.J. Lugg and D.A. Brown.   1973.   The biology of the Vestfold Hills, Antarctica. *ANARE Sci. Rep. Ser. B*, 1.

(4)   SC-CAMLR. 1989. Report of the Working Group for the CCAMLR Ecosystem Monitoring Program.   In: *Report of the Eighth Meeting of the Scientific Committee (SC-CAMLR-VIII)*, Annex 7.   CCAMLR, Hobart, Australia: 297–347.

(5)   Williams, T.D. and J.P. Croxall. 1991. Annual variation in breeding biology of the macaroni penguins, *Eudyptes chrysolophus,* at Bird Island, South Georgia. *J. Zool. Lond*., 223: 189–202.

(6)   Williams, T.D.   1990.   Annual variation in breeding biology of gentoo penguins, *Pygoscelis papua*, at Bird Island, South Georgia.   *J. Zool., Lond.*, 222.

BACKGROUND PAPERS:

Ainley, D.G., R.E. Leresche and W.J.L. Sladen.   1983.   *Breeding Biology of the Adélie Penguin.* University of California Press.

BIOMASS. 1983. Meeting of BIOMASS Working Party on Bird Ecology. *BIOMASS Report*, 34.

BIOMASS. 1982. Monitoring studies of seabirds. *BIOMASS Handbook*, 19.

BIOMASS. 1982. Penguin census methods. *BIOMASS Handbook*, 20.

Conroy, J.W.H., O.H.S. Darling and H.G. Smith. 1975. The annual cycle of the chinstrap penguin, *Pygoscelis antarctica*, on Signy Island, South Orkney Islands. In: Stonehouse, B. (Ed.). *The Biology of Penguins.* MacMillan: 353–362.

Croxall, J.P. 1984. Seabirds. In: Laws, R.M. (Ed.). *Antarctic Ecology*, 2. Academic Press: 533–619.

Gwynn, A.M. 1952. Egg laying and incubation periods of rockhopper, macaroni and gentoo penguins. *ANARE Rep. Ser. B*, 1.

SC-CAMLR. 1985. Report of the Ad Hoc Working Group on Ecosystem Monitoring. In: *Report of the Fourth Meeting of the Scientific Committee (SC-CAMLR-IV)*, Annex 7. CCAMLR, Hobart, Australia: 81–137.

SPECIES: Penguins: Adélie (*Pygoscelis adeliae*). Comments may be applicable to some other species.

PARAMETERS: Breeding population size

ASSOCIATED PARAMETERS:

Over-winter survival; weight on arrival, breeding success.

AIMS:

To determine interannual trends in the size of breeding populations.

DATA COLLECTION:

This method, using aerial photography, is an alternative method to ground counts of nests in entire colonies.

GENERAL PROCEDURE:

1. The most effective time for estimating the number of breeding pairs from a single count is (for the Ross Sea) in early December, when 70 to 90% of the birds ashore are incubating eggs, while their mates, and most non-breeding birds are feeding at sea. The evenly spaced nesting birds are then easy to identify from others present. For other areas of Antarctica, this optimum time will be different, and needs to be determined before the colonies are flown and photographed.

2. Use a fixed wing aircraft or helicopter to overfly the colonies. The minimum altitude needed to avoid disturbance to incubating adults will depend on the aircraft type, and also the length of time the aircraft is over the colonies and the number of passes needed. For example, a Bell 212, one of the noisiest helicopters employed in the Antarctic, should never be flown less than 2 000 feet above ground level, and preferably above this altitude. Smaller, quieter helicopters such as the Dauphin or the Squirrel, may make one pass at 1 500 feet above ground level, but if more passes or loitering is necessary, they also should fly above 2 000 feet. The Lockheed Hercules, because of its relative quietness and speed can make one pass over an Adélie colony at 1 500 feet and cause very little disturbance, but if multiple passes are needed, then the aircraft should stay above 2 000 feet above ground level. The same rule should basically be observed if a twin Otter is used.

    If a vertical large format camera is available with the aircraft, use it. Because of the clarity of image inherent with the large format, altitudes in excess of the minimums recommended above may be preferable. Otherwise use a medium format camera, with a negative not less than 60 x 40 mm, and take high angle obliques through the open door of the aircraft. For example, a Pentax 645 motor drive camera, with a 150 mm lens is suitable. Use a high quality black

and white film e.g. Ilford FP4, rated at 200ASA, and a shutter speed of 1/1 000 sec. Fly over the colony using parallel flight lines to ensure all parts of it are photographed, with each exposure overlapping the next by about 50%.

3. In the laboratory, print each negative to 20 x 26 cm size. Lay them out to show the entire colony. Mark up the best section on each photograph so that the whole colony is covered (avoid gaps or overlap). Enlarge the marked up sections to the optimum size and count under a magnifying lens to get the total number of occupied nests in each nesting group, and in the entire colony. This is best done by pricking through the photograph, with an electronic needle which activates a counter. Count only birds occupying nests. Ignore members of pairs standing between nests. Ignore birds standing or 'floating' around the colony/subcolonies.

MANDATORY DATA:

1. From the photographs record the total number of occupied nests for the entire colony.

2. Identify and date the set of negatives and the photo set.

HIGHLY DESIRABLE DATA:

PROBLEMS TO BE CONSIDERED:

It is important that the same colonies are counted annually. If data from a chronological study colony (Method A9) are available in the region, these should be used to determine the optimal time for the aerial photography.

COMMENTS:

Results from the Ross Sea region show that for small colonies (3 000 to 4 000 breeding pairs) counts from aerial photographs are as accurate as careful ground counts, but much less disruptive. For very large colonies, counts from aerial photographs are more accurate than ground counts which take days to complete, or only subsample subcolonies. Since the whole colony is counted from aerial photographs, this technique is especially suitable when colonies are in a rapid expansion or contraction phase. Estimates of colony size by subsampling are not reliable indicators of colony change.

DATA PROCESSING AND ANALYSIS:

ANALYTICAL METHODS:

1. After one person has counted an entire colony, 30 randomly selected subsamples containing approximately 50 to 100 birds should be checked by three additional counters (new prints each time). The results from the four sets of subsamples are then subjected to an analysis of variance, and used to achieve a corrected estimate of breeding pairs, with 95% confidence intervals. These confidence intervals reflect the quality of the photographs and the interpretive skills of the counters.

INTERPRETATION OF RESULTS:

The total number of birds engaged in breeding activity can be influenced by:

1. Cohort size at fledging and rate of recruitment of each cohort to the breeding population.

2. Food supply during pre-laying and incubation periods.

3. Ages of individual birds (and consequently the age structure of colony).

4. Previous breeding experience of the individuals.

5. Length of mate-bond.

6. Presence of mate.

7. Size and location of colony.

8. Ice conditions prior to colony occupation.

DATA REPORTING:

Data should be reported using the latest version of CCAMLR data submission form E/A3 (see Part III, Section 1).

BACKGROUND PAPERS:

Ainley, D.G., R.E. Leresche and W.J.L. Sladen. 1983. *Breeding Biology of the Adélie Penguin.* University of California Press.

BIOMASS. 1982. Monitoring studies of seabirds. *BIOMASS Handbook*, 19.

BIOMASS. 1982. Penguin census methods. *BIOMASS Handbook*, 20.

BIOMASS. 1983. Meeting of BIOMASS Working Party on Bird Ecology. *BIOMASS Report*, 34.

Conroy, J.W.H., O.H.S. Darling and H.G. Smith. 1975. The annual cycle of the chinstrap penguin, *Pygoscelis antarctica*, on Signy Island, South Orkney Islands. In: Stonehouse, B. (Ed.). *The Biology of Penguins.* MacMillan: 353–362.

Croxall, J.P. 1984. Seabirds. In: Laws, R.M. (Ed.). *Antarctic Ecology*, 2. Academic Press: 533–619.

Gwynn, A.M. 1952. Egg laying and incubation periods of rockhopper, macaroni and gentoo penguins. *ANARE Rep. Ser. B*, 1.

Johnstone, G.W., D.J. Lugg and D.A. Brown. 1973. The biology of the Vestfold Hills, Antarctica. *ANARE Sci. Rep. Ser. B*, 1.

Lishman, G.S. 1985. The comparative breeding biology of Adélie and chinstrap penguins, *Pygoscelis adeliae* and *P. antarctica* at Signy Island, South Orkney Islands. *Ibis*, 127: 84–99.

SC-CAMLR. 1985. Report of the Ad Hoc Working Group on Ecosystem Monitoring. In: *Report of the Fourth Meeting of the Scientific Committee (SC-CAMLR-IV)*, Annex 7. CCAMLR, Hobart, Australia: 81–137.

SC-CAMLR. 1989. Report of the Working Group for the CCAMLR Ecosystem Monitoring Program. In: *Report of the Eighth Meeting of the Scientific Committee (SC-CAMLR-VIII)*, Annex 7. CCAMLR, Hobart, Australia: 297–347.

Taylor, R.H., P.R. Wilson and B.W Thomas. 1990. Status and trends of Adélie penguin populations in the Ross Sea region. *Polar Record*, 26: 293–304.

Trivelpiece, W.Z. and N.J. Volkman. 1979. Nest site competition between Adélie and chinstrap penguins: an ecological interpretation. *Auk*, 96: 675–681.

Williams, T.D. 1990. Annual variation in breeding biology of gentoo penguins, *Pygoscelis papua*, at Bird Island, South Georgia. *J. Zool., Lond.*, 222.

Williams, T.D. and J.P. Croxall. 1991. Annual variation in breeding biology of the macaroni penguins, *Eudyptes chrysolophus,* at Bird Island, South Georgia. *J. Zool. Lond.*, 223: 189–202.

SPECIES: Penguins: Adélie, chinstrap, gentoo, macaroni (*Pygoscelis adeliae*, *Pygoscelis antarctica*, *Pygoscelis papua*, *Eudyptes chrysolophus*)

PARAMETERS: Age-specific annual survival and recruitment

ASSOCIATED PARAMETERS:

Size of breeding population; weight on arrival at breeding colony; breeding success; adult weight at chick fledging; adult weight before moult.

AIMS:

To determine the demographic parameters of the population.

DATA COLLECTION:

Two different methodologies are presented: Procedure A is much less labour-intensive than Procedure B but only yields an estimate of annual survival of breeding adults. Procedure B is more desirable because it provides age-specific estimates of annual survival and recruitment. Demographic measurements should not be undertaken unless there is a firm intention to continue these studies on a long-term basis. See Ref. 1 for further details of procedures.

GENERAL PROCEDURE

Procedure A:

1.   Within a colony, and preferably not at its periphery, choose three breeding sites each of about 30 nests; observe them daily during the egg-laying period, noting the number of nests which do or do not have eggs. On the day when one third of the nests (i.e. a total of 30 across all three sites) contain at least one egg, begin the procedures outlined below.

2.   Select 50 nests which are not being observed for other purposes, and which have at least one egg and both adults still present. These nests should be near the periphery of colonies (as the days go by, other pairs will likely establish nests to the periphery of these). Mark the nests with a numbered stake or rock (at the end of the season, a permanent marker should be established at each nest). Squirt dye on each bird.

3.   Observe both birds of each pair closely. Decide which is the larger and which does not have tread marks on its back (male); confirm sex by relative size and by incubation schedule (male Adélies and female chinstraps should incubate first).

4.   For each nest, capture and band both adults, using a hand net to capture the individual not incubating, and by placing a hand over the eyes of the incubating bird while slipping on the bands with the other hand (Ref. 1). Note the band numbers of each pair member by sex. Do not determine sex by internal cloacal examination, unless it is possible to capture one of the birds during the creche period. However the female may be identified for a short period after egg-laying by the presence of cloacal swelling.

5. The following year, before and during the laying period, search the site for these banded birds; most (but not all), if alive, will be found at or near the nest where originally banded. The search effort must be the same every year (same number of people looking for banded birds on the same number of days during the prelaying and laying periods).

6. Each year, band a new group of 50 pairs as in steps 1 to 3 above, and search for them the following year.

Procedure B:

1. Select a colony with a minimum of approximately 2 000 pairs. Note that in colonies of more than 10 000 pairs, there will be increasing difficulty in relocating banded birds.

2. Each year, during the late creche period, but before any chicks have fledged, band a minimum of 1 500 large creche-age chicks. Choose several neighbouring breeding sites in the same part of the colony for the banding. Record the band numbers used each year. Include in the sample, chicks of known-age birds (banded so that parents are known). If colonies are mapped and numbered as outlined in Method A3, record the exact colony where bands are applied.

3. In subsequent years, search the colony for banded birds; search effort must be the same every year (same number of persons, same number of days spent looking for banded birds). Young birds will appear late in the breeding season, arriving earlier with greater age.

4. When a banded bird establishes a nest site, pairs and lays eggs, mark the nest site and visit that bird/site in later years noting whether or not the bird breeds successfully. Perhaps band its mate.

5. Known age Adélie and chinstrap penguins returning to their natal colonies can be sexed with reasonable accuracy using a hierarchy of clues. The sexing criteria, listed from least to most accurate, are:

   I = Incubation: for Adélies, between 15 and 21 days after the first egg is laid, most (92 to 99% at colonies so far investigated) incubating birds are males.

   S = Size: within pairs at a nest site the male will have the larger bill/head of the pair (see Part IV, Section 1).

   B = Behaviour: pair at the nest with male doing ecstatic display accompanied by female doing quiet mutual display (see Ref. 1).

   T = Treadmarks: within pairs, the back of one member of the pair is covered in muddy footprints (female) while the other member's back is clean (male).

   C = Copulatory position: male on female's back during copulation.

   E = Egg laying.

6. Record the method used to sex the penguin, (i.e. I, S, B, T, C or E) and upgrade the data on an individual bird as better criteria become available (i.e. a bird is originally sexed by size and later sexed by copulatory position).

MANDATORY DATA:

1. List of band numbers resighted each breeding season.

2. List of band numbers for chicks and adults (including sex when known) newly banded each breeding season.

3. List of all band numbers recovered from dead chicks and adults each breeding season.

4. Dates and locations of newly banded birds.

HIGHLY DESIRABLE DATA:

1. Band number of partners.
2. Dates and locations of band resightings.
3. Records of any anomalous and/or extreme environmental conditions observed during the study (e.g. snow and ice cover, wind and temperature).

PROBLEMS TO BE CONSIDERED:

1. Disturbance caused by human visits can induce predation of eggs and chicks by skuas. Giant petrels, gulls, wekas and sheathbills may prey on eggs and chicks on sub-Antarctic islands.

2. Only stainless steel or other suitable alloy flipper bands are to be used. Stainless steel bands are obtainable from Lambournes Ltd[*]. Numbering should be coordinated among researchers working in the same islands/regions.

COMMENTS:

1. These are by far the most labour intensive parameters to monitor. It requires that observations be conducted every year from the beginning of penguin arrival in the spring, through egg-laying and into the creche period. The procedure requires banding penguins; some mortality is induced by banding. Band loss must also be considered.

2. Automatic data-loggers capable of recording some of the data would be helpful.

3. Equipment to record band number (e.g. coded into bar-code), date of arrival and departure of individuals would reduce the manual effort of data collection.

4. Band numbers should be coded by location using a three letter prefix followed by a five-digit number (advice of SCAR Sub-Committee on Bird Biology).

----

[*] Lambournes Ltd., Coleman House, Station Road, Knowle, West Midlands B930HL, England.

DATA PROCESSING AND ANALYSIS:

ANALYTICAL METHODS:

Procedure A: Adult Survival

Estimates of annual adult survival are calculated from resightings of penguins banded the previous season. Results are presented as mean annual survival rates for each year of the study (all birds) and for males and females separately.

Procedure B: Demography

Recruitment

1. Recruitment to the population is estimated from resighting of chicks banded as fledglings in the study colony. Recruitment may be defined as:

    (a) the proportion of fledged chicks which survive to breed (e.g., Standard Method B3); and

    (b) the proportion of fledged chicks which survive to age of first reproduction.

2. For penguins, reporting data under method (a) requires observation of birds to ensure that the year of first egg-laying is correctly identified.

3. Young, first-time breeders are often very poor parents, often losing their egg(s) within hours of laying. However, if accurate data of this kind can be collected, then a format useful for reporting recruitment in penguins might be to use a life table where data are presented as:

Year Banded	Number Banded	% Surviving to Age (years)									
		1	2	3	4	5	6	7	8	9	10+

4. If possible data for each sex should be presented separately.

5. Data on mean age at first reproduction can be summarised and reported as the mean age of first breeding for each cohort and for males and females separately in each cohort.

6. The appropriate formula for calculating mean age of first reproduction is:

    For reporting data under method (b), mean age of first reproduction for Adélie and chinstrap penguins is three years, for gentoos it is two years. Penguins are considered to have recruited to the populations if they survive to these ages respectively, regardless of whether or not there is evidence of actual breeding (e.g. Ref. 2). Data should be summarised and reported as the percentage of birds banded surviving to mean age of first breeding for each cohort and for males and females separately in each cohort.

Adult Survival

Data should be summarised and reported as for Procedure A.

INTERPRETATION OF RESULTS:

1. The return of banded birds to the colony following a winter period at sea can be used to calculate the annual survival rate of adults and non-adults. Mortality during winter months can be due to:

    (a) prey species availability (quantity, quality and access);
    (b) predation by leopard seals, killer whales;
    (c) weather conditions;
    (d) other.

2. Banding of chicks at pre-fledging allows determination of mortality within the cohort, i.e. age-specific mortality rates can be determined.

3. Large-scale banding over the lifespan of a cohort provides data on the year-to-year mortality (i.e. an environmental indicator) and if banding takes place in several geographically discrete colonies, the results can indicate whether an observed result is local or not. Eventually life tables could be generated from the data collected for each cohort.

4. The percentage of younger penguins that elect to attempt breeding will give an indication of the conditions in the preceding winter, with favourable conditions expected to produce a higher percentage of breeding attempts.

5. Pre-breeder activities might also be sensitive indices to overall conditions among the birds that in turn will reflect the marine conditions of the area. Years with above-average resources might be expected to be correlated with earlier first sighting dates for pre-breeders, longer total time spent at the colony and an increased proportion of time spent in breeding-related activities (i.e. alone at nest, paired at nest), relative to wandering behaviours.

PROBLEMS TO BE CONSIDERED:

1. Recruitment rates will be underestimates of true survival among fledgling cohorts due to several factors including:

    (a) immigration of fledglings to colonies other than the natal colony, a factor that will vary between species and possibly within species as a function of the size and proximity of other colonies in the area;

    (b) band loss and band-induced mortality.

2. Banding should only be done by experienced banders or personnel trained by experienced banders.

3. Studies of alternative marking techniques should be encouraged.

COMMENTS:

DATA REPORTING:

1.   No formats for submitting data have yet been designed.

2. The following databases are examples of the types of information that might be of interest to monitoring studies. Whenever a known-age penguin is encountered during the course of daily work at the colony the following information is recorded (e.g. Adélie, chinstrap and gentoo penguins at King George Island, South Shetland Islands).

Date
Band Number
Sex and how sexed (see criteria above)
Location (colony where bird is observed)
Status:
    0 = Wandering (not associated with a nest site)
    1 = Alone on Nest
    2 = Paired on Nest
    3 = Breeding.

This information is input into a dbase file for that bird for the year.

At the end of the season a summary file is created for each known-age penguin sighted during the year.

The database for pre-breeders is summarised into the following format/fields:

Band Number
Birth Year
Natal Colony
Year (current)
Age
Sex
Experience (0 = first year seen at colony, 1 = seen at colony in previous year but not known to breed).
Day First (date first seen this season).
Days Total (total number of days between the first and last sighting of the bird; i.e. a bird first seen on 1 December and last sighted on 31 January was in the area 61 days, even if these two dates are the only two sightings).
Total # Sightings
% Wandering (% of the total number of sightings in which the bird was recorded was Wandering).
% Alone on Nest
% Paired on Nest

The database for breeders is summarised into the following format/fields:

Band Number
Birth Year
Year (current)
Age

Sex
Experience (as above but add: 2 = prior breeder)
Mate Band
Clutch Initiation Date
Eggs
Chicks Hatched
Chicks Fledged

DATES OF OBSERVATION:

Reported mean dates (and ranges) of the first adult return to and mean chick departure from the nominated breeding colony:

	Adult Return*				Chick Departure				Refs
	Adélie	Chinstrap	Macaroni	Adélie	Chinstrap	Gentoo	Macaroni	
Prydz Bay	12 Oct (4–17 Oct)	NA	NA	X	NA		NA	3
South Orkneys	2 Oct (21 Sept–8 Oct)	31 Oct (16 Oct–12 Nov)	X	6 Feb (4–15 Feb)	1 Mar (25 Feb–2 Mar)		X	2
South Georgia	NA	X	17 Oct (14–23 Oct)	NA	X	23 Feb–1 Mar	25–26 Feb	5, 6
South Shetlands	20 Oct	2 Nov	X	X	X		X	4

*   gentoo penguin not included because it is a 'resident' species
X   data not available
NA   not applicable, species absent in specified area

REFERENCES:

(1)   Ainley, D.G., R.E. Leresche and W.J.L. Sladen. 1983. *Breeding Biology of the Adélie Penguin.* University of California Press.

(2)   Lishman, G.S. 1985. The comparative breeding biology of Adélie and chinstrap penguins, *Pygoscelis adeliae* and *P. antarctica*, at Signy Island, South Orkney Islands. *Ibis*, 127: 84–99.

(3)   Johnstone, G.W., D.J. Lugg and D.A. Brown. 1973. The biology of the Vestfold Hills, Antarctica. *ANARE Sci. Rep. Ser. B*, 1.

(4)   Trivelpiece, W.Z. and N.J. Volkman. 1979. Nest site competition between Adélie and chinstrap penguins: an ecological interpretation. *Auk*, 96: 675–681.

(5)   Williams, T.D. and J.P. Croxall. 1991. Annual variation in breeding biology of the macaroni penguins, *Eudyptes chrysolophus,* at Bird Island, South Georgia. *J. Zool. Lond.*, 223: 189–202.

(6)   Williams, T.D. 1990. Annual variation in breeding biology of gentoo penguins, *Pygoscelis papua*, at Bird Island, South Georgia. *J. Zool., Lond.*, 222.

BACKGROUND PAPERS:

Ainley, D.G., R.C. Wood and W.J.L. Sladen. 1978. Bird life at Cape Crozier, Ross Island. *Wilson Bull.*, 90: 492–510.

BIOMASS. 1983. Meeting of BIOMASS Working Party on Bird Ecology. *BIOMASS Report*, 34.

Conroy, J.W.H., O.H.S. Darling and H.G. Smith. 1975. The annual cycle of the chinstrap penguin, *Pygoscelis antarctica*, on Signy Island, South Orkney Islands. In: Stonehouse, B. (Ed.). *The Biology of Penguins.* MacMillan: 353–362.

Croxall, J.P. 1984. Seabirds. In: Laws, R.M. (Ed.). *Antarctic Ecology*, 2. Academic Press: 533–619.

Croxall, J.P. and P.A. Prince. 1980. Food, feeding ecology and ecological segregation of seabirds at South Georgia. *Biol. J. Linn. Soc.*, 14: 103–131.

Downes, M.C., E.H.M. Ealey, A.M. Gwynn and P.S. Young. 1959. The birds of Heard Island. *ANARE Rep. Ser. B*, 1.

SC-CAMLR. 1985. Report of the Ad Hoc Working Group on Ecosystem Monitoring. In: *Report of the Fourth Meeting of the Scientific Committee (SC-CAMLR-IV)*, Annex 7. CCAMLR, Hobart, Australia: 81–137.

Watson, G.E. 1975. *Birds of the Antarctic and Sub-Antarctic.* American Geophysical Union.

SPECIES: Penguins: Adélie, chinstrap, macaroni
(*Pygoscelis adeliae*, *Pygoscelis antarctica*, *Eudyptes chrysolophus*)

PARAMETERS: Duration of foraging trips

ASSOCIATED PARAMETERS:

Breeding success; chick weight at fledging; diet.

AIMS:

To determine intra-annual and interannual differences in the amount of time required to procure food for chicks as an indicator of foraging range, foraging effort and food availability.

DATA COLLECTION:

GENERAL PROCEDURE:

1. This parameter can be measured effectively with the use of radio frequency telemetry and automatic data-logging instruments. Materials required include 20 to 40 radio transmitters (battery life two months, range 0.5 km, weight less than 25 g), antenna, scanning receiver, and data or strip-chart recorder.

2. Select a minimum of 20 pairs guarding one- to two-week old chicks and attach a radio transmitter to both adults, noting the sex of each. Because the foraging patterns of male and female macaroni penguin are substantially different from each other, it would be preferable to monitor one sex only so that interannual comparisons will have a sufficient sample size; for macaroni penguins, attach the radio transmitters only to adult males (at 40 nests).

3. Two people should be involved in attaching the radio transmitters. Preferably, upon observing a change in incubation shift, capture the departing member of the pair and affix a transmitter of known weight as described below. Band bird or mark with dye before release. If capture of the departing member is not possible, capture the other adult of the pair as it guards the chicks. Place chicks in a pocket to keep warm and safe from predation. Just before releasing adult, after affixing transmitter, return chicks to the nest.

4. Place cloth or glove over adult's eyes to help keep it calm while attaching transmitter. While one person holds the penguin, mix quick-setting adhesive[1] and apply to back feathers midway between the shoulders using an applicator. Area covered should be 1 cm larger than size of the transmitter. Press epoxy into plumage so that it reaches basal part of feathers. Set transmitter on epoxy (antenna should point toward the head or tail depending on type) and secure using one or two plastic electronic ties; ties should encircle transmitter and the epoxied feathers beneath it. Smooth the upper and lateral edges of the transmitter/epoxy unit with additional epoxy to form a solid, hydrodynamic

---

[1] Epoxy brands used with success include: RS Components (Corby, Northants, UK); Devcon (five-minute epoxy). Adhesives found to be less suitable for long-term deployment include cyanoacrylic glues (e.g. Loctite 501).

bond to feathers. Some researchers have had success in attaching radio transmitters using metal hose-clamps or plastic cable ties as an alternative to adhesives. This has the advantage of quicker attachment and easy removal without damage to feathers. The disadvantage is the possibly slightly higher rate of instrument loss.

5. Position a frequency-scanning receiver in a location close enough to the study nests and beach such that all instrumented birds are detected if present. Program each transmitter frequency (each should be different) on the data logger. A scanning rate of checking for each bird every 20 minutes or less is recommended. The precision of measurements of the foraging trip duration increases as the interval between scanning each bird decreases. Transmitted signals are only received when each bird is within range (i.e. ashore), thus providing a continuous record of the at-sea/on-shore intervals.

6. The number of chicks present at each nest and their fate during the observation period will have an important impact on the foraging pattern of the adults. Note the number of chicks at each nest at the time of initial instrumentation. Within subsequent five-day periods thereafter, record the number of chicks present. In cases where both adults are not instrumented (macaroni), a weekly assessment of whether or not both adults are alive should be made.

MANDATORY DATA:

1. Dates and times of arrival to and departure from the nest for each instrumented bird's foraging trip to sea throughout the observation period.

2. Record (by date) of the number of chicks present at each nest throughout the observation period.

3. Record (by date) of the number of adults feeding chicks at each nest throughout the observation period.

4. List of the nest identification numbers and the band and/or transmitter identification numbers for the adults monitored at each nest.

5. A description of the scanning rate of the radio receivers used. This rate determines the precision of the measured duration of foraging trips.

HIGHLY DESIRABLE DATA:

1. Dates of egg hatching at each nest monitored. If unknown exactly, an estimate would be useful.

2. The number of chicks a pair is feeding should be recorded as it may influence the foraging behaviour (and diet) of the adults.

3. Records of any anomalous and/or extreme environmental conditions observed during the study (e.g. snow and ice cover, wind and temperature).

PROBLEMS TO BE CONSIDERED:

1. If the radio receiver is set up in a position that can receive signals from birds that are not near their nest (e.g. walking some distance from the nest to the sea, swimming at sea close to shore), these signals will affect the estimation of the duration of feeding trips. One solution is to adjust (lower) the gain of the receiver so that it only receives signals in the immediate vicinity of the monitored nests. In any event, care should be taken to set up the radio antenna and receiving system in the same way each year so that interannual comparisons of the birds' behaviour are not confounded by changes in the sensitivity or position of the monitoring hardware.

COMMENTS:

1. If transmitters are removed from the birds at the end of the observation period (alternatively, they can be left to fall off by themselves during the moult), care should be taken to cut as few feathers as possible. It is better to leave some residual glue on the external edges of the feathers (which will moult in a few weeks following fledging of the chicks) than to cut feathers, which are essential for the birds' insulation.

2. Investigators are encouraged to undertake directed research to evaluate in more detail whether it would be preferable to instrument one or both mates at a nest. Factors to be considered include: (a) the impact of the instruments on the birds' behaviour; (b) the statistical ramifications of monitoring two birds each feeding the same chicks; and (c) the extent to which differences between sexes (for Adélie and chinstrap) confound general interannual comparisons.

DATA PROCESSING AND ANALYSIS:

ANALYTICAL METHODS:

1. Males and females must be analysed separately. To fully describe foraging duration the data should be analysed by both mean foraging duration per standard five-day period (paragraphs 2 to 5 below) and per bird.

2. To avoid bias in the computations due to foraging trip frequency, mean foraging duration in a five-day period should be calculated from the means of individual bird foraging trip durations without weighting by number of trips. Thus, mean foraging duration of bird i in period j, $B_{ij} = \dfrac{\sum_{k=1}^{n} d_{ijk}}{n_{ij}}$ and overall mean foraging duration in the period, $D_j = \dfrac{\sum_{i=1}^{a} B_{ij}}{a_j}$ where d_{ijk} is the duration of foraging trip k in period j for bird i, n_{ij} is the number of foraging trips by bird i in period j, and a_j is the number of birds foraging in the sample period.

3. The standard deviation of this mean D_j and maximum and minimum values for B_{ij} should be computed and reported.

4. Allocation to five-day periods; for the purposes of this calculation a trip belongs to the five-day period within which the trip starts.

5. Birds should only be included in the analysis of mean foraging duration if they have chicks; they must be excluded from the analysis of all periods for which they did not have chicks throughout the whole period.

6. Summary statistics for each bird monitored should also be computed, to include the start and end dates and the number of chicks at the beginning and end of the period. The period here should be the whole period of recording.

7. Computation of an annual index should probably include analysis by time period to investigate the variance characteristics of five-day periods and individuals.

INTERPRETATION OF RESULTS:

1. The duration of foraging trips is exceedingly sensitive to food availability and is of fundamental importance to the (breeding) success of the breeding pairs. Delays in returning to the nest with a meal for the growing chick can cause desertion by the partner as well as starvation in the chick.

2. Duration of foraging trips may be influenced by the following:

   (a) sea-ice and weather conditions; and
   (b) prey species availability, quality and quantity.

3. Interannual differences in foraging trip durations from sites adjacent to broad-shelf regions may reflect differences in krill distribution, not availability or biomass *per se*. For example, long trips by Adélie penguins at Anvers Island occur in conjunction with the dominance of large size classes in the krill population, short foraging trips correlate with the dominance of juvenile krill. Large krill are distributed at the shelf break where spawning occurs, small krill are found inshore. For sites such as Anvers Island where the shelf break is 120+ km distant, large interannual variability in foraging durations reflects differences in krill distribution and the distances Adélie penguins must travel to obtain food.

PROBLEMS TO BE CONSIDERED:

1. If some birds display activity patterns with high variability in foraging period, or highly-skewed activity patterns, it may be advisable to omit these data from the analysis. The summary data reported here would be sufficient to identify this problem but re-calculation of foraging duration would necessitate referral to the raw data.

2. The methods described above do not make use of linked sex data (where males and females from the same pair are monitored). Members are encouraged to investigate the foraging behaviour of such linked pairs.

COMMENTS:

DATA REPORTING:

Data should be reported using the latest version of CCAMLR data submission form E/A5 (see Part III, Section 1). Data for different colonies, species and sexes should be reported on separate forms.

DATES OF OBSERVATION:

Chronology of chick development: (a) mean date of hatching of first egg ± standard error and range, (b) duration of guard stage ± standard error and range, (c) duration of creche stage:

		Adélie	Chinstrap	Gentoo	Macaroni*	Refs
Prydz Bay	a	13 Dec ± 1.3 (10–16 Dec)	NA	NA	NA	2
	b	X				
	c	X				
South Orkneys	a	4 Dec (1–12 Dec)	1 Jan (26 Dec–7 Jan)	X	X	3
	b	18 days ± 1.3; (14–24 days)	24 days ± 1.5 (20–30 days)		X	
	c	42 days	30 days		X	
South Georgia	a	X	X	7 Dec ± 0.6 (1–13 Dec)	27 Dec ± 0.8 (21 Dec–3 Jan)	1, 6, 7
	b	NA	X	29 days ± 0.2 (19–35)	24 days ± 0.5 (21–28)	
	c	X	X	c 51 days	37 days ± 0.5 (32–41)	
South Shetlands	a	23 Nov	20 Dec	X	X	4, 5
	b	X	X		X	
	c	X	X		X	

*   second egg data (first egg is usually lost before second is laid)
X   data not available
NA not applicable, species absent in specified area

REFERENCES:

(1)   Croxall, J.P. 1984. Seabirds. In: Laws, R.M. (Ed.). *Antarctic Ecology*, 2. Academic Press: 533–619.

(2)   Johnstone, G.W., D.J. Lugg and D.A. Brown. 1973. The biology of the Vestfold Hills, Antarctica. *ANARE Sci. Rep. Ser. B*, 1.

(3)   Lishman, G.S. 1985. The comparative breeding biology of Adélie and chinstrap penguins, *Pygoscelis adeliae* and *P. antarctica*, at Signy Island, South Orkney Islands. *Ibis*, 127: 84–99.

(4)   Trivelpiece, W.Z., S.G. Trivelpiece and N.J. Volkman. 1987. Ecological segregation of Adélie, gentoo and chinstrap penguins at King George Island, Antarctica. *Ecology*, 68: 351–361.

(5)   Nielsen, D.R. 1983. Ecological and behavioural aspects of the sympatric breeding of the south polar skua (*Catharacta maccormicki*) and the brown skua (*Catharacta lönnbergi*) near the Antarctic Peninsula. Unpubl. MS Thesis, Univer. Minnesota, Minneapolis.

(6)   Williams, T.D. and J.P. Croxall. 1991. Annual variation in breeding biology of the macaroni penguins, *Eudyptes chrysolophus,* at Bird Island, South Georgia. *J. Zool. Lond*., 223: 189–202.

(7)   Williams, T.D. 1990. Annual variation in breeding biology of gentoo penguins, *Pygoscelis papua*, at Bird Island, South Georgia. *J. Zool., Lond.*, 222.

BACKGROUND PAPERS:

Ainley, D.G., R.E. Leresche and W.J.L. Sladen. 1983. *Breeding Biology of the Adélie Penguin*. University of California Press.

BIOMASS. 1983. Meeting of BIOMASS Working Party on Bird Ecology. *BIOMASS Report*, 34.

Croll, D.A., S.D. Osmek and J.L. Bengtson. 1991. An effect of instrument attachment on foraging trip duration in chinstrap penguins. *Condor*, 93: 777–779.

Croxall, J.P., R.W. Davis and M.J. O'Connell. 1988. Diving patterns in relation to diet of gentoo and macaroni penguins at South Georgia. *Condor,* 90: 157–167.

Culik, B., R. Bannasch and R.P. Wilson. 1994. External devices on penguins: how important is shape? *Marine Biology*, 118: 353–357.

Heath, R.G.M. 1987. A method for attaching transmitters to penguins. *J. Wildl. Manage.,* 51: 399–401.

Heath, R.G.M. and R.M. Randall. 1989. Foraging ranges and movements of jackass penguins, *Spheniscus demersus,* established through radio telemetry. *J. Zool. Lond*., 217: 367–379.

SC-CAMLR. 1985. Report of the Ad Hoc Working Group on Ecosystem Monitoring. In: *Report of the Fourth Meeting of the Scientific Committee (SC-CAMLR-IV)*, Annex 7. CCAMLR, Hobart, Australia: 81–137.

Trivelpiece, W.Z., J.L. Bengtson, S.G. Trivelpiece and N.J. Volkman. 1986. Foraging behaviour of gentoo and chinstrap penguins as determined by new radiotelemetry techniques. *Auk*, 103: 777–781.

Warham, J. 1975. The crested penguins. In: Stonehouse, B. (Ed.). *The Biology of Penguins.* Macmillan: p. 555.

Williams, A.J. 1982. Chick feeding rates of macaroni and rockhopper penguins at Marion Island. *Ostrich,* 53: 129–34.

Williams, T.D. and P. Rothery. 1990. Factors affecting variation in foraging and activity patterns of gentoo penguins, *Pygoscelis papua*, during the breeding season at Bird Island, South Georgia. *J. Appl. Ecol*., 27: 1042–1054.

Wilson, R.P. and C.A.R. Bain. 1984a. An inexpensive depth gauge for penguins. *J. Wildl. Manage.*, 48: 1077–84.

Wilson, R.P. and C.A.R. Bain. 1984b. An inexpensive speed meter for penguins at sea. *J. Wildl. Manage.*, 48: 1360–1364.

Wilson, R.P., W.S. Grant and D.C. Duffy. 1986. Recording devices on free-ranging marine animals: does measurement affect foraging performance? *Ecology,* 67: 1091–1093.

SPECIES: Penguins: Adélie, chinstrap, gentoo, macaroni (*Pygoscelis adeliae*, *Pygoscelis antarctica*, *Pygoscelis papua*, *Eudyptes chrysolophus*)

PARAMETERS: Breeding success

AIMS:

1. To assess productivity. This may be achieved either indirectly by providing an index of relative change in the number of chicks produced one year to the next (Procedure A), or directly, by actually measuring chick production (Procedures B and C).

2. Note: For new studies, it is mandatory to use either Procedure B or C. Procedure A is encouraged as a valuable addition to programs. These procedures must be carried out every year for at least 10 years in order to be able to demonstrate trends in breeding success.

3. Adélie and chinstrap penguins lay two eggs which often hatch but sometimes only one chick is raised to fledging. In seasons of abundant food close to colonies, more birds raise two chicks than in other seasons. Macaroni penguins often lay two eggs, but one of these is always discarded.

DATA COLLECTION:

GENERAL PROCEDURE:

Procedure A (chick counts):

1. Select one or more colonies that are discrete, can each be counted as a whole unit, and which will not be affected by other studies or station activities. These sites should be well defined and distributed in various parts of the study area – some in the centre, some far or near to the beach, etc. Ideally, the total number of nests in the area being counted annually should be around 1 000 to 2 000 nests; the minimum total for an area would be 100 nests. The same colonies are to be censused for this parameter each year.

2. The colonies should be the same as those used to assess breeding population size (see Method A3), and must have the same criteria for selection, especially no disturbance by human activities (station, research, or other). Colonies must be clearly marked and mapped. Number each colony and permanently mark them using metal stakes or other means. Map these sites showing position in the study area (perhaps with an aerial photo), and provide this map to the CCAMLR Secretariat; refer to it in all reports.

3. **On the same day every year**, count the number of chicks present in each colony. This date should be when about two-thirds of chicks have entered creches: for Adélie penguin, 7 January at 77°S (Ross Island), 2 January at 62°S (King George Island); for chinstrap penguin, 2 February at 62°S; for macaroni penguin, 25 January at 60°S (South Georgia). Record counts by colony.

4. Three separate counts should be made of each of the selected colonies on the same day. If one of the three counts differs more than 10% from the others, a fourth count should be made on the same day as the other three counts. Record each count separately.

CCAMLR Standard Method A6 (v5)

GENERAL PROCEDURE:

Procedure B (chicks raised per breeding pair):

1. On the day the first egg is laid in the colony (about 20 October and 20 November, respectively, for Adélie and chinstrap penguins on King George Island; 28 October and 14 November for gentoo and macaroni penguins respectively at South Georgia), select 100 contiguous nests along a line which runs through several breeding sites. Mark every pair of nests with a painted rock or flagged nail driven into the ground between the two; every tenth nest mark with a numbered stake (1, 10, 20, 30 etc.). If possible, squirt dye on the breast of nest occupants (no need for capture).

2. On that first day, and every five days thereafter, record the number of eggs, chicks and adults present at each nest. When chicks hatch, squirt dye on their backs. Continue visits until chicks depart for creches. The productivity is determined as the number of chicks reared to creche age per territorial pair of penguins.

3. For a slightly greater level of accuracy (especially during the period when chicks become mobile) the frequency of observations can be increased (e.g. to every other day); however, frequency should not be different from one year to the next (Ref. 1).

GENERAL PROCEDURE:

Procedure C (chicks raised per colony):

1. Select one or more colonies that are discrete, relatively isolated, and can each be counted as a whole unit (at least five for Adélie or chinstrap penguins; one of suitable size for macaroni penguins) and make three counts during the season:

    (a) on the day when 95% of the nests have eggs, count the number of nests with eggs;

    (b) when hatching has ended, count the number of nests with chicks; and

    (c) when all chicks have entered the creche, count the number of chicks in creche.

2. The timing of the counts should be determined by data from a chronology study (Method A9).

3. For each of the counts (a, b, c), three separate counts should be made on the same day (e.g., when hatching has ended, make three separate counts of the number of nests with chicks in a particular colony). If one of the three counts differs more than 10% from the others, a fourth count should be made on the same day as the other three counts. Record each count separately.

MANDATORY DATA:

Procedure A:

1. Number of chicks present at each site or colony (record three to four counts separately).

2. Date of counts.

Procedure B:

1. Nest identification numbers.

2. Number of eggs, chicks, and adults present at each individual nest on each date the nest is observed (every two or five days).

3. Time and date of observation.

Procedure C:

1. Number of nests with eggs at each colony or site (record three to four counts separately).

2. Number of nests with chicks at each colony or site (record three to four counts separately).

3. Number of chicks in creche at each colony or site (record three to four counts separately).

4. Date of counts.

HIGHLY DESIRABLE DATA:

Procedure A:

1. Number of adults present at each site or colony.
2. Time of day when counts were made.

Procedure B:

No complementary data have been specified at present.

Procedure C:

1. Number of eggs per nest (one egg versus two egg nests).
2. Number of chicks per nest (one chick versus two chick nests).

Procedures A, B and C:

Records of any anomalous and/or extreme environmental conditions observed during the study (e.g. snow and ice cover, wind and temperature).

PROBLEMS TO BE CONSIDERED:

Human interference is a major factor in egg loss as any disruption in the colony causes the breakage of eggs or predation by skuas. Interference also dissuades recruitment of sub-adults into the colony and thus over a series of years the number of breeding birds (and chicks) will decline if disturbance is too high. Therefore, walk slowly.

COMMENTS:

DATA PROCESSING AND ANALYSIS:

ANALYTICAL METHODS:

1. The three procedures identified for this parameter require different approaches in analysis. For this reason the same procedure should be used each year in a time series at a particular site. The procedures employed should be chosen carefully at the initiation of a monitoring project, as should the colonies to be investigated. Procedures and colonies should not change in successive years.

2. The time of sampling should be checked against the times of events observed in the chronology study (Method A9) and where they differ significantly chick counts should be adjusted accordingly. If chick counts have to be adjusted the time of sampling should be changed in subsequent years.

3. The results from Procedure A should be analysed to produce mean numbers of chicks at each colony or breeding area for the number of counts employed (minimum three). These data can be used as an index of breeding success directly by comparing counts for specific colonies or groups of colonies, or indirectly by expressing the results as the mean number of chicks per adult over a group of colonies, yielding an attendant variance. It is important that the colonies or breeding areas, and dates of counts are standardised.

4. The results from Procedure B should be analysed to yield the number of pairs rearing 0, 1 and 2 chicks. Mean and standard deviation of the number of chicks per pair should be computed. For Adélie and chinstrap penguins, the annual index could be the mean number of chicks reared per pair; standard methods may be used to compare means between years. Alternatively, methods for the analysis of proportions could be employed; this would probably be the most useful method with marcaroni penguin data.

5. When analysing Procedure C, means and standard deviations should be computed from a number of counts in a similar way to that for Procedure A. An index of number of chicks per nest with eggs may be computed and used as an index in the same way as for Procedure A. Once again, it is important that comparisons between years utilise the same colonies and count times.

INTERPRETATION OF RESULTS:

1. Breeding success will be indicative of many factors, notably adult condition and colony size, food availability, predator pressure, ice conditions and other

environmental features. The success of breeding expressed both as total number of chicks raised and number of chicks raised per adult will have important implications for future population size.

2. Season-to-season variation in breeding success can be considerable. For example, Ref. 6 reports the breeding success in Adélie penguins at Cape Royds as 26, 47 and 68% in three seasons.

PROBLEMS TO BE CONSIDERED:

1. The use of means of ratios in these analyses may lead to biased estimates of variance. For this reason, comparisons between proportions may be more appropriate than considering numbers of chicks per nest/adult.

2. The analyses may be very sensitive to year-to-year changes in the numbers of colonies monitored.

COMMENTS:

DATA REPORTING:

Data should be reported using the latest versions of CCAMLR data submission forms E/A6/A and E/A6/B and E/A6/C for Procedures A, B and C (see Part III, Section 1). Data for different species should be reported on separate forms.

DATES OF OBSERVATION:

Mean laying date of first egg ± standard error (a), range of laying dates (b) and mean date and range of departure of chicks (c):

		Adélie	Chinstrap	Gentoo	Macaroni*	Refs
Prydz Bay	a	10 Nov ± 1.0	NA	NA	NA	2
	b	5–13 Nov				
	c	X		X		
South Orkneys	a	3 Nov ± 0.3	4 Dec ± 0.3	28 Oct ± 0.4 (8 Oct–18 Nov)	X	3
	b	27 Oct–9 Nov	28 Nov–10 Dec	35 days ± 0.1 (32–38)	X	
	c	6 Feb (4–15 Feb)	1 Mar (25 Feb–2 Mar)		X	
South Georgia	a	NA	X	23 Feb–1 Mar	24 Nov ± 0.2	4, 5
	b		X	X	22–24 Nov	
	c		X		25 Feb	

* second egg data (first egg is usually lost before second is laid)
X data not available
NA not applicable, species absent in specified area

REFERENCES:

(1)   Ainley, D.G. and R.P. Schlatter.   1972.   Chick raising ability in Adélie penguins. *Auk*, 89: 559–566.

(2)   Johnstone, G.W., D.J. Lugg and D.A. Brown.   1973.   The biology of the Vestfold Hills, Antarctica. *ANARE Sci. Rep. Ser. B*, 1.

(3)   Lishman, G.S.   1985.   The comparative breeding biology of Adélie and chinstrap penguins, *Pygoscelis adeliae* and *P. antarctica*, at Signy Island, South Orkney Islands. *Ibis*, 127: 84–99.

(4)   Williams, T.D. and J.P. Croxall. 1991. Annual variation in breeding biology of the macaroni penguins, *Eudyptes chrysolophus,* at Bird Island, South Georgia. *J. Zool. Lond*., 223: 189–202.

(5)   Williams, T.D.   1990.   Annual variation in breeding biology of gentoo penguins, *Pygoscelis papua*, at Bird Island, South Georgia. *J. Zool., Lond.*, 222.

(6)   Yeates, G.W. 1968. Studies on the Adélie penguin at Cape Royds 1964–65 and 1965–66. *N.Z. J. Mar.,* 8; *Fresh-Wat. Res.*, 2: 472–496.

BACKGROUND PAPERS:

Ainley, D.G., R.E. Leresche and W.J.L. Sladen.   1983.   *Breeding Biology of the Adélie Penguin.* University of California Press.

BIOMASS 1979. Antarctic Bird Biology. *BIOMASS Report*, 8.

BIOMASS. 1982. Monitoring studies of seabirds. *BIOMASS Handbook*, 19.

BIOMASS. 1982. Penguin census methods. *BIOMASS Handbook*, 20.

BIOMASS. 1983. Meeting of BIOMASS Working Party on Bird Ecology. *BIOMASS Report*, 34.

Emison, W.B. 1968. Feeding preferences of the Adélie penguin at Cape Crozier, Ross Island. *Antarct. Res. Series,* 12: 191–212.

SC-CAMLR. 1985. Report of the Ad Hoc Working Group on Ecosystem Monitoring. In: *Report of the Fourth Meeting of the Scientific Committee (SC-CAMLR-IV)*, Annex 7. CCAMLR, Hobart, Australia: 81–137.

SPECIES: Penguins: Adélie, chinstrap, gentoo, macaroni (*Pygoscelis adeliae*, *Pygoscelis antarctica*, *Pygoscelis papua*, *Eudyptes chrysolophus*)

PARAMETERS: Chick weight at fledging

ASSOCIATED PARAMETERS:

Duration of foraging trips; breeding success.

AIMS:

To determine the mean weight of chicks at fledging.

DATA COLLECTION:

Two methods are outlined for this parameter. Procedure A is preferred (at least for Adélie and chinstrap penguins) because it samples throughout the fledging period. Procedure B is suggested only for cases where fledging is highly synchronous (macaroni penguins) or when the logistics schedule does not allow sampling over a longer period.

GENERAL PROCEDURE:

Procedure A:

Procedure A requires sampling throughout the fledging period. This attempts to allow for biases that might occur if the timing of fledging is related to chick size or colony location:

1. Weigh 50 to 100 chicks per five-day period (to a total of not less than 250 chicks), beginning and ending, respectively, in the periods when the first and last fledglings appear on the beach.

2. Chicks should be captured on the beach as they await departure for sea; capture should be done using a hand net. Put a spot of dye on chicks which have been weighed so that they will not be weighed again. If a banding study is underway, include weighed fledglings in the banding sample (record band number and weight).

3. Weigh each bird to the nearest 10 to 50 g (depending on conditions and accuracy of the scale used). Test the scales against a known weight at periodic intervals.

Procedure B:

Procedure B involves weighing chicks on a single day near the peak of fledging. This method is likely to be mainly appropriate for macaroni penguins where there is highly synchronous fledging:

1. Around the time of peak fledging, as determined by the chronology study colony (Method A9) and regular observations of the beaches where fledglings are likely to occur, weigh a total of approximately 250 to 500 fledglings on the beach;

2. Steps 2 and 3 of Procedure A also apply to Procedure B.

Procedure C:

Procedure C involves weighing chicks which are banded as part of ongoing demographic studies (Method A4).

1. Capture banded chicks which are on the beach and about to fledge. Weigh each chick (to nearest 10 to 50 g) and record its band number.

2. Make regular (once or twice daily) visits to all beaches throughout the fledging period, continuing to capture and weigh banded chicks.

3. Attempt to capture 200 to 300 individuals per year.

MANDATORY DATA:

Procedure A:

1. Dates of samples (in each five-day period).
2. Individual weights of fledglings (in each five-day period).

Procedure B:

1. Date of sample.
2. Individual weights of fledglings.

Procedure C:

1. Date of sample.
2. Individual weights of fledglings.
3. Band number.

HIGHLY DESIRABLE DATA:

1. Daily counts of chicks in creches and/or at water's edge;

2. Observed dates of departures to sea, range of departure dates (i.e. date when first and last fledgling is observed on the beach).

3. Date, weight, band number (if banded) and age of chicks which die during creche stage.

4. Causes of chick mortality where possible.

5. Records of any anomalous and/or extreme environmental conditions observed during the study (e.g. snow and ice cover, wind and temperature).

PROBLEMS TO BE CONSIDERED:

Moulted but unfledged chicks from colonies very close to the beach may be confused with fledglings loitering on the beach prior to their departure to sea. Chicks still being fed by their parents are likely to be heavier than true fledglings and will therefore bias samples. Care should be taken to weigh fledgling chicks in an area where possible confusion with unfledged chicks will be minimised. A recent study of relationships between chick weight and an index of krill availability (Ref. 4) indicated that, while weight at creching showed a positive relationship, weight at fledging showed an inverse relationship. It was hypothesised that this reflects differential chick survival in 'good' and 'bad' years, whereby only heavy chicks survive in bad years but a complete cross-section survive in good years. Until the generality of these findings is investigated, it is suggested that researchers consider weighing penguin chicks at creching as well as at fledging.

COMMENTS:

1. Procedure C will provide a chronology of fledging dates each year and will allow later examination of the relationship between chick fledging weights and survival.

2. The proposed procedure for selecting a sample of nests appears to be too restrictive. The procedure should be made more flexible to allow for differences in site conditions and colony size while maintaining the required sample size.

DATA PROCESSING AND ANALYSIS:

ANALYTICAL METHODS:

1. Calculate the mean weight and standard deviation of all birds fledging in a five-day period. Use of Procedure A, sampling throughout the period, will yield data covering many five-day periods. Procedure B will probably yield weights for a single five-day period.

2. The percentage of birds fledging in the five- day periods must also be obtained to provide a weighting factor for computation of a fledging weight index. This percentage should be calculated using the results of the chronological study (Method A9), or estimated from another source.

3. Development of an annual index of fledging weight will most probably involve mean weights; statistical tests for differences between years would include comparison of means and nested ANCOVA computations.

INTERPRETATION OF RESULTS:

1. The weight of chicks at fledging will give an indication of the likelihood of survival over the winter period at sea, with lighter chicks less likely to survive than heavier chicks. Chick weights at fledging can reflect prey species availability as well as parent breeding experience.

2. Chick weight at fledging may be affected by:

    (i)   breeding experience and age of parents;
    (ii)   prey species availability;
    (iii) individual variation; and
    (iv) variation in timing of breeding events.

PROBLEMS TO BE CONSIDERED:

Where analysis of variance reveals significant seasonal differences in fledging weight, especially when following a trend, it may be more appropriate to choose a particular set of five-day periods for the annual index. Alternatively, ANCOVA analyses may prove necessary. See also Ref. 4 for a cautionary note on interpretation of data on chick fledging weight.

COMMENTS:

DATA REPORTING:

Data should be reported using the latest version of CCAMLR data submission form E/A7 (see Part III, Section 1).

DATES OF OBSERVATION:

Reported mean fledging dates ± standard error at nominated breeding areas:

	Adélie	Chinstrap	Gentoo	Macaroni	Refs
Prydz Bay	X	NA	NA	NA	
South Orkneys	6 Feb ± 0.6	1 Mar ± 0.5	X	X	1
South Georgia	NA	X	23 Feb–1 March	25 Feb ± 1	3, 4
South Shetlands	25 Jan (first fledging)	25 Feb (first fledging)	X	X	2, 3

X   data not available
NA not applicable, species absent in specified area

REFERENCES:

(1)   Lishman, G.S.   1985.   The comparative breeding biology of Adélie and chinstrap penguins, *Pygoscelis adeliae* and *P. antarctica*, at Signy Island, South Orkney Islands. *Ibis*, 127: 84–99.

(2)   Nielsen, D.R. 1983.   Ecological and behavioural aspects of the sympatric breeding of the south polar skua (*Catharacta maccormicki*) and the brown skua (*Catharacta lönnbergi*) near the Antarctic Peninsula.   Unpubl. MS Thesis, Univer. Minnesota, Minneapolis.

(3)   Williams, T.D. and J.P. Croxall. 1991. Annual variation in breeding biology of the macaroni penguins, *Eudyptes chrysolophus,* at Bird Island, South Georgia. *J. Zool. Lond*., 223: 189–202.

(4)   Williams, T.D. and J.P. Croxall. 1990. Is chick fledging weight a good index of food availability in seabird populations? *Oikos*, 59 (3): 414–416.

BACKGROUND PAPERS:

Ainley, D.G. and R.J. Boekelheide.   1990.   *Seabirds of the Farallon Islands: Ecology, Structure and Dynamics of an Upwelling-system Community*.   Stanford University Press, California.

Croxall, J.P. 1984. Seabirds.   In: Laws, R.M. (Ed.).   *Antarctic Ecology*, 2. Academic Press: 533–619.

Harris, M.P. 1984. *The Puffin*. Poyser.

Johnstone, G.W., D.J. Lugg and D.A. Brown. 1973. The biology of the Vestfold Hills, Antarctica. *ANARE Sci. Rep. Ser. B*, 1.

Ricklefs, R.E., D.C. Duffy and M. Coulter. 1984. Weight gains of blue-footed booby chicks: an indicator of marine resources. *Ornis. Scand.*, 15: 162–66.

Trivelpiece, W.Z., S.G. Trivelpiece and N.J. Volkman. 1987.   Ecological segregation of Adélie, gentoo and chinstrap penguins at King George Island, Antarctica. *Ecology*, 68: 351–361.

Williams, T.D. 1990. Annual variation in breeding biology of gentoo penguins, *Pygoscelis papua*, at Bird Island, South Georgia. *J. Zool., Lond.*, 222.

SPECIES: Penguins: Adélie, chinstrap, macaroni
(*Pygoscelis adeliae*, *Pygoscelis antarctica*, *Eudyptes chrysolophus*)

PARAMETERS: Chick diet

AIMS:

To characterise the general composition of chick diet.

DATA COLLECTION:

Two procedures are outlined for this method. Conducting Procedure A is mandatory. Procedure B provides highly desirable, complementary data to the results of Procedure A.

GENERAL PROCEDURE:

Procedure A:

1. Collect five samples in each five-day period throughout the entire creche period. Thirty samples (at least) should be collected.

2. Capture adults on the beach as they leave the sea. Use a hand-held net. Do not include marked individuals being used in other studies.

3. Using the stomach flushing technique, as described in Part IV, Section 2, collect the stomach contents of the birds into a bucket (see Refs 1, 4 and 7).

4. Record wet weight of whole sample after draining. Then sort material into the three main categories (squid, fish, crustaceans) and record wet weight of each category.

5. Sort crustacean material into four categories: (a) *Euphausia superba*, (b) *E. crystallorophias*, (c) other euphausiids, (d) other crustaceans; record wet weight of each category.

Procedure B:

Squid:

1. Try to identify any intact squid (Ref. 3). Fix and preserve whole in 4% formaldehyde/seawater or Steedman's solution any more or less intact squid. From other squid material, remove beaks and preserve these in 70% ethyl alcohol or 1% formaldehyde. Keep beaks from each sample together and ensure that every container has a label. Record number of intact squid and of lower beaks.

2. Identify beaks (Ref. 2) and measure length of lower rostrum. Determine length and weight of squid from the appropriate regression equations (Ref. 2).

Fish:

1. Try to identify any intact fish (Ref. 3). Remove otoliths from intact crania. Keep each pair of otoliths so extracted separate (so one knows that both came from the same individual) and labelled. Collect all loose otoliths and keep together as a separate batch. Store dry in a safe place (otoliths are fragile). Record number of otolith pairs and loose otoliths in each sample.

2. Give each pair of extracted otoliths a reference number. Identify (Ref. 5) and measure maximum length and breadth of each. Record number, measurement and identification. Use standard equations (e.g. Ref. 5) to estimate original length and weight of each fish eaten. Loose otoliths are likely to be eroded and difficult to identify but it should be possible to divide them into the major taxonomic groups – and possibly further. Estimates of fish length and weight from loose otoliths will be less accurate (because of digestion) than those from otoliths removed from crania, which are undigested.

Crustaceans:

1. If further analysis does not directly follow determination of general composition, fix material in 4% buffered formaline/seawater for subsequent detailed analysis. The formalin should be replaced at frequent intervals.

2. Sort and identify material in the other euphausiid and other crustacean categories as required.

3. From the *E. superba* and *E. crystallorophias* material in each sample, select randomly 25 to 50 specimens which have an intact carapace with at least the first abdominal segment and legs still attached. If fewer than 25 specimens meet this criterion, use all of them. Remove carapaces off underlying tissues. For each specimen record sex (Ref. 6), determine maturity stage (Ref. 8) and measure by means of graticulation a length of removed carapace along the mid-dorsal line, with carapace dorsal side down. Total length can then be calculated from the following regression equations (Ref. 9) in Table 1 (see 'Analytical Methods' below).

MANDATORY DATA (Procedure A):

1. Sex of the sampled birds (see Part IV, Section 1).

2. Number of chicks of the bird at the time of sampling. This could be obtained by either capturing the bird at its nest site instead of on the beach or by marking the bird following sampling and following it to the nest.

3. Record all data irrespective of stomach content. (i.e. even when stomach is empty).

4. Time and date of each sample.

5. Total wet weight of drained sample.

6. Wet weight of each of the following categories: squid, fish and total crustaceans.

7. Wet weight of each of the following crustacean categories: *E. superba*, *E. crystallorophias*, other euphausiids and other crustaceans.

HIGHLY DESIRABLE DATA

(Procedure B):

1. Identity and number of fish and squid in sample.

2. Length of lower rostrum of squid beaks.

3. Estimate of squid length and weight derived from regression equations.

4. Maximum length and breadth of otoliths (one from each pair).

5. Estimate of original lengths and weight of fish derived from regression equations.

6. Sex, maturity stage and calculated total length of a sample of *E. superba* and *E. crystallorophias*.

7. Identity and contributions by weight of any crustacean, other than *E. superba* and *E. crystallorophias*, comprising a significant proportion of any sample.

Procedures A and B:

Records of any anomalous and/or extreme environmental conditions observed during the study (e.g. snow and ice cover, wind and temperature).

PROBLEMS TO BE CONSIDERED:

1. All stomach samples should be drained of water in an identical way (as near as possible) to provide comparable wet weights. An example of methodology applied to this problem would be to put the samples into a plastic measuring cylinder with the base replaced by mesh of a fixed size. It would then be subjected to a standard 3 kg pressure for two minutes before packaging. This methodology would require standardisation.

2. Given that the time of day may influence the relative availability of prey and therefore the prey eaten by birds, investigators may wish to standardise the time at which they take samples at their research sites.

3. Stomach lavage should only be attempted by experienced researchers or those directly under their supervision.

4. Penguins should be lavaged with soft latex tubing as it does not get stiff and brittle in the cold and risk of injury is greatly reduced. Tubing can be permanently softened by carefully controlled autoclaving.

5. For Adélie penguins in the Prydz Bay area, the first and subsequent vomits should be analysed and reported separately, particularly since it has been demonstrated that there are different foraging strategies for male and female Adélies with males taking more food from the neritic zone. Food from such areas is more common in the first vomit as it is collected by birds as they return to their breeding colony.

6. A possible bias for species with individuals whose foraging trips may or may not include overnight periods at sea should be considered.

7. The development of a standardised procedure which would enable a quantitative evaluation of stomach content needs to be considered. This would include evaluation of the sample wet weight versus displacement volume, methods of getting excess water from the sample, and using a standard volume of water for each sample.

COMMENTS:

The development of proposals concerning specific objectives that could be addressed with further modification of Procedure B are encouraged. In particular, it would be useful to evaluate the data required to detect and differentiate changes in prey characteristics across time within a season. Similarly, Members are encouraged to undertake analyses that clarify the statistical properties of estimates of general prey composition under Procedure A.

DATA PROCESSING AND ANALYSIS:

ANALYTICAL METHODS:

1. The methods mentioned here address only the general composition of chick diet (Procedure A). Analytical methods for Procedure B including length frequencies, maturity stage and sex of, for example, krill (highly desirable data) have not yet been developed.

2. The equations listed in Table 1 should be used to determine the total length of specimens from carapace length alone. This should be carried out for all specimens for which sex and age class is determinable. For samples which are so badly degraded that these characteristics are not determinable, an estimate of total length may be obtained from the composite equation for all stages given in Table 1. However, these results should be used cautiously because the Root Mean Square (RMS) of this equation is much higher than for the others.

3. Record raw data for submission to CCAMLR. These data will yield mean weights and proportions of different food items.

4. The analyses to be conducted using these data to develop an annual index of food availability have yet to be determined, but collection and submission of raw data will ensure that the appropriate analyses are possible. Suggestions of the type of analyses to be considered could be analysis of frequencies of food occurrence, and analysis of variances of absolute mean foodstuff weights.

Table 1: Regression equations for calculation of total *E. superba* length (L) from its carapace length (*l*), taken from Ref. 6. Similar relationships are not yet available for *E. crystallorophias*.

	Regression Equation	R-squared	Root Mean Square (RMS)
Juvenile	$L = -1.59 + 3.28\ l$	95.4%	1.248
Sub-adults:			
Males	$L = 3.33 + 2.99\ l$	90.7%	1.541
Females	$L = 14.6 + 2.17\ l$	61.8%	1.818
Adults:			
Males	$L = 15.6 + 2.48\ l$	40.0%	2.811
Females	$L = 13.5 + 2.48\ l$		
All stages:	$L = 11.6 + 2.44\ l$	77.4%	7.70

INTERPRETATION OF RESULTS :

Chick diet has a direct impact on chick survival. Indirectly, the availability of food will affect adult condition and foraging time, which may alter rates of nest desertion. Analysis of proportional composition of chick diet and total volume of food is most directly indicative of species specific prey availability.

PROBLEMS TO BE CONSIDERED:

COMMENTS:

DATA REPORTING:

Mandatory data should be reported using the latest version of CCAMLR data submission form E/A8 (see Part III, Section 1). Data for different penguin species and beaches should be reported on separate forms.

DATES OF OBSERVATION:

REFERENCES:

(1) Adams, N.J. and N.T. Klages. 1987. Seasonal variation in the diet of the king penguin (*Aptenodytes patagonicus*) at sub-Antarctic Marion Island. *J. Zool., Lond.*, 212: 303–324.

(2) Clarke, M.R. (Ed.). 1986. *A Handbook for the Identification of Cephalopod Beaks*. Clarendon Press, Oxford: 1–273.

(3) Fischer, W. and J.-C. Hureau (Eds). 1985. *FAO Species Identification Sheets for Fishery Purposes. Southern Ocean (CCAMLR Convention Area Fishing Areas 48, 58 and 88)*, Vol. II. Prepared and published with the support of the Commission for the Conservation of Antarctic Marine Living Resources. FAO, Rome: 233–470.

(4) Gales, R.P. 1987. Validation of the stomach-flushing technique for obtaining stomach contents of penguins. *Ibis,* 129: 335–343.

(5) Hecht, T. 1987. A guide to the otoliths of Southern Ocean fishes. *S. Afr. J. Antarct. Res.,* 17: 1–87.

(6) Hill, H.J. 1990. A new method for the measurement of Antarctic krill, *Euphausia superba* Dana, from predator food samples. *Polar Biol.,* 10: 300–317.

(7) Kirkwood, J.M. 1982. A guide to the Euphausiacea of the Southern Ocean. *ANARE Research Notes,* 1: 1–45.

(8) Makarov, R.R. and C.J. Denys. 1982. Stages of sexual maturity of *Euphausia superba* Dana. *BIOMASS Handbook,* 11.

(9) Wilson, R.P. 1984. An improved stomach pump for penguins and other seabirds. *J. Field Ornithol.,* 55: 109–112.

BACKGROUND PAPERS:

Anon. Bird Island Penguin Monitoring Studies. Collection and Processing of Prey Samples. Available from: British Antarctic Survey, Cambridge, UK.

Clarke, J. and K. Kerry. 1994. The effects of monitoring procedures on Adélie Penguins. *CCAMLR Science,* 1: 155–164.

Robertson, G., S. Kent and J. Seddon. Effects of the water-offloading techniques on Adélie penguins. *J. Field Ornithol.,* 65 (3): 376–380.

SPECIES: Penguins: Adélie, chinstrap, gentoo, macaroni (*Pygoscelis adeliae*, *Pygoscelis antarctica*, *Pygoscelis papua*, *Eudyptes chrysolophus*)

PARAMETERS: Breeding chronology

AIMS:

1. To determine on an annual basis the rate of arrival at the colony for both sexes, the rate of egg-laying, the rate of hatching, the date of completion of brooding (date of creching), and the dates of fledging.

2. The parameters of adult weight on arrival (Method A1(B)), annual trend in breeding population (Method A3), age-specific survival and recruitment (Method A4(A)), breeding success (Method A6), and chick fledging weight (Method A7) all depend on obtaining the necessary data identified in 1. above (see Table 1). However, it is likely that the timing of these events vary from year to year. The purpose of this method is to obtain chronological data on an annual basis to provide an opportunity to correct data gathered at sub-optimal dates.

DATA COLLECTION:

GENERAL PROCEDURE:

1. Select a colony containing about 200 pairs close to the colony (colonies) where monitoring of parameters A1, A3, A6 and A7 is being undertaken. This colony should be situated so that the approach to the colony over ice and its access to the open sea is similar to others and should not be affected by other studies or station activities. So that the rate of fledging can be readily determined, a colony should be selected which is clearly separated from the beach at which the chicks assemble before departing for sea.

2. Several of the standard methods require data to be collected in standard five-day blocks (see Part III, Section 2). It is better, however, in establishing the chronology of the colony that data be gathered on a more frequent basis (e.g. daily or every other day) and summarised into the five-day blocks as required.

3. **Rate and mean date of arrival**. Count on a daily basis the number of birds present within the boundaries of the colony as determined by the area occupied by the nests of the previous season. Continue the daily counts until the number of birds present in the colony is approximately constant.

4. **Mean date of laying**. On the day the first egg is laid in the colony (about 20 October and 20 November, respectively, for Adélie and chinstrap penguins on King George Island; 28 October and 14 November for gentoo and macaroni penguins respectively at South Georgia), select 100 contiguous nests along a line which runs through several breeding sites. Mark every pair of nests with a painted rock or flagged nail driven into the ground between the two; every tenth nest mark with a numbered stake (1, 10, 20, 30 etc.). Squirt dye on the breast of nest occupants on the day the first egg is observed. Every second day thereafter, note the number of eggs present. Record also all nests which fail.

5. **Rate and mean date of hatching**. As hatching approaches check all the nests identified in step 4 above on a daily basis and record for each nest the date the first chick is completely out of the shell (i.e. hatching date). Continue observations of each marked nest on a daily basis until a chick has hatched or the nest fails.

6. **Cessation of brooding**. Starting on a day known to fall prior to the onset of creching (based on data from previous seasons), visit each of the marked nests on a daily basis and record the presence of an adult obviously guarding the chick. Continue the recording until 90% of the nests which contained chicks are no longer being brooded.

7. **Mean date of fledging**. Record the date on which the last chick in the colony ceases to be brooded. Thereafter count on a daily basis the total number of chicks present in the colony. Continue daily counts until all chicks have departed the colony for the beach. It is not necessary to record marked nests as counts for all nests in the colony will suffice.

MANDATORY DATA:

1. Total number of adults present each day during arrival period (count daily).

2. Date on which first egg is laid in colony.

3. Number of eggs present in each nest (of 100-nest sample) from start of egg-laying to end of hatching (count every second day).

4. Hatching date for the first egg in each nest (of 100-nest sample).

5. For each nest (of 100-nest sample), date on which brooding stops.

6. Date on which the last chick ceases to be brooded (in 100-nest sample).

7. Total number of chicks present in colony from cessation of brooding to completion of fledging (count daily).

8. Dates of all counts.

HIGHLY DESIRABLE DATA:

Records of any anomalous and/or extreme environmental conditions observed during the study (e.g. snow and ice cover, wind and temperature).

PROBLEMS TO BE CONSIDERED:

1. The chronology of the breeding cycle will need to be determined annually (initially for 10 years) in order to establish the range of critical dates for the monitoring parameter.

2. Human interference is a major factor in egg loss as any disruption in the colony causes the breakage of eggs or predation by skuas. Interference also dissuades recruitment of sub-adults into the colony and thus over a series of years the number of breeding birds (and chicks) will decline if disturbance is too high. Therefore, walk slowly.

COMMENTS:

The proposed procedure for selecting a sample of nests appears to be too restrictive. The procedure should be made more flexible to allow for differences in site conditions and colony size while maintaining the required sample size.

DATA PROCESSING AND ANALYSIS:

ANALYTICAL METHODS:

1. Two types of data summaries are required for this method, rates of events and dates of events. To calculate both these sets of data, create a frequency table of days versus number of events. Days should be expressed both as dates and numbers of days elapsing from the first day of monitoring. The events for each day should be: number of adults arriving, number of nests with first egg laid, number of nests with first hatching, number of nests ceasing brooding and number of chicks fledging.

2. From the frequency table calculate mean dates of events and where applicable dates of 1/3, 2/3 and 95% completion of events. Dates of initiation and completion of events are also available from this table.

3. From the data in the first frequency table, produce a second table of five-day periods versus number of events. Each of the columns in this table should have the form of a frequency distribution.

4. If Methods A1 and A7 have been monitored, calculate the percentage of adults arriving or chicks fledging for each five-day period and use these results in the analysis of Methods A1 and A7.

INTERPRETATION OF RESULTS:

1. These results are directly applicable to Methods A1, A3, A6 and A7; five-day periods of peak occurrence of events can be easily seen from the data.

2. Long-term analysis will yield estimates of the variability of various events and should influence future planning of research.

3. Season-to-season variation in breeding success can be considerable.

4. Breeding success may be influenced by:
   [colony size – large colonies tend to have better success;]
   [ice conditions – daily maps of ice cover desirable].

PROBLEMS TO BE CONSIDERED:

True representation of chronology parameters will only come with regular recording of events from or before the start of those events. For this reason mean arrival date is highly sensitive to the start of recording at the beginning of a field season. Median or modal arrival dates may be less biased.

CCAMLR Standard Method A9 (v4)

COMMENTS：

Note that if a nest fails during one period it should not be included in the 'totals monitored' calculation for the next section (Items 35 and 36 of form E/A9).   For example, if 100 nests were monitored for egg-laying and five failed then the total monitored for hatching should be 95.

DATA REPORTING:

Data should be reported using the latest version of CCAMLR data submission form E/A9 (see Part III, Section 1). Data for different species should be reported on different forms.

DATES OF OBSERVATION:

Mean laying date of first egg ± standard error (a), range of laying dates (b) and mean date and range of departure of chicks (c).

		Adélie	Chinstrap	Gentoo	Macaroni*	Refs
Prydz Bay	a	10 Nov ± 1.0	NA	NA	NA	1
	b	5–13 Nov				
	c	X				
South Orkneys	a	3 Nov ± 0.3	4 Dec ± 0.3	X	X	2
	b	27 Oct–9 Nov	28 Nov–10 Dec		X	
	c	6 Feb (4–15 Feb)	1 Mar (25 Feb–2 Mar)		X	
South Georgia	a	NA	X	28 Oct ± 0.4 (8 Oct–18 Nov)	23 Nov ± 3	3, 4
	b		X	35 days ± 0.1 (32–38)	X	
	c		X	23 Feb–1 March	X	

*   second egg data (first egg is usually lost before second is laid)
X   data not available
NA not applicable, species absent in specified area

Figure 1: Schematic diagram of the relationship between timing of standard methods, chronology study and penguin behaviour.

Table 1:   Relationships of chronology parameters to other standard methods.

Chronology Parameter	Chronology Method	Relevant Standard Method
Rate of adult arrival	Total colony count	A1(A) (adult arrival weight) A1(B) (adult arrival weight)
Rate of egg-laying and failure	100 marked nests	
Date when 1/3 eggs laid	100 marked nests	A4(A) (survival and recruitment)
Date when 95% nests have eggs	100 marked nests	A6 (C)a (nests with eggs)
Date when laying complete	100 marked nests	A3 (breeding population trend)
Rate of chick hatching and mortality	100 marked nests	
Date when hatching is complete	100 marked nests	A5 (foraging trips) A6(C)b (nests with chicks)
Rate of chicks entering creche	100 marked nests	
Date when 2/3 chicks in creche	100 marked nests	A6(A) (chick count)
Date when all chicks in creche	100 marked nests	A6(C)c (chick count)
One week prior to onset of fledging	Approximation	A6(B) (chick count) A4(B) (survival and recruitment)
Rate of fledging	Total colony count	A7(A) (fledging weight) A7(B) (fledging weight)

Standard Methods:

- A1   Adult weight on arrival at breeding colony
- A2   Duration of the first incubation shift
- A3   Annual trend in size of breeding population
- A4   Age-specific annual survival and recruitment
- A5   Duration of foraging trips
- A6   Breeding success
- A7   Chick weight at fledging
- A8   Chick diet

REFERENCES:

(1) Johnstone, G.W., D.J. Lugg and D.A. Brown. 1973. The biology of the Vestfold Hills, Antarctica. *ANARE Sci. Rep. Ser. B*, 1.

(2) Lishman, G.S. 1985. The comparative breeding biology of Adélie and chinstrap penguins, *Pygoscelis adeliae* and *P. antarctica*, at Signy Island, South Orkney Islands. *Ibis*, 127: 84–99.

(3) Williams, T.D. 1990. Annual variation in breeding biology of gentoo penguins, *Pygoscelis papua*, at Bird Island, South Georgia. *J. Zool., Lond.*, 222.

(4) Williams, T.D. and J.P. Croxall. 1991. Annual variation in breeding biology of the macaroni penguins, *Eudyptes chrysolophus*, at Bird Island, South Georgia. *J. Zool. Lond.*, 223: 189–202.

BACKGROUND PAPERS:

Ainley, D.G., R.E. Leresche and W.J.L. Sladen. 1983. *Breeding Biology of the Adélie Penguin*. University of California Press.

Ainley, D.G. and R.P. Schlatter. 1972. Chick raising ability in Adélie penguins. *Auk*, 89: 559–566.

BIOMASS. 1979. Antarctic bird biology. *BIOMASS Report*, 8.

BIOMASS. 1982. Monitoring studies of seabirds. *BIOMASS Handbook*, 19.

BIOMASS. 1982. Penguin census methods. *BIOMASS Handbook*, 20.

BIOMASS. 1983. Meeting of BIOMASS Working Party on Bird Ecology. *BIOMASS Report*, 34.

Emison, W.B. 1968. Feeding preferences of the Adélie penguin at Cape Crozier, Ross Island. *Antarct. Res. Series,* 12: 191–212.

SC-CAMLR. 1985. Report of the Ad Hoc Working Group on Ecosystem Monitoring. In: *Report of the Fourth Meeting of the Scientific Committee (SC-CAMLR-IV)*, Annex 7. CCAMLR, Hobart, Australia: 81–137.

Yeates, G.W. 1968. Studies on the Adélie penguin at Cape Royds 1964–65 and 1965–66. *N.Z. J. Mar.,* 8; *Fresh-Wat. Res.*, 2: 472–496.

SECTION 2

FLYING BIRDS: METHODS B1 – B6

SPECIES: Black-browed albatross (*Diomedea melanophris*)

PARAMETERS: Breeding population size

ASSOCIATED PARAMETERS:

Breeding success, diet, age-specific annual survival and recruitment.

AIMS:

Determine interannual trends in size of breeding population.

DATA COLLECTION:

Two methods are provided. Procedure A should be conducted in conjunction with the demographic studies and requires daily visits throughout the laying period. Procedure B involves one visit.

GENERAL PROCEDURE:

Procedure A:

1. At the study colony of 200 to 500 pairs, make daily visits during the egg-laying period (19 October to 11 November at South Georgia), and place numbered tags in the pedestals of nests where pairs have laid.

2. When laying is complete record the total number of nests at which eggs were laid.

Procedure B:

1. Count all nests with incubating birds present as soon as possible after laying ceases (11 November at South Georgia).

2. Three separate counts should be made of each of the selected colonies on the same day. If one of the three counts differs more than 10% from the others, a fourth count should be made on the same day as the other three counts. Record each count separately.

MANDATORY DATA:

Procedure A:

1. Date and time of observations.
2. Number of tags placed each day.
3. Nest identification number.
4. Total number of nests at which eggs were laid should be reported.

CCAMLR Standard Method B1 (v3)

Procedure B:

1. Date of counts.
2. Total number of nests at which eggs were laid.

HIGHLY DESIRABLE DATA:

Procedure A:

Dates of start and cessation of laying.

Procedures A and B:

Records of any anomalous and/or extreme environmental conditions observed during the study (e.g. snow and ice cover, wind and temperature).

PROBLEMS TO BE CONSIDERED:

COMMENTS:

DATA PROCESSING AND ANALYSIS:

ANALYTICAL METHODS:

1. If Procedure B was used, calculate the mean number of nests incubating eggs over the three (or four) counts. If Procedure A was used, absolute numbers of nests incubating eggs should be used.

2. Means of the number of incubating nests (Procedure B) or total numbers and rates of laying (Procedure B) may provide useful indices for yearly comparisons.

INTERPRETATION OF RESULTS:

Large changes in the breeding population size, dates of cessation of laying, or rates of laying, may indicate changes in pre-breeding condition. When the appropriate models of laying rate are fitted, comparison of successive years/colonies may be possible. The total number of incubating nests has important consequences for future demographic trends.

PROBLEMS TO BE CONSIDERED:

COMMENTS:

DATA REPORTING:

Data from Method B1 should be reported using the latest version of CCAMLR data submission form E/B1 (see Part III, Section 1). This form is to be used for both Methods B1 and B2, which should usually be carried out in conjunction.

DATES OF OBSERVATION:

Timing of breeding season events in the black-browed albatross (South Georgia):

Lay	Hatch	Fledge	Ref.
27 Oct (19 Oct–11 Nov)	3 Jan (26 Dec–11 Jan)	28 Apr (17 Apr–9 May)	1

REFERENCES:

(1)   Tickell, W.L.N. and R. Pinder. 1975. Breeding biology of the black-browed albatross,   *Diomedea   melanophris*,   and   grey-headed   albatross, *D. chrysostoma*, at Bird Island, South Georgia. *Ibis,* 117: 433–450.

BACKGROUND PAPERS:

Croxall, J.P., T.S. McCann, P.A. Prince and P. Rothery. 1988. Reproductive performance of seabirds and seals at South Georgia and Signy Island, South Orkney Islands, 1976–1987: implications for Southern Ocean monitoring studies. In: Sahrhage, D. (Ed.).   *Antarctic Ocean and Resources Variability*. Springer-Verlag, Berlin, Heidelberg: 261–285.

Prince, P.A., P. Rothery, J.P. Croxall and A.G. Wood. 1994. Population dynamics of black-browed and grey-headed albatrosses, *Diomedea melanophris* and *D. chrysostoma*, at Bird Island, South Georgia. *Ibis*, 136: 50–71.

SPECIES: Black-browed albatross (*Diomedea melanophris*)

PARAMETERS: Breeding success

ASSOCIATED PARAMETERS:

Breeding population size, diet.

AIMS:

To assess productivity, ideally in terms of both eggs hatched and chicks fledged.

DATA COLLECTION:

Two methods are provided. Procedure A is a continuation of the method used in determining breeding population size and requires daily visits throughout the hatching period and several visits around the time of fledging. Procedure B involves two visits.

GENERAL PROCEDURE:

Procedure A:

1. At the same colony where all nests were tagged for the determination of breeding population size (Method B1), make daily visits between 26 December and 11 January to determine how many eggs hatch successfully. Remove tags from failed nests and record total.

2. Not later than 16 April band all surviving chicks and remove tags from all nests where chicks have disappeared.

3. Visit the colony every two to three days until all birds have fledged recording the number of nests at which dead ringed chicks are present. Record total number of chicks that died since ringing and add to this chick losses between hatching and banding and calculate overall hatching success (chicks fledged as a proportion of chicks hatched).

4. Overall breeding success is the proportion of chicks fledged from the eggs laid.

Procedure B:

1. At the same colony where the breeding population census was made around 12 January count the number of nests with adult birds brooding chicks.

2. Around 16 April count the number of chicks surviving.

3. From these two counts calculate hatching and fledging success.

4. Three separate counts should be made of the study colony on the same day. If one of the three counts differs more than 10% from the others, a fourth count should be made on the same day as the other three counts. Record each count separately.

CCAMLR Standard Method B2 (v3)

MANDATORY DATA:

Procedure A:

1. Dates of all counts.
2. Numbers of eggs present or hatched at each visit.
3. Numbers of chicks dying between hatching and banding.
4. Numbers of chicks dying between banding and fledging.
5. Band numbers of all chicks with date banded, date fledged, and/or date died.
6. Total number of failed nests.

Procedure B:

1. Dates of all counts.
2. Number of nests with adult birds brooding chicks.
3. Number of chicks surviving to near fledging.

HIGHLY DESIRABLE DATA:

1. Dates of first and last laying, hatching and fledging.

2. Records of any anomalous and/or extreme environmental conditions observed during the study (e.g. snow and ice cover, wind and temperature).

PROBLEMS TO BE CONSIDERED:

It is important that the same dates (or nearly the same) are used each year for Procedure B.

COMMENTS:

DATA PROCESSING AND ANALYSIS:

ANALYTICAL METHODS:

1. Calculate the number of eggs laid (Procedure A only), chicks hatched and chicks fledged. From these numbers compute:

   (a) breeding success = chicks fledged / eggs laid;
   (b) hatching success = chicks hatched / eggs laid; and
   (c) fledging success = chicks fledged / chicks hatched.

2. Breeding success is probably the most useful index to use for interannual comparisons. The most appropriate statistics for these comparisons are probably analyses of frequencies. A method for computing the sample size required to detect a true difference between two proportions ('Power analysis') is given in box 17.10, p. 766 of Ref. 2.

INTERPRETATION OF RESULTS:

PROBLEMS TO BE CONSIDERED:

COMMENTS:

DATA REPORTING:

Data from Method B2 should be reported using the latest version of CCAMLR data submission form E/B1 (see Part III, Section 1). This is the same form as for Method B1. The data from Method B2 should be reported as continuous with the data from Method B1 on this form, and the two methods should usually be carried out in conjunction.

DATES OF OBSERVATION:

REFERENCES:

(1) Prince, P.A., P. Rothery, J.P. Croxall and A.G. Wood. 1994. Population dynamics of black-browed and grey-headed albatrosses, *Diomedea melanophris* and *D. chrysostoma*, at Bird Island, South Georgia. *Ibis*, 136: 50–71.

(2) Sokal, R.R. and F.J. Rohlf. 1981. *Biometry: the Principles and Practice of Statistics in Biological Research.* 2nd Edition. Freeman, New York.

BACKGROUND PAPERS:

SPECIES: Black-browed albatross (*Diomedea melanophris*)

PARAMETERS: Age-specific annual survival and recruitment

ASSOCIATED PARAMETERS:

Breeding population size, breeding success.

AIMS:

To determine the demographic parameters of the population.

DATA COLLECTION:

This study requires a colony of between 200 and 500 pairs and can be conveniently combined with the determination of breeding population size and success, which would ideally be recorded on a pair-specific basis, using the tagged nests.

GENERAL PROCEDURE:

1. Make daily visits during egg-laying (19 October to 11 November) and ring and record identity of both partners at all nests at which eggs are laid.

2. Ring all chicks just prior to fledging before 17 April.

3. Record identity of all chicks dying before fledging.

4. Continue this annually.

See description of field methods in Ref. 3.

MANDATORY DATA:

1. List of band numbers of breeding adults.
2. List of band numbers of chicks surviving to fledging.

HIGHLY DESIRABLE DATA:

1. Determine sex of birds (by observed copulation or measurement of bill length).

2. Records of any anomalous and/or extreme environmental conditions observed during the study (e.g. snow and ice cover, wind and temperature).

PROBLEMS TO BE CONSIDERED:

After about seven years it will be necessary to check any adjacent breeding colonies for chicks which were banded in the study colony and have emigrated to these other

colonies to breed. Note that once adults have bred in a colony they remain faithful to this colony thereafter. See data on analysis of immigration and emigration effects in Ref. 3.

COMMENTS:

DATA PROCESSING AND ANALYSIS:

1. Because of the complexity and large number of approaches to the analysis of demographic data, standard data processing, analysis and reporting protocols will be developed in the future, following consideration of procedures already in use in individual Member's programs.

2. For the study of black-browed albatrosses at Bird Island, South Georgia, data processing and analytical techniques are described in Ref. 3. Briefly, data are stored in an ORACLE relational database management system. Data are entered at the field site and preliminary validation performed at this time. Additional checking programmes are run on the data once it has been transferred to a mainframe computer in the UK. Data are extracted for analysis using queries written in Structured Query Language.

   Full details of the database, its management system and the analytical protocols can be obtained from Dr A.G. Wood, British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, UK.

ANALYTICAL METHODS:

Adult Survival:

Estimates of adult survival rate (calculated using recaptures in subsequent years of birds after their first observed breeding attempt) were obtained using the method in Ref. 1. To test for annual variation in survival over a specified period, a reduced model in which survival was assumed constant over that period was compared with the fit of a model allowing variation; this was fitted using the package SURGE (Ref. 2).

Recruitment:

Recruitment, defined as the proportion of fledged chicks which survive to breed, was estimated from recaptures of chicks ringed as fledglings and recovered subsequently in the study colonies.

INTERPRETATION OF RESULTS:

PROBLEMS TO BE CONSIDERED:

Adult Survival:

Some potential minor biases and other problems are discussed in Ref. 3.

Recruitment:

Recruitment rates will be underestimated by the extent to which fledglings recruit into colonies other than their natal one. Ref. 3 concluded that in their study this bias was fairly small but it is important to check this for each study site/population by searching for ringed fledglings in colonies away from their natal study colony.

DATA REPORTING:

Adult Survival:

Results should be presented as arithmetic mean annual survival rates (with standard errors) for each year of the study, for females, males and all birds separately. Reporting survival data in this format used in Ref. 3, Table 10.

Recruitment:

The content and format used in Ref. 3, Table 6 is probably appropriate at least in the interim.

DATES OF OBSERVATION:

REFERENCES:

(1)   Cormack, R.M. 1965. Estimates of survival from the sightings of marked animals. *Biometrika*, 51: 429–438.

(2)   Lebreton, J.D. and J. Clobert. 1986. *User's Manual for Program SURGE*. CEPE/CNRS, Montpellier, France.

(3)   Prince, P.A., P. Rothery, J.P. Croxall and A.G. Wood. 1994. Population dynamics of black-browed and grey-headed albatrosses, *Diomedea melanophris* and *D. chrysostoma*, at Bird Island, South Georgia. *Ibis*, 136: 50–71.

BACKGROUND PAPERS:

SPECIES: Cape petrel, Antarctic petrel (*Daption capense*, *Thalassoica antarctica*)

PARAMETERS: Chick diet

ASSOCIATED PARAMETERS:

AIMS:

To characterise the general composition of chick diet.

DATA COLLECTION:

Two procedures are outlined for this method. Conducting Procedure A is mandatory. Procedure B provides highly desirable, complementary data to the results of Procedure A.

GENERAL PROCEDURE:

Procedure A:

1.   Within the colony, select a breeding group (up to 100 pairs) which will not be subject to other studies.

2.   Collect five samples in each five-day period throughout the entire chick-rearing period. A minimum of 30 samples should be collected.

3.   Capture adults in the proximity of the nest as they arrive to feed their chicks. Only adult birds with stomachs which seem full when handled should be sampled.

4.   Collect and store any spontaneous regurgitation that takes place when birds are handled and add to main sample.

5.   Using a stomach flushing technique similar to that in Part IV, Section 2, collect samples in a bucket (Refs. 4 and 11). Each bird should be pumped until clear water emerges. Multiple flushings are not necessary if clear water emerged at the first flush. The overall efficiency of water off-loading is to a large extent dependent on the operator's experience (Ref. 9). It is strongly advised that water be warmed before pumping it into the birds. Filter the stomach samples through a sieve set over another bucket. Water excess must be slowly removed from the bucket pouring out most of it until material, presumably including otoliths, is encountered. This material must be added back to the main samples. Record the wet weight of the whole drained sample.

6.   Material should be sorted into three main categories (fish, squid and crustaceans) and the wet weight of each one must also be measured.

7.   Sort the crustacean material into the three following categories: (i) *Euphausia superba*; (ii) other euphausiids; and (iii) other crustaceans. Record the weight of each category.

8. Preserve the crustacean material in 70% ethyl alcohol for further detailed analysis.

Procedure B:

Squid:

1. Try to identify any intact squid (Ref. 3). Fix and preserve in 4% formaldehyde/seawater. From the remaining squid material, remove beaks and preserve in 70% ethyl alcohol. Count and record the number of squid lower beaks.

2. Measurement of lower rostrums should be taken and used to estimate the squid's length and weight by using appropriate regression equations (Ref. 2).

Fish:

1. Try to identify any intact fish (Ref. 3). Remove otoliths from intact crania. Keep each pair of extracted otoliths separated and labelled. Collect all loose otoliths and keep them together as one separate batch. Store dry in a safe place. Record number of pairs and loose otoliths.

2. The otoliths of each fish species must be separated into right and left, the most abundant being considered as the approximate number of individuals present by species in the sample (Ref. 1).

3. The lengths of otoliths must be measured; the fish length and mass will be estimated using standardised equations (see Refs 5 and 10).

Crustaceans:

1. After sorting the crustacean material, the number of specimens within each category must be recorded.

2. With the *E. superba* material, specimens having intact carapace and at least the first abdominal segment and legs still attached, have to be selected. Their carapaces should be removed leaving exposed the underlying tissues. For each specimen, sex (Ref. 7) and maturity stage (Ref. 8) have to be determined; the length of the removed carapaces, in dorsal-side down position, has to be measured along the mid-dorsal line by using the graticulation method. Total length can then be calculated (Ref. 6).

3. Regarding other crustacean categories, count of specimens must be recorded and the whole category weighed.

MANDATORY DATA:

HIGHLY DESIRABLE DATA:

Records of any anomalous and/or extreme environmental conditions observed during the study (e.g. snow and ice cover, wind and temperature).

PROBLEMS TO BE CONSIDERED:

1. The sample draining technique should be standardised.
2. The daily sampling time should be standardised.
3. Induced regurgitation and stomach flushing of chicks is not recommended.
4. Colony disturbance leading to regurgitation by non-target birds should be avoided.

COMMENTS:

DATA PROCESSING AND ANALYSIS:

ANALYTICAL METHODS:

INTERPRETATION OF RESULTS:

PROBLEMS TO BE CONSIDERED:

COMMENTS:

DATA REPORTING:

Data should be reported using the latest version of CCAMLR data submission form E/B4/A (see Part III, Section 1).

DATES OF OBSERVATION:

REFERENCES:

(1) Casaux, R. and E. Barrera-Oro. 1995. A methodological proposal to monitor changes in coastal fish populations by the analysis of pellets of the blue-eyed shag *Phalacrocorax atriceps*. Document *WG-EMM-95/84*. CCAMLR, Hobart, Australia.

(2) Clarke, M.R. (Ed.). 1986. *A Handbook for the Identification of Cephalopod Beaks*. Clarendon Press, Oxford: 1–273.

(3) Fischer, W. and J.-C. Hureau (Eds). 1985. *FAO Species Identification Sheets for Fishery Purposes. Southern Ocean (CCAMLR Convention Area Fishing Areas 48, 58 and 88)*, Vol. II. Prepared and published with the support of the Commission for the Conservation of Antarctic Marine Living Resources. FAO, Rome: 233–470.

(4) Gales, R.P. 1987. Validation of the stomach-flushing technique for obtaining stomach contents of penguins. *Ibis,* 129: 335–343.

(5) Hecht, T. 1987. A guide to the otoliths of Southern Ocean fishes. *S. Afr. J. Antarct. Res.,* 17: 1–87.

(6) Hill, H.J. 1990. A new method for the measurement of Antarctic krill, *Euphausia superba* Dana, from predator food samples. *Polar Biol.,* 10: 300–317.

(7) Kirkwood, J.M. 1982. A guide to the Euphausiacea of the Southern Ocean. *ANARE Research Notes,* 1: 1–45.

(8) Makarov, R.R. and C.J. Denys. 1982. Stages of sexual maturity of *Euphausia superba* Dana. *BIOMASS Handbook,* 11.

(9) Ryan, P.G. and S. Jackson. 1986. Stomach pumping: is killing seabirds necessary? *Auk*, 103: 427–428.

(10) Williams, R. and A. McEldowney. 1990. A guide to the fish otoliths from waters off the Australian Territory, Heard and Macquarie Islands. *ANARE Research Notes*, 75: 1–173.

(11) Wilson, R.P. 1984. An improved stomach pump for penguins and other seabirds. *J. Field Ornithol.*, 55: 109–112.

BACKGROUND PAPERS:

Ainley, D.G., E.G. O'Connor and R.J. Boekelheide. 1984. The marine ecology of birds in the Ross Sea, Antarctica. *Am. Orn. Un. Ornith. Monogr.*, 32: 1–97.

Arnould, J.P.Y. and M.D. Whitehead. 1991. The diet of Antarctic petrels, Cape petrels and southern fulmars rearing chicks in Prydz Bay. *Antarc. Sc.*, 3 (1): 19–27.

Beck, J.R. 1969. Food, moult and age of first breeding in the Cape pigeon, *Daption capensis* Linnaeus. *Brit. Antarc. Sur. Bull.*, 21: 33–44.

Bierman, W.H. and K.H. Voous. 1950. Bird observed and collected during the whaling expedition of the Willem Barendz in the Antarctic 1946–57. *Ardea*, 37 (extra no.): 1–123.

Coria, N.R., G.E. Soave and D. Montalti. 1996. Diet of Cape petrel *Daption capense* during the post-hatching period at Laurie Island, South Orkney Islands, Antarctica. Document *WG-EMM-96/44*. CCAMLR, Hobart, Australia.

Creet, S., J.A. van Franeker, T.M. Spanje and W.J. Wolff. 1994. Diet of the pintado petrel *Daptioncapense* at King George Island, Antarctica, 1990/91. *Marine Ornithol.*, 22: 221–229.

Croxall, J.P. and P.A. Prince. 1980. Food, feeding ecology and ecological segregation of seabirds at South Georgia. *Biol. J. Linn. Soc.*, 14: 103–131.

Green, K. 1986. Food of the Cape pigeon (*Daption capense*) from Princess Elizabeth Land, east Antarctica. *Notornis*, 33: 151–154.

Ridoux, V. and C. Offredo. 1989. The diets of five summer breeding seabirds in Adélie Land, Antarctica. *Polar Biol.*, 9: 137–145.

Soave, G.E., N.R. Coria and D. Montalti. 1995. Diet of Cape petrel *Daption capense* during late incubation and chick-rearing period at Laurie Island, South Orkney Islands, Antarctica. Document *WG-EMM-95/85*. CCAMLR, Hobart, Australia.

Soave, G.E., N.R. Coria, P. Silva, M. Favero and D. Montalti. 1996. Diet of Cape petrel at Fildes Peninsula (King George Island) and Harmony Point (Nelson Island), South Shetland Islands, Antarctica. Document *WG-EMM-96/17*. CCAMLR, Hobart, Australia.

van Franeker, J.A. and R. Williams. 1992. Diet of fulmarine petrels in the Windmill Islands, Wilkes Land, Antarctica. Preliminary results. *CircumpolarJournal*, 1–2: 134–138.

SPECIES: Antarctic petrel (*Thalassoica antarctica*)

PARAMETERS: Population size, breeding success

ASSOCIATED PARAMETERS:

Diet, annual survival and recruitment, breeding chronology

AIMS:

1. To determine interannual trends in size of breeding populations.
2. To determine productivity, ideally both in terms of eggs hatched and chicks fledged.

DATA COLLECTION:

1. Data are collected from 'study plots' and 'reference plots'. Study plots may be subjected to regular visits for nest-checks, bird-handling, etc. Reference plots are usually only viewed from a distance (from a fixed viewpoint) and only entered on exceptional occasions. Comparison of study and reference plots is recommended to check on immediate (visit), short-term (breeding season) and long-term (future years) effects of the study activities themselves.

2. The size and position of the study and reference plots will depend on the number of nests and local conditions of colony that is to be monitored. Where the colony comprises less than about 500 pairs, split the area in two with further subdivisions as required. Where colonies are larger, set up a random stratified grid of study and reference plots using the method set out in Part IV, Section 3. Establish viewpoints which have clear views over the colony but are sufficiently distant so that birds do not flush when visited. Clearly mark study and reference plots and viewpoints with identification numbers and record details on maps and photographs.

3. Three methods are provided: Procedure A is for intensive studies on a very regular or daily basis throughout the breeding season (15 November to 10 March) using individually marked nests within study plots. Procedure B is based on making a small number of visits and focuses on periods of laying (ca. 20 November to 5 December) (after the birds have returned from the pre-laying exodus), hatching (ca. 5 to 20 January) and pre-fledging (ca. 20 February to 1 March). Procedure C is based on making single visits after laying (about 5 December), and/or after hatching (about 20 January), and/or pre-fledging (about 20 February). There is a progressive decrease in accuracy and reliability from Procedure A to Procedure C. Breeding chronology should be determined for each colony monitored.

4. These procedures will also provide quantitative data on the interannual variations in the non-breeding component of the population. Distant counts of study plots are part of such procedures because non-breeding birds may leave sites when observers enter the area.

GENERAL PROCEDURE:

Procedure A:

1. Start this procedure preferably before the start of the laying period or as soon as possible thereafter, and continue throughout the breeding season or for as long as possible.

2. Make very regular counts, preferably daily, of study and reference plot(s) from the fixed viewpoints.

3. After counting from the fixed viewpoints (distant counts) enter the study plot(s) and count for all nest sites the presence of adult birds and the presence/absence of an egg or chick. Entering the colony will probably cause all the non-breeding birds to leave the study plot.

4. At the beginning of the season, mark and number all the nest sites in the study plots if no permanent markings from previous years are available.

Procedure B:

1. During the periods of laying, hatching and before fledging, make repetitive counts over a few days (three to five?) of study and reference plot(s) from the fixed viewpoint.

2. After the first distant count, enter the study plot(s) and temporarily mark nest sites with new eggs or chicks. Record the numbers of newly marked nests.

3. Repeat this procedure at more or less regular intervals during the periods of laying and hatching, and towards fledging. Three visits during each period should be considered a minimum; interannual consistency in number and dates of visits is desirable.

Procedure C:

1. Make counts of study and reference plot(s) from the fixed distant viewing location after laying, and/or hatching, and/or before fledging periods.

2. After the distant count, enter the study plot(s) and count the number of eggs or chicks present.

3. Attempt to maintain interannual consistency in dates of each visit.

MANDATORY DATA:

Procedures A, B and C: counts from a distance (population size):

1. For each count, record the plot type and its identification number, date and time.

2. Number of Apparently Occupied Sites (AOS*).

Procedures A, B and C: counts in study plot(s) (population size):

1. For each count, record the plot type and its identification number, date and time.

2. Number of eggs and/or chicks.

Procedures A, B and C: counts in study plot(s) (productivity):

1. For each count, record the plot type and its identification number, date and time.

2. Number of eggs and/or chicks present during count.

3. Band numbers of all chicks with date banded, date fledged, and/or date died.

4. Total number of failed nests.

Procedure C, in study plots:

1. For each count, record the plot type and its identification number, date and time.

2. Number of eggs and/or chicks present during visit.

HIGHLY DESIRABLE DATA:

Procedures A, B and C: counts from a distance (study and reference plots):

1. Number of nest sites attended by pairs.
2. Number of nest sites attended by a single adult.
3. Number of nest sites with unattended egg or chick.
4. Number of other (non-breeders/failed breeders) birds in the study plot.
5. Weather and amount of snow and/or ice covering the plots.

---

*   Definition of AOS (Ref. 4): A site is counted as occupied when a bird appears to be sitting tightly on a reasonably horizontal area judged large enough to hold an egg. Two birds on such a site, apparently paired, count as one site. This should exclude birds which are sitting or crouching on sloping sections of cliffs. Many AOS will look obviously suitable (e.g. depressions/pockets in turf or soil on a cliff or slope), but other occupied, reasonably horizontal sites, where an egg could be present, should not be excluded.

Procedures A and B, in study plots. Daily records on an individual nest-site basis (of both breeding and non-breeding sites):

1.   Adult attendants, with identity and pair-bond.
2.   Breeding status of attendants (with egg, chick, failed, non-breeding).
3.   Identity records of birds not associated with nests.
4.   Number of non-attended nest sites.
5.   Number of breeding sites attended by single/paired adult(s).
6.   Number of non-breeding sites attended by single/paired adult(s).
7.   Total number of adult birds.
8.   Dates of first and last laying, hatching and fledging.
9.   Weather and amount of snow and/or ice covering the plots.

Procedure C, in study plots:

1.   Number of breeding sites attended by adult(s).
2.   Number of non-breeding sites attended by adult(s).
3.   Total number of adult birds.
4.   Weather and amount of snow and/or ice covering the plots.

Procedures A, B and C:

Records of any anomalous and/or extreme environmental conditions observed during the study (e.g. snow and ice cover, wind and temperature).

PROBLEMS TO BE CONSIDERED:

1.   Adult birds within the study plots or demography fields should not be used for other purposes (e.g. diet sampling) which might affect their breeding success.

2.   Study and reference plots should include both central and peripheral parts of the colony, and preferably also potential breeding sectors outside the current nesting periphery (see Part IV, Section 3).

3.   Diurnal variation in attendance needs to be checked regularly. If observations do not take place at a standard time each day, then they should be taken randomly over the 24-hour period; date and time of all such observations should be recorded. Later analysis will show if any bias is introduced by sampling at a particular time of day.

4.   Breeding population size is preferably estimated in the early phase of breeding, but many colonies may usually not be reached until late in the egg phase. As long as the same part of the breeding cycle is covered each year, this is unlikely to be a problem for monitoring purposes.

5.   It is very important that (nearly) the same dates (or stage in the breeding cycle) are used each year for Procedures B and especially for Procedure C.

6.   Methods as described assume annual coverage of the full breeding cycle, but for individual locations adaptations to the logistic constraints of presence in the field may be required.

7. Distant counts are part of the procedures, but may not be possible in detail if borders of study plots are not permanently marked in the field (e.g. when using this procedure for large colonies, see Part IV, Section 3 and Ref. 2). Interannual variation in the non-breeding component is not obtainable unless specific study plots are established for this purpose. Possibly other types of observations could be used to estimate effects of the observer.

8. Distant counts normally do not give any reliable estimate of productivity.

COMMENTS:

Counts from a distance not only serve to monitor observer effects, but also give an estimate of the potential breeding population, which may be very different from the number of pairs producing an egg (actual breeding population), even over a large number of successive years.

DATA PROCESSING AND ANALYSIS:

ANALYTICAL METHODS:

1. Population size may be determined from these data as the maximum number of eggs and/or chicks.

2. Appropriate statistics for comparisons may be rank correlations and GLM analysis. Monte Carlo simulations may be used for population trends (Ref. 1). A method for computing the sample size required to detect a true difference between two proportions ('power analysis') is given in box 17.10, p. 766, of Ref. 3.

3. Reproductive success may be expressed from these data as (Procedure A – accurate, Procedure B – estimate):

breeding success = chicks fledged / eggs laid;
hatching success = chicks hatched / eggs laid;
fledging success = chicks fledged / chicks hatched.

4. Population effort may be expressed as (Procedure A – accurate, Procedure B – estimate):

eggs laid / maximum number attended sites.

INTERPRETATION OF RESULTS:

The total number of birds engaged in breeding activity and reproductive success can be influenced by, for example:

Cohort size at fledging and rate of recruitment of each cohort to the breeding population, food supply during the breeding period, ages of individual birds (and consequently the age structure of the colony), previous breeding experience of the individuals, length of mate-bond, presence of mate, size and location of colony, ice conditions prior to colony occupation, adverse weather during critical periods.

CCAMLR Standard Method B5 (v1)

    PROBLEMS TO BE CONSIDERED:

    COMMENTS:

    DATA REPORTING:

       Data should be reported using the latest version of CCAMLR data submission form E/B5 (see Part III, Section 1).

DATES OF OBSERVATION:

REFERENCES:

(1)   Anker-Nilssen, T., K.E. Erikstad and S.-H. Lorentsen. 1996. Aims and effort in seabird monitoring: an assessment based on Norwegian data. *Wildlife Biology*, 2: 17–26.

(2)   Lorentsen, S.-H., N. Røv and G. Bangjord. 1993. Documentation of the demography and population monitoring systems for Antarctic petrels at Svarthamaren, Dronning Maud Land. *NINA Oppdragsmelding*, 240: 1–71.

(3)   Sokal, R.R. and F.J. Rohlf. 1981. *Biometry: the Principles and Practice of Statistics in Biological Research.* 2nd Edition. Freeman, New York.

(4)   Walsh, P.M., D.J. Halley, M.P. Harris, A. del Nevo, I.M.W. Sim and M.L. Tasker. 1995. *Seabird Monitoring Handbook for Britain and Ireland.* JNCC/RSPB/ITE/ Seabird Group, Peterborough.

BACKGROUND PAPERS:

Anker-Nilssen, T. and O.W. Røstad. 1993. Census and monitoring of puffins *Fratercula arctica* on Røst, N Norway, 1979–1988. *Ornis Scand.*, 24: 1–9.

Green, K. and G.W. Johnstone. 1986. Breeding distribution and abundance of surface-nesting petrels in the Rauer Island, East Antarctica. *ANARE Research Notes*, 35.

Lorentsen, S.-H. 1995. *Reproductive Effort in the Antarctic Petrel Thalassoica antarctica: the Effect of Parental Body Size and Condition.* Dr scient. Thesis. University of Trondheim, Dept of Zoology, Trondheim: 41 pp + VI papers.

van Franeker, J.A. 1994. Breeding ecology and aspects of demography of the Antarctic petrel *Thalassoica antarctica* on Ardery Island, Windmill Islands, Antarctic. In: *SCAR Antarctic Communities: Species, Structure and Survival.* Abstracts SCAR VI Biology Symposium, Venice, 30 May to 3 June 1994. SCAR, Cambridge: p. 274.

Whitehead, M.D., G.W. Johnstone and H.R. Burton. 1990. Annual fluctuations in productivity and breeding success of Adélie penguins and fulmarine petrels in Prydz Bay, East Antarctica. In: Kerry, K.R. and G. Hempel (Eds). *Antarctic Ecosystems: Ecological Change and Conservation.* Springer-Verlag, Berlin Heidelberg: 214–223.

SPECIES: Antarctic petrel (*Thalassoica antarctica*)

PARAMETERS: Adult annual survival and recruitment

ASSOCIATED PARAMETERS:

Population size, breeding success, diet, mean age at first breeding.

AIMS:

To determine the demographic parameters of the population.

DATA COLLECTION:

Two procedures are provided in association with Procedures A and B from Standard Method B5. Visits to study plots in Procedure C from Method B5 are too infrequent for data collection on survival or recruitment (chick banding and checks for banded individuals should only be considered for general purposes).

GENERAL PROCEDURE:

Procedure A:

1. Within study plots, band all unbanded breeding birds and site-attending adults during visits (see 'Problems to be Considered').

2. Measure each bird when banding (for sex determination, see Refs 1 and 3).

3. Record the identity of all banded birds during each visit. Ideally records should be kept on nest-specific and pair-specific bases, using permanently marked nests.

4. Band all chicks after two-thirds of the chick-rearing period (before mid-February).

5. No banding should occur in reference areas unless for specific experimental purposes (e.g. to study separate long-term effects of chick banding on later recruitment).

Procedure B:

1. Within study plots, band all chicks after two-thirds of the chick-rearing period (before mid-February).

2. Check all birds for bands during visits.

3. No banding should occur in reference areas unless for specific experimental purposes (e.g. to study separate long-term effects of chick banding on later recruitment).

CCAMLR Standard Method B6 (v1)

MANDATORY DATA:

1. List of band numbers resighted each breeding season.
2. List of band numbers of breeding adults.
3. List of band numbers recovered (dead/live recoveries).
4. List of band numbers of chicks surviving to fledging.
5. Dates and locations of first banding of birds.

HIGHLY DESIRABLE DATA:

1. Nest and pairbond-specific listing of adults.
2. Sex of the bird.
3. List of band numbers of site-attending non-breeders.
4. Records of any anomalous and/or extreme environmental conditions observed during the study (e.g. snow and ice cover, wind and temperature).

PROBLEMS TO BE CONSIDERED:

1. Adult birds within the study plots or demography fields should not be used for other purposes (e.g. diet sampling) which might affect their breeding success.

2. When records of site attendance of adults are required (from start of laying until about 12 days after hatching of the chick), extreme care should be taken in handling or banding birds. Breeding birds should only be caught during this period when both partners are present at the site. Capture of single breeding birds should only be considered if there are sufficient guarantees that egg/chick losses through predation or cooling can be avoided.

3. Females should not be caught/handled during the egg-laying period.

4. Only stainless steel bands should be used.

5. For large and dense colonies, it will be difficult to determine recruitment because it is virtually impossible to find all banded birds. Furthermore, birds do not necessarily return to their natal colony when mature. Once the adults commence breeding, they apparently return to the same nest site.

6. Recruitment rates will be underestimated by the extent to which fledglings recruit into colonies other than their natal one. It is recommended to check this by searching for banded fledglings in adjacent breeding colonies.

COMMENTS:

DATA PROCESSING AND ANALYSIS:

ANALYTICAL METHODS:

1. Estimates of adult annual survival are calculated from resightings of individuals banded or recorded the previous season. Results are presented as mean annual survival rates for each year of the study (all birds) and for males and females separately.

2. Probability of recapture and annual survival may be estimated by the SURGE program (Ref. 2).

3. Recruitment, defined as the proportion of fledged chicks which survive to breed, can be estimated from recaptures of chicks banded as fledglings and recovered subsequently in the study colonies.

INTERPRETATION OF RESULTS:

PROBLEMS TO BE CONSIDERED:

COMMENTS:

DATA REPORTING:

DATES OF OBSERVATION:

REFERENCES:

(1)   Lorentsen, S.-H. and N. Røv. 1994. Sex discrimination of Antarctic petrels *Thalassoica antarctica* by discriminant analysis of morphometric characters. *Polar Biol.*, 14: 143–145.

(2)   Pradel and J.D. Lebreton. 1991. *Users Manual for Program SURGE, Version 4.1.* Unpubl. report, Centre d'Ecologie Fonctionelle et Evolutive, NRS, Montpellier, France.

(3)   van Franeker, J.A. and C.J.F. Terbraak. 1993. A generalised discriminant for sexing fulmarine petrels from external measurements. *Auk*, 110: 492–502.

BACKGROUND PAPERS:

Lorentsen, S.-H. 1995. *Reproductive Effort in the Antarctic Petrel Thalassoica antarctica: the Effect of Parental Body Size and Condition.* Dr scient. Thesis. University of Trondheim, Dept of Zoology, Trondheim: 41 pp + VI papers.

van Franeker, J.A. and T. Montague. 1987. Recoveries of petrels banded near Casey Station, Wilkes Land, Antarctica, 1984 to 1985. *Corella*, 11: 37–43.

SECTION 3

SEALS: METHODS C1 – C2

SPECIES: Antarctic fur seal (*Arctocephalus gazella*)

PARAMETERS: Duration of cow foraging/attendance cycles

ASSOCIATED PARAMETERS:

Breeding success, life histories, weight change during breeding season.

AIMS:

To measure the duration of (a) the perinatal attendance periods, (b) the at-sea foraging trips, and (c) the on-shore attendance periods to feed pups, and to determine the number of feeding trips made within the breeding season.

DATA COLLECTION:

Two methods of measuring this parameter are presented. Procedure A utilises radio transmitters to facilitate monitoring the presence of female fur seals ashore. Procedure B relies on visually resighting paint marked and tagged females during their visits ashore. Measurements of attendance patterns for radio-tagged animals will be more precise (and will give exact arrival and departure times, etc.) but cows have to be caught for radio attachment and at large sites, animals may move out of radio range or 'line of sight' of automatic recording equipment.

GENERAL PROCEDURE:

Procedure A:

1. This parameter can be measured effectively with the use of radio-frequency telemetry and automatic data-logging instruments. Materials required include 40 radio transmitters (battery life three months, range 0.5 km, weight less than 50 g), antenna, scanning receiver, and data or strip-chart recorder.

2. Select a minimum of 40 perinatal females with pups. Capture each female and attach a radio transmitter prior to her departure for her first feeding trip to sea postpartum.

3. To capture a female, slip a choker pole (Ref. 5) over her head. By twisting the pole, the noose tightens round the cow's neck. With the head restrained, a second person catches the cow's hind flippers. The cow can now be carried to, and strapped into, the restraint board (Ref. 5) for weighing, tagging and radio attachment.

4. Mix fast-setting epoxy[2] and apply to the seal's back fur midway between the shoulders using an applicator (e.g., wooden tongue depressor). Area covered

---

[2]   Epoxy brands used with success include: RS Components (Corby, Northants, UK), Devcon five-minute epoxy). Adhesives found to be less suitable for long-term deployment include cyanoacrylic glues (e.g. Loctite 501).

should be 1 cm larger than size of the transmitter. Set transmitter on epoxy (antenna should point toward the tail). Smooth the upper and lateral edges of the transmitter/epoxy with additional epoxy to form a solid, hydrodynamic bond.

5. Release the female as close as possible to her initial capture site, taking care to ensure that she returns to her pup with a minimum of disturbance.

6. Position a frequency-scanning receiver in a location close enough to the study beach so that all instrumented seals will be detected if present ashore. Program each transmitter frequency (each should be different) on the radio receiver and data logger. A scanning rate of checking for each seal every 20 minutes or less is recommended. The precision of measuring foraging trip duration increases as the interval between scanning each seal decreases. Transmitted signals are only received when each seal is within range (i.e. ashore), thus providing more or less a continuous record of the at-sea/on-shore intervals.

7. The presence of a female's pup and its fate during the observation period will have an important impact on the female's foraging pattern. Attempts should be made to obtain at least a weekly assessment of whether or not the pup has been sighted with its mother during her trips ashore.

8. Record foraging/attendance cycles for as long as possible, continuing until the cow weans her pup. At the minimum, attempts should be made to monitor the first six trips to sea following the perinatal period. As the season progresses, some cows at some locations (depending on the topography of the site), will disperse from the natal beaches and may become increasingly difficult to find.

9. Record failures of animals with transmitters to complete their first six post-natal trips.

Procedure B:

1. Select a minimum of 100 perinatal females with pups. Capture each female, and mark for visual resighting prior to her departure for her first feeding trip to sea postpartum.

2. Cows can be marked quickly and effectively by pouring household gloss paint onto their pelt from a small pot fixed to a long pole. Make a note of each paint pattern, colour, and location on the seal's body.

3. In addition to paint marks, some form of permanent identification, such as tags should be used if possible. Use a hoop net or choker pole (noose on a pole) to restrain cows for tagging (Ref. 5). One person catches the cow with a noose pole or net. At an opportune moment a second person pins the cow's head to the ground by grabbing or placing a bar over her neck. The first person can now apply the tags. It is advisable to clean tag sites with mild disinfectant (e.g. Savlon, Dettol) to minimise tag hole infection.

4. Visually census the beach once or twice daily to determine the presence of individually recognisable cow/pup pairs.

5. Steps 7 and 8 of Procedure A also apply to Procedure B.

MANDATORY DATA:

1. Date of pupping for each female monitored.

2. Dates and times of arrival to and departure from the beach for each female throughout the observation period.

3. Dates on which pups were observed with their mothers throughout the observation period.

4. Transmitter identification numbers and/or tag numbers for each female monitored (as appropriate for the method employed).

5. A description of the rate at which the presence or absence of females ashore was monitored (frequency of electronic scanning or visual observation). This rate determines the precision of the measured duration of foraging trips.

6. Records of failures of animals with transmitters to complete their first six post-natal trips.

HIGHLY DESIRABLE DATA:

1. The following data should be collected when possible:

   (i)   initial date of female's arrival at the colony;
   (ii)   birth weight and sex of the pup; and
   (iii) date of copulation.

2. Data on a female's pup provide useful ancillary information. The following methods should be used to mark pups:

   (i)   pups should be sexed and weighed the day they are born but should not be handled for one hour after birth to allow mother/pup bonds to form. Pups can be lifted away from cows using a slip noose. This is a long hollow alloy pole with a doubled length of (approx.) 8mm cord running through it (Figure 1);

   (ii)   place the noose over the head and one foreflipper of the pup. Take up all the slack cord by pulling the spliced end and trap the pup firmly but not too tightly. Double the free cord down against the pole and grip tightly to prevent the noose opening. The pup can now be lifted away from its mother to another person or to a suitable site for marking, etc. The procedure is reversed for returning pups to their mothers; and

   (iii) pups can be marked (numbered) very effectively by clipping a small number in the fur on the back or by bleaching with hair bleach (e.g. 'Lady Clairol Born Blonde Hair Lightener' by Bristol-Meyers). This leaves a vivid straw-coloured mark (numbers or letters) in the black neonatal coat and will last until the first moult. Wet coats should be dried a bit before applying bleach.

3. Records of any anomalous and/or extreme environmental conditions observed during the study (e.g. snow and ice cover, wind and temperature).

CCAMLR Standard Method C1 (v3)

If the radio receiver is set up in a position that can receive signals from seals which are not nearby (e.g. swimming at sea close to shore), these signals will affect the estimation of the duration of feeding trips. One solution is to adjust (lower) the gain of the receiver so that it only receives signals in the immediate vicinity of the beach being monitored. In any event, care should be taken to set up the radio antenna and receiving system in the same way each year so that interannual comparisons of the seals' behaviour are not confounded by changes in the sensitivity or position of the monitoring hardware.

COMMENTS:

DATA PROCESSING AND ANALYSIS:

ANALYTICAL METHODS:

1. Use data for the first six perinatal trips by females only. This will eliminate biases due to season and unequal trip lengths by different females.

2. Two types of calculation are necessary: the mean duration of trips for each trip number (all females combined), and the mean duration of trips for each female (all trips combined). The latter calculation will have $n = 6$, and should only include those females who completed all six trips.

3. If there is little difference in the variances of the duration of trips for the first six trips, and for the separate females, the data should be pooled to give a mean for the year. This may produce a useful annual index.

4. If some seals display activity patterns with high variability in foraging period, or highly skewed activity patterns, it may be advisable to omit this data from the analysis.

INTERPRETATION OF RESULTS:

Foraging trip duration is affected by food abundance, quality, and availability. Long foraging trips result in relatively short pup-feeding bouts leading to increased pup mortality due to starvation and low pup growth rates. Breeding success of cows raising pups in poor food years will be reduced. Reproductive success of pups raised in poor food years may be lower than that of pups raised in years of food abundance.

PROBLEMS TO BE CONSIDERED:

COMMENTS:

DATA REPORTING:

Data should be reported using the latest version of CCAMLR data submission form E/C1 (see Part III, Section 1).

DATES OF OBSERVATION:

Reported dates of pups birth and durations of perinatal and lactation periods in the Antarctic fur seal:

	Location		Refs
	South Georgia	South Shetlands	
Date of birth Median range Typical mean ± SD Range	4–8 Dec 6 Dec ± 8 days 21 Oct–24 Dec	X	2, 4, 6
Perinatal period Mean ± SD Range	7 ± 1 day 6–9 days	X	1, 4
Lactation period Range of mean ± SD Range	112–116 ± 11 days 90–132 days	X	3, 4

X data not available

Figure 1: Diagram of a slip noose for the capture of pups.

REFERENCES:

(1)   Croxall, J.P., T.S. McCann, P.A. Prince and P. Rothery. 1988. Reproductive performance of seabirds and seals at South Georgia and Signy Island, South Orkney Islands, 1976-1987: implications for Southern Ocean monitoring studies. In: Sahrhage, D. (Ed.). *Antarctic Ocean and Resources Variability*. Springer-Verlag, Berlin Heidelberg: 261-285.

(2)   Doidge, D.W., J.P. Croxall and C. Ricketts. 1984. Growth rates of Antarctic fur seal *Arctocephalus gazella* pups at South Georgia. *J. Zool. Lond.*, 203: 87–93.

(3)   Doidge, D.W., T.S. McCann and J.P. Croxall. 1986. Attendance behaviour of Antarctic fur seals. In: Gentry, R.C. and G.L. Kooyman (Eds). *Fur Seals*: *Maternal Strategies on Land and at Sea.* Princeton University Press, Princeton.

(4)   Doidge, D.W. and J.P. Croxall. 1988. Factors affecting weaning weight in Antarctic fur seals *Arctocephalus gazella* at South Georgia. *Polar Biology*, 8.

(5)   Gentry, R.L. and J.R. Holt. 1982. Equipment and techniques for handling northern fur seals. *NOAA Tech. Rep. NMFS SSRF*, 758: 1–15.

(6)   McCann, T.S. and D.W. Doidge. 1987. Antarctic fur seal *Arctocephalus gazella*. In: Croxall, J.P. and R.L. Gentry (Eds). Status, Biology and Ecology of Fur Seals. *NOAA Tech. Rep. NMFS,* 51: 5–8.

BACKGROUND PAPERS:

Doidge, D.W., J.P. Croxall and J.R. Baker. 1984. Density-dependent pup mortality in the Antarctic fur seal *Arctocephalus gazella* at South Georgia. *J. Zool. Lond.*, 202: 449–460.

Kooyman, G.L., R.W. Davis and J.P. Croxall 1986. Diving behaviour of Antarctic fur seals. In: Gentry, R.L. and G.L. Kooyman (Eds). *Fur Seals: Maternal Strategies on Land and at Sea*. Princeton University Press, Princeton: 115–125.

SPECIES: Antarctic fur seal (*Arctocephalus gazella*)

PARAMETERS: Pup growth

ASSOCIATED PARAMETERS:

Birth weight, weight at weaning, survival, causes of mortality.

AIMS:

To measure the growth rates of pups in order to facilitate inter- and intra-annual comparisons within and between breeding colonies.

DATA COLLECTION:

Two procedures can be employed to measure pup growth rates, the choice being determined by colony size, site topography, and the number of personnel available for such work. Procedure A is more precise and involves working with individually marked pups (Ref. 5). It is, however, more labour intensive and potentially more disruptive to colonies. Procedure B calculates the growth rate of pups by recording the weight of subsamples of the population at intervals throughout the season.

GENERAL PROCEDURE:

Procedure A:

1. Mark and weigh individual pups on the day of birth and determine sex by examination. In smaller colonies, day-old pups can be located by observing births and recording the locations for later sampling of pups. In larger colonies, newborn pups are chosen by observing the presence of the umbilicus, fresh and undried. The initial sample size, i.e. pups whose birth weight is known, should be approximately 75 to 200 pups depending on the ease of recapture at the site. All captures should be made using a slip noose as illustrated in Figure 1.

2. Throughout the season, opportunistically recapture and weigh marked pups. When possible, record the date of last feeding before weighing.

3. It is important that the dates of weighing newborn pups be distributed proportionately to pupping dates or at least be centred around the mean date of pupping of the colony.

Procedure B:

Determine the median pupping date (the date by which 50% of pups are born) for the colony. Weigh a random sample of about 100 pups, including a minimum of 40 of either sex, at 30-day intervals starting 30 days after the median pupping date. Ideally the last sample should be collected just prior to weaning, i.e. at about 100 to 110 days after birth. Determine the mean mass for each sex.

MANDATORY DATA:

Procedure A:

1. Identification number or mark.
2. Birth date.
3. Sex.
4. Time and date of each weighing.
5. Weight (to nearest 0.1 kg).

Procedure B:

1. Dates of each sample.
2. Start and end time of the sample periods.
3. Sex of each pup.
4. Weight of each pup (to nearest 0.1 kg).
5. Median pupping date.

HIGHLY DESIRABLE DATA:

Procedure A:

1. Date when first pup is born in the colony.
2. Median pupping date for colony.
3. Date when last pup is born in the colony.
4. Date and time of last feeding prior to weighing.

Procedure B:

1. Date when first pup is born in the colony.
2. Median pupping date for colony.
3. Date when last pup is born in the colony.

Procedures A and B:

Records of any anomalous and/or extreme environmental conditions observed during the study (e.g. snow and ice cover, wind and temperature).

PROBLEMS TO BE CONSIDERED:

1. In Procedure A obtaining the weights of newborn pups is the most labour intensive and potentially the most disruptive operation. Care must be taken to return each newborn pup to its mother's side. Pups should not be released until recognition by the mother has occurred. The return of newborn pups to their mothers should be done slowly to give mothers the opportunity to inspect the pup, as a pup thrust at its mother's side may be bitten. Newborn pups not returned to their mothers wander unprotected and may approach aggressive females. Separating mothers and pups immediately after birth during the bonding and imprinting process compromises pup survival.

2. Weights of pups during the first month of suckling are obtained by capturing animals from breeding areas; care should be taken to minimise disturbance by approaching animals slowly and, whenever possible, crouched and making only slow deliberate movements. Approaching animals from below (from the downhill) or ocean side of the colony often helps to minimise disturbance.

3. After one month of age, pups begin exploring and wandering greater distances, and can often be found in groups resting and playing around the periphery of breeding areas, especially in intertidal areas. At this time, opportunities to capture pups without disturbing the breeding areas become more frequent.

COMMENTS:

DATA PROCESSING AND ANALYSIS:

ANALYTICAL METHODS:

1. Growth of males and females must be analysed separately.

2. Data from Procedures A and B require different analysis techniques.

3. **For Procedure A**, fit a linear regression of the form, weight $(Kg) = a + b.(days)$ taking the birth day as day 0. Calculate the parameters: regression coefficient (slope,b) and standard error (s_b); intercept (a) and standard error (s_a); F ratio for the regression; and N, the number of weighings. Compute also the mean weight $(\overline{Y})$ and its standard error $(s_{\overline{Y}})$.

4. In order to obtain an annual index for comparisons with other years/colonies it is proposed that the mean of the regression coefficients be computed. Before this can be done it may be advisable to remove from the analysis those animals with obviously deviant growth patterns. Tests for equality of slopes should be used to identify, and note, those animals in this category.

5. The intercept may also prove to be a useful index. However, see 'Problems to be Considered' below.

6. **For Procedure B**, an index of growth deviate (*gd*) in year *y* should be calculated as follows:

   let N_y be the number of sampling occasions in year *y* such that I_y is the set of ages in days since the median pupping date on which sampling occurred in year *y*, e.g. I_y = [30,60,90], N_y = 3;

   for each *i* in the set I_y in year *y* calculate $m_{(y,i)}$, the mean mass of pups at age *i* in year *y*;

   calculate the regression relationship $m_{(y,i)} = a + bi$ for all years *y* and ages *i*;

   for each year calculate the growth deviate (gd_y) where:

   $$gd_y = \frac{\sum_i \left(m_{(i,y)} - a - bi\right)}{N_y}$$

INTERPRETATION OF RESULTS:

Pup growth rates are an indication of prey availability, abundance and quality for their foraging mothers. Pup growth and subsequent weight at weaning may affect post-weaning growth and survival as well as the onset of sexual maturity and reproductive success as an adult.

PROBLEMS TO BE CONSIDERED:

The data analysis described above will, when reported to the Secretariat, create a database consisting of regression parameters. However, if further analysis is required before comparisons of colonies/years can proceed (for instance, comparing correlation coefficients), or if the comparisons themselves involve complex statistics such as analysis of covariance, then it may be advisable to compute and report only the following data describing the regressions from Procedure A:

   N, SX, SY, SX^2, SY^2, SXY, where X = days and Y = weight (kg) and N = number of weighings for each seal pup.

Reporting of the data in this format will enable the computation of all the above statistics.

DATA REPORTING:

Data should be reported using the latest version of CCAMLR data submission forms E/C2/A and E/C2/B (see Part III, Section 1). Data for different sexes of pups should be reported on separate forms.

DATES OF OBSERVATION:

Reported dates of pups birth and durations of perinatal and lactation periods in the Antarctic fur seal:

	Location		Refs
	South Georgia	South Shetlands	
Date of birth Median range Typical mean ± SD Range	4–8 Dec 6 Dec ± 8 days 21 Oct–24 Dec	X	2, 4, 6
Perinatal period Mean ± SD Range	7 ± 1 day 6–9 days	X	1, 4
Lactation period Range of means ± SD Range	112–116 ± 11 days 90–132 days	X	3, 4

X data not available

Figure 1: Diagram of a slip noose for the capture of pups.

alloy pole 3 or 4 m x 3 cm diameter

end, spliced or tied

pin/bolt/wire to stop cord slipping through pole

REFERENCES:

(1)   Croxall, J.P., T.S. McCann, P.A. Prince and P. Rothery. 1988. Reproductive performance of seabirds and seals at South Georgia and Signy Island, South Orkney Islands, 1976–1987: implications for Southern Ocean monitoring studies. In: Sahrhage, D. (Ed.). *Antarctic Ocean and Resources Variability*. Springer-Verlag, Berlin, Heidelberg: 261–285.

(2)   Doidge, D.W., J.P. Croxall and C. Ricketts. 1984. Growth rates of Antarctic fur seal *Arctocephalus gazella* pups at South Georgia. *J. Zool. Lond*., 203: 87–93.

(3)   Doidge, D.W., T.S. McCann and J.P. Croxall. 1986. Attendance behaviour of Antarctic fur seals. In: Gentry, R.C. and G.L. Kooyman (Eds). *Fur Seals*: *Maternal Strategies on Land and at Sea.* Princeton University Press, Princeton.

(4)   Doidge, D.W. and J.P. Croxall. 1988. Factors affecting weaning weight in Antarctic fur seals *Arctocephalus gazella* at South Georgia. *Polar Biology,* 8.

(5)   Gentry, R.L., M.E. Goebel and J. Calambokidis. 1988. Growth rates of northern fur seal neonates. Available from: Northwest and Alaska Fisheries Center. National Marine Mammal Laboratory, Seattle, Washington, USA.

(6)   McCann, T.S. and D.W. Doidge. 1987. Antarctic fur seal *Arctocephalus gazella*. In: Croxall, J.P. and R.L. Gentry (Eds). Status, Biology and Ecology of Fur Seals. *NOAA Tech. Rep. NMFS,* 51: 5–8.

(7)   Sokal, R.R. and F.J. Rohlf. 1981. *Biometry: the Principles and Practice of Statistics in Biological Research*. 2nd Edition. Freeman, New York.

BACKGROUND PAPERS:

Calambokidis, J. and R.L. Gentry. 1985. Mortality of northern fur seal pups in relation to growth and birth weights. *J. Wildl. Dis*., 21: 327–330.

Gentry, R. and J.R. Holt. 1982. Equipment and techniques for handling northern fur seals. *NOAA Tech. Rep. NMFS SSRF*, 758: 1–15.

Kerley, G.I.H. 1985. Pup growth in the fur seals *Arctocephalus tropicalis* and *A. gazella* on Marion Island. *J. Zool. Lond.*, 205: 315–324.

SECTION 4

MONITORING NON KRILL-DEPENDENT SPECIES

SPECIES: Antarctic shag (*Phalacrocorax bransfieldensis*)

PARAMETER: Diet of adult shags during the breeding season

ASSOCIATED PARAMETERS:

Other parameters, such as size of the breeding population, breeding chronology and success, duration of foraging trips, should be taken into account.

AIMS:

To monitor changes in coastal fish populations.

The analysis of Antarctic shag pellets seems to be the best indirect method of monitoring changes in coastal fish populations. In comparison to the analysis of stomach contents, the analysis of pellets is a non-disturbing technique that demands less time in the field and covers both adult and chick diets, thereby reflecting a wider trophic spectrum.

DATA COLLECTION:

1. If present, all pellets produced in previous breeding seasons should be removed from the study colony and discarded.

2. Collect a representative number of pellets only around the nests. In order to be representative, the number of pellets to be collected will depend on the size of the colony. Based on the size of the colonies at the South Shetland Islands, a minimum of 30 pellets per sample should be collected. Keep each sample in a separate bag.

3. The frequency of sample collection will depend on the accessibility of the colony. However, given that the diet changes throughout the breeding season, samples from the different periods (pre-laying/laying, incubation, early and late rearing and fledging) should be collected, if possible.

PROCESSING OF SAMPLES:

1. In order to break down the mucilaginous pellet and to allow easier separation of the otoliths and other hard parts, two alternative procedures are recommended:

    (i)   dry the pellets (at 60°C) until friable; or
    (ii) soak the pellets (overnight) in a mixture of detergent and disinfectant.

2. All solid food remnants from pellets must be separated into categories and the otoliths, where possible, identified to fish species.

---

*   This standard method for monitoring non krill-dependent species was approved by WG-EMM for a five-year trial period (SC-CAMLR-XVII, Annex 4, paragraph 9.30).

3. The otoliths of each fish species must be separated into right and left, the most abundant being considered as the number of individuals present by species in the sample.

4. The length of otoliths must be measured, and fish length and mass are estimated using a number of standardised equations (see Refs 2, 6 and 9). The appropriate equation should be chosen taking into account the fish species considered.

DATA PROCESSING AND ANALYSIS:

1. Calculate the mean length and size range for each fish species.
2. Calculate the mean mass of fish represented in pellets.
3. Calculate contributions (%) to the diet by each fish species by number and mass.

INTERPRETATION OF RESULTS:

These estimations will provide information on seasonal variations in the availability to shags of various fish species and changes in size and structure of the fish populations. These data can also be used to assess variation in shag food consumption rates and population energy requirements.

PROBLEMS TO BE CONSIDERED:

1. The main bias of the pellet analysis method is related to the erosion or loss of otoliths throughout the gastrointestinal tract. This bias, however, is thought to be of a constant magnitude at all times. Therefore, the relative contribution of each fish species to the diet should not be affected and comparisons between years should be valid.

    Nevertheless, if needed, the underestimation of mass for each fish species could be compensated by applying correction factors to mass values. These factors could be calculated using two techniques:

    (i) by comparing the fish fed to a captive shag with the contents of pellets recovered (Ref. 4); and

    (ii) by comparing pellets and stomach contents collected simultaneously from shags in the wild (Ref. 2) (see Appendix 1).

2. The diet of shags changes throughout the breeding season. Therefore, the sampling time should be standardised to allow comparison of results from different areas and/or seasons.

3. Where snowy sheathbills (*Chionis alba*) breed and/or forage near shag colonies, it can be very difficult to obtain pellets because these are removed by the sheathbills. This should be taken into account in selecting study sites for dietary studies of shags.

REFERENCES:

(1)   Casaux, R. 1997. On the accuracy of the pellet analysis method to estimate the food intake in the Antarctic shag *Phalacrocorax bransfieldensis*. Document *WG-EMM-97/61*. CCAMLR, Hobart, Australia: 13 pp.

(2)   Casaux, R., E. Barrera-Oro, M. Favero and P. Silva. 1995a. New correction factors for the quantification of fish represented in pellets of the blue-eyed shag *Phalacrocorax atriceps*. Document *WG-EMM-95/83*. CCAMLR, Hobart, Australia: 18 pp.

(3)   Casaux, R., M. Favero, E. Barrera-Oro and P. Silva. 1995b. Feeding trial on an imperial cormorant *Phalacrocorax atriceps*: preliminary results of fish intake and otolith digestion. *Marine Ornithology*, 23 (2): 50–56.

(4)   Casaux, R., M. Favero, M. Coria and P. Silva. 1995c. Comparison of the diet of the blue-eyed shag *Phalacrocorax atriceps* by the analysis of pellets and stomach contents. Document *WG-EMM-95/79*. CCAMLR, Hobart, Australia: 14 pp.

(5)   Favero, M., R. Casaux, P. Silva, E. Barrera-Oro and N. Coria. 1998. The diet of the blue-eyed shag during summer at Nelson Island, Antarctica. *The Condor*, 100: 112–118.

(6)   Hecht, T. 1987. A guide to the otoliths of Southern Ocean fishes. *S. Afr. J. Antarct. Res.*, 17 (1): 1–86.

(7)   Russell, A., S. Wanless and M. Harris. 1995. Factors affecting the production of pellets by shag *Phalacrocorax aristotelis*. *Seabird*, 17: 44–49.

(8)   Wanless, S., M. Harris and F. Russell. 1993. Factors influencing food-load sizes brought in by shags *Phalacrocorax aristotelis* during chick rearing. *Ibis*, 135: 19–24.

(9)   Williams, R. and A. McEldowney. 1990. A guide to the fish otoliths from waters off the Australian Territory, Heard and Macquarie Islands. *ANARE Research Notes*, 75: 1–173.

Initially it was thought that, as the stomach contents seem to reflect mainly the chicks' diet rather than the adults' diet (Refs 5 and 8), whereas the pellets do both, the correction factors estimated by this method probably mainly adjust the differences between chick and adult diets, rather than compensate for erosion by digestion and loss of otoliths. However it has been observed that:

(i) at least from pre-laying to mid-rearing the food carried to the nests by Antarctic shags also reflects the adults' diet (Casaux, in prep.); and

(ii) plausible results were obtained by applying the factors estimated by this method (Ref. 1; Casaux, in prep.).

If a quantitative estimate is required, the daily food intake per bird (*DFI*) can be calculated as follows:

$$DFI = è\,(MP \cdot RC_i \cdot NP \cdot CF_i)$$

where *MP* is the mean mass of fish represented in pellets, RC_i (= $M_i\%/100$) is the relative contribution of prey '*i*' to the diet (M_i is the diet contribution (%) by mass of prey '*i*'), *NP* is the mean number of pellets produced daily per individual (0.51, 0.74, 0.59 and 0.60 pellets for the Antarctic shag during incubation, early and late rearing and for the whole breeding season respectively) (taken from Ref. 2) and CF_i is the correction factor to compensate for the loss and digestion of the otoliths of the species '*i*' (see Table 1 below).

In those species that represent a small fraction of the diet for which the correction factor was not estimated, exclude 'CF_i'. These estimates might be obtained for the whole or for different periods of the breeding season.

Table 1: Correction factors estimated to compensate for digestion and loss (through the gastrointestinal tract) of otoliths of fish represented in pellets of the Antarctic shag (*Phalacrocorax bransfieldensis*) (from Ref. 2).

	Incubation	Early Rearing	Late Rearing	Whole Period
Notothenia coriiceps	2.87	4.23	9.52	5.20
Harpagifer antarcticus	0.76	0.58	6.50	1.43
Lepidonotothen nudifrons	1.95	2.17	12.77	4.28
Trematomus newnesi	4.17	3.78	5.59	5.15
Gobionotothen gibberifrons	6.80	-	1.36	2.30
Notothenia rossii	-	2.36	-	-
Pagothenia bernacchii	-	0.75	133.00	2.00

The rate of pellet production in different species/individuals may vary according to diet composition (see Ref. 3) or in relation to the age, sex and reproductive status of individuals (see Ref. 7). In view of this, if possible, the number of pellets produced daily per bird should be calculated for each colony. New correction factors should also be estimated for those shag colonies/species whose main fish prey items differ from those presented in Table 1.

PART II

**STANDARD METHODS FOR MONITORING
ENVIRONMENTAL PARAMETERS**

METHODS F1 – F4∗

CATEGORY: Environmental parameters which have a direct effect on predators

PARAMETERS: Sea-ice cover viewed from the CEMP site

AIMS:

To determine the amount of sea-ice cover in the vicinity of colonies prior to and during the arrival of predators ashore.

DATA COLLECTION:

1. Beginning two to three weeks prior to the arrival of adult birds or seals, observe the extent of sea-ice in the vicinity of and the approaches to the study area. Observations should be made at least once per five-day period. Continue the observations as long as and whenever sea-ice is visible from the colony during monitoring activities.

2. Choose an observation site(s) from which coastal areas in close proximity to study colonies can be viewed. Mark the site(s) using a metal stake or other means, and indicate the location(s) on a map provided to the CCAMLR Secretariat.

3. Record the ice cover (in tenths), extent (observed distance from shore) and type (annual, multi-year, floe, land-fast). Note and describe the presence of major leads that may be present in the ice. Experience suggests that a map or photo may be a useful complement to interpreting the numeric values recorded.

MANDATORY DATA:

Investigators are asked to archive these data at their home laboratories for subsequent analysis and presentation at CCAMLR.

HIGHLY DESIRABLE DATA:

PROBLEMS TO BE CONSIDERED:

COMMENTS:

DATA PROCESSING AND ANALYSIS:

DATA REPORTING:

At present submission of data is not requested.

REFERENCES:

BACKGROUND PAPERS:

CATEGORY: Environmental parameters which have a direct effect on predators

PARAMETERS: Sea-ice within the Integrated Study Regions (ISRs)

AIMS:

To determine the amount and characteristics of sea-ice within the ISRs.

DATA COLLECTION:

1. Information on the regional distribution of sea-ice can only feasibly be obtained using remote sensing techniques. Sea-ice imagery is available from a number of satellites whose orbits pass over the ISRs.

2. Sea-ice data should be collected at least for the period beginning two to three weeks prior to the arrival of adult birds or seals, and should continue until counts indicate that most breeding adults have arrived. In addition, it may be desirable to consider sea-ice data obtained via satellite throughout the year.

3. As feasible, it would be desirable to obtain data on sea-ice cover, extent and type.

MANDATORY DATA:

HIGHLY DESIRABLE DATA:

PROBLEMS TO BE CONSIDERED:

COMMENTS:

DATA PROCESSING AND ANALYSIS:

DATA REPORTING:

Data reporting formats have not yet been designed for this parameter and submission of data is not requested at present.

REFERENCES:

BACKGROUND PAPERS:

CATEGORY: Environmental parameters which have a direct effect on predators

PARAMETERS: Local weather

AIMS:

To obtain synoptic observations on temperature, precipitation, pressure, wind speed and wind direction throughout the study period.

DATA COLLECTION:

1. Collect weather data at least throughout the period when researchers are collecting biological data on study colonies. Ideally, this period should begin two to three weeks before the first arrival of adults and should continue until the end of the study season.

2. Choose a location for weather observations which, to the greatest extent possible, is typical for the CEMP site. In some cases the position of an existing meteorological station may be considered to adequately reflect conditions at the CEMP site and should be used for this purpose.

3. On a daily basis or more frequently (Ref. 1), record temperature (minimum and maximum), amount of precipitation within the past 24 hours, barometric pressure (minimum and maximum), wind speed (minimum and maximum) and predominant wind direction.

4. Take special note of the nature, magnitude and duration of catastrophic meteorological events (such as extreme winds, etc.).

MANDATORY DATA:

Investigators are asked to archive these data at their home laboratories for subsequent analysis and presentation to CCAMLR.

HIGHLY DESIRABLE DATA:

PROBLEMS TO BE CONSIDERED:

COMMENTS:

DATA PROCESSING AND ANALYSIS:

DATA REPORTING:

At present submission of data is not requested.

CCAMLR Standard Method F3 (draft)

REFERENCES:

(1)   Agnew, D.J.   1990.   Investigations of required sampling regimes for environmental parameters.   In: *Selected Scientific Papers, 1990 (SC-CAMLR-SSP/7)*. CCAMLR, Hobart, Australia: 561–573.

BACKGROUND PAPERS:

CATEGORY: Environmental parameters which have a direct effect on predators

PARAMETERS: Snow cover at CEMP site

AIMS:

To determine the depth and extent of snow at colonies in which monitoring studies are being undertaken.

DATA COLLECTION:

1. Throughout the field season, record snow cover during each five-day period. Continue whenever snow is present.

2. Select a number of colonies which represent different habitats present at the CEMP site (for example, near to or far from the beach, high or low elevations, steep or level slopes). In each of these, measure the average depth and extent (proportion covered) of snow.

MANDATORY DATA:

Investigators are asked to archive these data at their home laboratories for subsequent analysis and presentation to CCAMLR.

HIGHLY DESIRABLE DATA:

PROBLEMS TO BE CONSIDERED:

COMMENTS:

DATA PROCESSING AND ANALYSIS:

DATA REPORTING:

Data reporting formats have not yet been designed for this parameter and submission of data is not requested at present.

REFERENCES:

BACKGROUND PAPERS:

PART III

CEMP DATA REPORTING AND PROCESSING

SECTION 1

CEMP DATA SUBMISSION FORMS

CCAMLR Data Submission

CEMP METHOD A1: Penguin Adult Weight on Arrival

CATEGORY A – ALL ITEMS MUST BE COMPLETED

1.   Standard Method Version A1 • __

2.   Date of preparation   (Y/M/D) __ __ __ __ / __ __ / __ __

3.* Member __ __ __

4.   Researcher contact __ __ __ __ __ __ __ __ __ __

5.   Data collected according to standard method protocol?   Y ☐   N ☐

6.* Area/subarea/division __ __ __ __

7.   Split-year __ __ __ __

8.   Site designator __ __ __

9.   Colony or beach designator __ __ __ __

10.* Species __ __ __

11. Sex: Total ☐   Male ☐   Female ☐   Unsexed ☐

12. Procedure A (throughout period) ☐   Procedure B (at peak arrival) ☐

CATEGORY B – COMPLETE AS APPROPRIATE - Data on % arrival from chronology sheet E/A9?   Y ☐   N ☐

First date of 5-day period or date if Procedure B (Y/M/D)	Mean arrival weight (g)	Std. deviation weight (S_{n-1})	Minimum weight (g)	Maximum weight (g)	Sample size (*n*)	% arriving in this period
13. __ __ / __ __ / __ __	__ __ __ __ . __	__ __ __ . __	__ __ __ __	__ __ __ __	__ __ __	__ __
14. __ __ / __ __ / __ __	__ __ __ __ . __	__ __ __ . __	__ __ __ __	__ __ __ __	__ __ __	__ __
15. __ __ / __ __ / __ __	__ __ __ __ . __	__ __ __ . __	__ __ __ __	__ __ __ __	__ __ __	__ __
16. __ __ / __ __ / __ __	__ __ __ __ . __	__ __ __ . __	__ __ __ __	__ __ __ __	__ __ __	__ __
17. __ __ / __ __ / __ __	__ __ __ __ . __	__ __ __ . __	__ __ __ __	__ __ __ __	__ __ __	__ __
18. __ __ / __ __ / __ __	__ __ __ __ . __	__ __ __ . __	__ __ __ __	__ __ __ __	__ __ __	__ __

19. Comments (in particular, on any anomalous and/or extreme environmental conditions, e.g. snow/ice cover, wind, temperature): _____

* For appropriate codes see Part III, Section 2 of the *CEMP Standard Methods* manual

Use capital letters and dark pencil or black ink

E/A1 V4

page _____   of _____

CCAMLR Data Submission
CEMP METHOD A2: Duration of Penguin Incubation Shift

CATEGORY A – ALL ITEMS MUST BE COMPLETED

1. Standard Method Version A2 • __
2. Date of preparation   (Y/M/D) __ __ __ __ / __ __ / __ __
3.* Member __ __ __ __
4. Researcher contact __ __ __ __ __ __ __ __ __ __ __ __
5. Data collected according to standard method protocol?   Y ☐   N ☐
6.* Area/subarea/division __ __ __ __ __
7. Split-year __ __ __ __ __
8. Site designator __ __ __ __
9. Colony designator __ __ __ __
10.* Species __ __ __ __

CATEGORY B – COMPLETE AS APPROPRIATE

First incubation shift

	Mean duration (days)	Std. deviation (S_{n-1})	Min. duration (days)	Max. duration (days)	Sample size (n)	Start date for shift (Y/M/D) Earliest	Latest
11. Successful relief[1]	__ __ • __	__ __ • __ __	__ • __	__ • __	__ __ __	__ __ / __ __ / __ __	__ __ / __ __ / __ __
12. Failure by non-return[2]	__ __ • __	__ __ • __ __	__ • __	__ • __	__ __ __	__ __ / __ __ / __ __	__ __ / __ __ / __ __
13. Duration of pre-relief presence[3]	__ __ • __	__ __ • __ __	__ • __	__ • __	__ __ __		
14. Total nests monitored	__ __ __						
15. Total nests failing by non-return	__ __ __						
16. Number of reverse roles	__ __ __						
17. Total other failures	__ __ __						

---

[1] Include here incubation shift duration for nests correctly relieved – exclude failures and reversals
[2] Include here incubation shift duration for failures due to late return or non-return of mate
[3] Include here duration of presence of relieving bird at the nest prior to relief

* For appropriate codes see Part III, Section 2 of the *CEMP Standard Methods* manual

PLEASE TURN THE PAGE FOR CONTINUATION OF FORM
Use capital letters and dark pencil or black ink

page ____ of ____

(Colony __ __ __ Species __ __ __)

Form E/A2 V4

Second incubation shift

	Mean duration (days)	Std. deviation (S_{n-1})	Min. duration (days)	Max. duration (days)	Sample size (n)	Start date for shift (Y/M/D) Earliest	Latest
18. Successful relief[1]	__ . __	__ . __	__	__	__ __	__ / __ / __	__ / __ / __
19. Failure by non-return[2]	__ . __	__ . __	__	__	__ __	__ / __ / __	__ / __ / __
20. Duration of pre-relief presence[3]	__ . __	__ . __	__	__	__ __		
21. Total nests monitored	__ __						
22. Total nests failing by non-return	__ __						
23. Total other failures	__ __						

24. Comments (in particular, on any anomalous and/or extreme environmental conditions, e.g. snow/ice cover, wind, temperature):

_____

_____

[1] Include here incubation shift duration for nests correctly relieved – exclude failures and reversals
[2] Include here incubation shift duration for failures due to late return or non-return of mate
[3] Include here duration of presence of relieving bird at the nest prior to relief

* For appropriate codes see Part III, Section 2 of the *CEMP Standard Methods* manual

Use capital letters and dark pencil or black ink

| **E/A2 V4** | Page 2 |

page ____ **of** ____

CCAMLR Data Submission

CEMP METHOD A3: Penguin Breeding Population Size

CATEGORY A – ALL ITEMS MUST BE COMPLETED

1. Standard Method Version A3 • _ _

2. Date of preparation   (Y/M/D) _ _ _ _ / _ _ / _ _

3.* Member _ _ _ _

4. Researcher contact _ _ _ _ _ _ _ _ _ _

5. Data collected according to standard method protocol?   Y ☐   N ☐

6.* Area/subarea/division _ _ _ _ _

7. Split-year _ _ _ _

8. Site designator _ _ _ _

9.* Species _ _ _ _

CATEGORY B – COMPLETE AS APPROPRIATE

10. Data collection method: Visual ☐   Photographic ☐

	Colony designator	Mean number nests occupied	Std. deviation (occupied) (S_{n-1})	Mean number nests incubating	Std. deviation (incubating) (S_{n-1})	Date of counts (Y/M/D)	Sample size (n)
11.	_ _ _ _	_ _ _ _	_ _ • _ _	_ _ _ _ _	_ _ _ _ • _ _	_ _ _ _ / _ _ / _ _	_ _ _
12.	_ _ _ _	_ _ _ _	_ _ • _ _	_ _ _ _ _	_ _ _ _ • _ _	_ _ _ _ / _ _ / _ _	_ _ _
13.	_ _ _ _	_ _ _ _	_ _ • _ _	_ _ _ _ _	_ _ _ _ • _ _	_ _ _ _ / _ _ / _ _	_ _ _
14.	_ _ _ _	_ _ _ _	_ _ • _ _	_ _ _ _ _	_ _ _ _ • _ _	_ _ _ _ / _ _ / _ _	_ _ _
15.	_ _ _ _	_ _ _ _	_ _ • _ _	_ _ _ _ _	_ _ _ _ • _ _	_ _ _ _ / _ _ / _ _	_ _ _

16. Comments (in particular, on any anomalous and/or extreme environmental conditions, e.g. snow/ice cover, wind, temperature):

_____

_____

* For appropriate codes see Part III, Section 2 of the *CEMP Standard Methods* manual

Use capital letters and dark pencil or black ink

CCAMLR Data Submission

CEMP METHOD A5: Duration of Penguin Foraging

CATEGORY A – ALL ITEMS MUST BE COMPLETED

1.   Standard Method Version A5 • __

2.   Date of preparation   (Y/M/D)   __ __ __ / __ __ / __ __

3.*   Member   __ __ __

4.   Researcher contact   __ __ __ __ __ __

5.   Data collected according to standard method protocol?   Y ☐   N ☐

6.*   Area/subarea/division   __ __ __ __

7.   Split-year   __ __ __ __

8.   Site designator   __ __ __

9.   Colony designator   __ __ __

10.* Species   __ __ __

11.   Sex: Male ☐   Female ☐   Mixed/Unknown ☐

CATEGORY B – COMPLETE AS APPROPRIATE

Foraging Duration by Period

12.   Data on hatching available from chronology sheet E/A9?   Y ☐   N ☐

13.   Data on cessation of brooding available from chronology sheet E/A9?   Y ☐   N ☐

First day of 5-day period (Y/M/D)	Mean foraging duration[1] (hours)	Std. deviation[1] (S_{n-1})	Minimum duration[1] (hours)	Maximum duration[1] (hours)	Sample size (n)	Mean number of chicks per bird
14. __ __ / __ / __	__ __ • __	__ __ • __	__ __ • __	__ __ • __	__ __ __	__ • __
15. __ __ / __ / __	__ __ • __	__ __ • __	__ __ • __	__ __ • __	__ __ __	__ • __
16. __ __ / __ / __	__ __ • __	__ __ • __	__ __ • __	__ __ • __	__ __ __	__ • __
17. __ __ / __ / __	__ __ • __	__ __ • __	__ __ • __	__ __ • __	__ __ __	__ • __
18. __ __ / __ / __	__ __ • __	__ __ • __	__ __ • __	__ __ • __	__ __ __	__ • __
19. __ __ / __ / __	__ __ • __	__ __ • __	__ __ • __	__ __ • __	__ __ __	__ • __
20. __ __ / __ / __	__ __ • __	__ __ • __	__ __ • __	__ __ • __	__ __ __	__ • __
21. __ __ / __ / __	__ __ • __	__ __ • __	__ __ • __	__ __ • __	__ __ __	__ • __

[1]   Calculated as mean, SD, min., max. of all individual bird means in period (see Standard Method Sheet A5.2 'Analytical Methods')

* For appropriate codes see Part III, Section 2 of the *CEMP Standard Methods* manual

PLEASE TURN THE PAGE FOR CONTINUATION OF FORM
Use capital letters and dark pencil or black ink

(Colony _ _ _ _   Species _ _ _   Sex (M/F/U) _ _)

CATEGORY C – COMPLETE AS APPROPRIATE
Foraging duration by individual

	Period dates		Nest identification	Mean duration (hours)	Std. deviation duration	Sample size (n)	Number of chicks		Date of chick loss (Y/M/D)
	Start (Y/M/D)	End (Y/M/D)					start	end	
22.	_ _/_ _/_ _	_ _/_ _/_ _	_ _ _ _	_ _ . _ _	_ _ . _ _	_ _ _	_ _	_ _	_ _/_ _/_ _
23.	_ _/_ _/_ _	_ _/_ _/_ _	_ _ _ _	_ _ . _ _	_ _ . _ _	_ _ _	_ _	_ _	_ _/_ _/_ _
24.	_ _/_ _/_ _	_ _/_ _/_ _	_ _ _ _	_ _ . _ _	_ _ . _ _	_ _ _	_ _	_ _	_ _/_ _/_ _
25.	_ _/_ _/_ _	_ _/_ _/_ _	_ _ _ _	_ _ . _ _	_ _ . _ _	_ _ _	_ _	_ _	_ _/_ _/_ _
26.	_ _/_ _/_ _	_ _/_ _/_ _	_ _ _ _	_ _ . _ _	_ _ . _ _	_ _ _	_ _	_ _	_ _/_ _/_ _
27.	_ _/_ _/_ _	_ _/_ _/_ _	_ _ _ _	_ _ . _ _	_ _ . _ _	_ _ _	_ _	_ _	_ _/_ _/_ _
28.	_ _/_ _/_ _	_ _/_ _/_ _	_ _ _ _	_ _ . _ _	_ _ . _ _	_ _ _	_ _	_ _	_ _/_ _/_ _
29.	_ _/_ _/_ _	_ _/_ _/_ _	_ _ _ _	_ _ . _ _	_ _ . _ _	_ _ _	_ _	_ _	_ _/_ _/_ _
30.	_ _/_ _/_ _	_ _/_ _/_ _	_ _ _ _	_ _ . _ _	_ _ . _ _	_ _ _	_ _	_ _	_ _/_ _/_ _
31.	_ _/_ _/_ _	_ _/_ _/_ _	_ _ _ _	_ _ . _ _	_ _ . _ _	_ _ _	_ _	_ _	_ _/_ _/_ _
32.	_ _/_ _/_ _	_ _/_ _/_ _	_ _ _ _	_ _ . _ _	_ _ . _ _	_ _ _	_ _	_ _	_ _/_ _/_ _
33.	_ _/_ _/_ _	_ _/_ _/_ _	_ _ _ _	_ _ . _ _	_ _ . _ _	_ _ _	_ _	_ _	_ _/_ _/_ _
34.	_ _/_ _/_ _	_ _/_ _/_ _	_ _ _ _	_ _ . _ _	_ _ . _ _	_ _ _	_ _	_ _	_ _/_ _/_ _
35.	_ _/_ _/_ _	_ _/_ _/_ _	_ _ _ _	_ _ . _ _	_ _ . _ _	_ _ _	_ _	_ _	_ _/_ _/_ _
36.	_ _/_ _/_ _	_ _/_ _/_ _	_ _ _ _	_ _ . _ _	_ _ . _ _	_ _ _	_ _	_ _	_ _/_ _/_ _
37.	_ _/_ _/_ _	_ _/_ _/_ _	_ _ _ _	_ _ . _ _	_ _ . _ _	_ _ _	_ _	_ _	_ _/_ _/_ _
38.	_ _/_ _/_ _	_ _/_ _/_ _	_ _ _ _	_ _ . _ _	_ _ . _ _	_ _ _	_ _	_ _	_ _/_ _/_ _
39.	_ _/_ _/_ _	_ _/_ _/_ _	_ _ _ _	_ _ . _ _	_ _ . _ _	_ _ _	_ _	_ _	_ _/_ _/_ _
40.	_ _/_ _/_ _	_ _/_ _/_ _	_ _ _ _	_ _ . _ _	_ _ . _ _	_ _ _	_ _	_ _	_ _/_ _/_ _
41.	_ _/_ _/_ _	_ _/_ _/_ _	_ _ _ _	_ _ . _ _	_ _ . _ _	_ _ _	_ _	_ _	_ _/_ _/_ _

42. Comments (in particular, on any anomalous and/or extreme environmental conditions, e.g. snow/ice cover, wind, temperature):

_____

_____

* For appropriate codes see Part III, Section 2 of the *CEMP Standard Methods* manual

Use capital letters and dark pencil or black ink

CCAMLR Data Submission
CEMP METHOD A6: Penguin Breeding Success – Procedure A

CATEGORY A – ALL ITEMS MUST BE COMPLETED

1.   Standard Method Version A6 • __

2.   Date of preparation   (Y/M/D) __ __ __ __ / __ __ / __ __

3.* Member __ __ __

4.   Researcher contact __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __

5.   Data collected according to standard method protocol?   Y ☐   N ☐

6.* Area/subarea/division __ __ __ __

7.   Split-year __ __ __ __

8.   Site designator __ __ __

9.* Species __ __ __

CATEGORY B – COMPLETE AS APPROPRIATE

Procedure A only (chick counts)

	Colony designator	Mean no. of chicks	Std. deviation chicks (S_{n-1})	Date of counts (Y/M/D)	Sample size (n)
10.	__ __ __ __	__ __ __ __	__ __ __ • __ __	__ __ / __ __ / __ __	__
11.	__ __ __ __	__ __ __ __	__ __ __ • __ __	__ __ / __ __ / __ __	__
12.	__ __ __ __	__ __ __ __	__ __ __ • __ __	__ __ / __ __ / __ __	__
13.	__ __ __ __	__ __ __ __	__ __ __ • __ __	__ __ / __ __ / __ __	__
14.	__ __ __ __	__ __ __ __	__ __ __ • __ __	__ __ / __ __ / __ __	__
15.	__ __ __ __	__ __ __ __	__ __ __ • __ __	__ __ / __ __ / __ __	__
16.	__ __ __ __	__ __ __ __	__ __ __ • __ __	__ __ / __ __ / __ __	__
17.	__ __ __ __	__ __ __ __	__ __ __ • __ __	__ __ / __ __ / __ __	__
18.	__ __ __ __	__ __ __ __	__ __ __ • __ __	__ __ / __ __ / __ __	__
19.	__ __ __ __	__ __ __ __	__ __ __ • __ __	__ __ / __ __ / __ __	__

20. Comments (in particular, on any anomalous and/or extreme environmental conditions, e.g. snow/ice cover, wind, temperature):

_____

_____

_____

* For appropriate codes see Part III, Section 2 of the *CEMP Standard Methods* manual

Use capital letters and dark pencil or black ink

CCAMLR Data Submission
CEMP METHOD A6: Penguin Breeding Success – Procedure B

CATEGORY A – ALL ITEMS MUST BE COMPLETED

1. Standard Method Version A6 • __

2. Date of preparation   (Y/M/D) __ __ __ __ / __ __ / __ __

3.* Member __ __ __

4. Researcher contact __ __ __ __ __ __ __ __ __ __ __ __ __ __ __

5. Data collected according to standard method protocol?   Y ☐   N ☐

6.* Area/subarea/division __ __ __ __

7. Split-year __ __ __ __

8. Site designator __ __ __

9. Colony designator __ __ __ __

10.* Species __ __ __

CATEGORY B – COMPLETE AS APPROPRIATE

Procedure B only (chicks raised per breeding pair)

11. Date when observations began (Y/M/D) __ __ / __ __ / __ __

12. Date when observations concluded (Y/M/D) __ __ / __ __ / __ __

13. Date when first egg laid (Y/M/D) __ __ / __ __ / __ __

14. Date when first egg hatched (Y/M/D) __ __ / __ __ / __ __

15. Date when first chick entered creche (Y/M/D) __ __ / __ __ / __ __

16. Total number of nests observed __ __ __

17. Total number of nests with 1 egg laid __ __ __

18. Total number of nests with 2 eggs laid __ __ __

19. Total number of eggs that hatch from 1-egg nests __ __ __

20. Total number of eggs that hatch from 2-egg nests __ __ __

21. Total number of pairs rearing 1 chick to creche __ __ __

22. Total number of pairs rearing 2 chicks to creche __ __ __

23. Mean number of chicks per nest reared to creche __ __ __

24. Standard deviation (of #22) $[S_{n-1}]$ __ • __ __

25. Comments (in particular, on any anomalous and/or extreme environmental conditions, e.g. snow/ice cover, wind, temperature):

_____

_____

_____

* For appropriate codes see Part III, Section 2 of the *CEMP Standard Methods* manual

Use capital letters and dark pencil or black ink

CCAMLR Data Submission

CEMP METHOD A6: Penguin Breeding Success – Procedure C

CATEGORY A – ALL ITEMS MUST BE COMPLETED

1. Standard Method Version A6 • __ __

2. Date of preparation (Y/M/D) __ __ __ __ / __ __ / __ __

3.* Member __ __ __

4. Researcher contact __ __ __ __ __ __ __ __ __ __ __ __

5. Data collected according to standard method protocol? Y ☐   N ☐

6.* Area/subarea/division __ __ __ __ __

7. Split-year __ __ __ __ __

8. Site designator __ __ __ __

9. Colony designator __ __ __ __

10.* Species __ __ __ __

CATEGORY B – COMPLETE AS APPROPRIATE

Procedure C only (chicks raised per colony)

	Date of counts (Y/M/D)	Mean of counts	Std. deviation (S_{n-1})	Sample size (n)
11. At 95% with eggs – number of nests with eggs	__ __ / __ __ / __ __	__ __ __ __	__ __ • __ __	__ __
12. At end of hatching – number of nests with chicks	__ __ / __ __ / __ __	__ __ __ __	__ __ • __ __	__ __
13. When all chicks in creche – number in creche	__ __ / __ __ / __ __	__ __ __ __	__ __ • __ __	__ __

14. Comments (in particular, on any anomalous and/or extreme environmental conditions, e.g. snow/ice cover, wind, temperature):

_____

_____

*For appropriate codes see Part III, Section 2 of the *CEMP Standard Methods* manual

Use capital letters and dark pencil or black ink

E/A6/C V4   page _____ of _____

CCAMLR Data Submission

CEMP METHOD *A7*: Penguin Chick Weight at Fledging

CATEGORY A - ALL ITEMS MUST BE COMPLETED

1. Standard Method Version A7 • ___

2. Date of preparation   (Y/M/D) ___ ___ ___ ___ / ___ ___ / ___ ___

3. * Member ___ ___ ___

4. Researcher contact ___ ___ ___ ___ ___ ___ ___ ___ ___ ___

5. Data collected according to standard method protocol?   Y ☐   N ☐

6. * Area/subarea/division ___ ___ ___ ___

7. Split year ___ ___ — ___ ___

8. Site designator ___ ___ — ___

9. Colony or beach designator ___ ___ — ___ ___

10. * Species ___ ___ ___

11. Procedure A (sampling throughout period) ☐   Procedure B (sampling at peak fledging) ☐

CATEGORY B – COMPLETE AS APPROPRIATE

12. Is % fledged calculated from chronology sheet E/A9?   Y ☐   N ☐

First day of 5-day period (Y/M/D) (or date if Procedure B)	Mean weight (g)	Std. deviation (S_{n-1})	Minimum weight (g)	Maximum weight (g)	Sample size (n)	% of total that fledged in this period
13. ___ ___ / ___ ___ / ___ ___	___ ___ ___ ___	___ ___ ___ • ___	___ ___ ___ ___	___ ___ ___ ___	___ ___ ___	___ ___ ___
14. ___ ___ / ___ ___ / ___ ___	___ ___ ___ ___	___ ___ ___ • ___	___ ___ ___ ___	___ ___ ___ ___	___ ___ ___	___ ___ ___
15. ___ ___ / ___ ___ / ___ ___	___ ___ ___ ___	___ ___ ___ • ___	___ ___ ___ ___	___ ___ ___ ___	___ ___ ___	___ ___ ___
16. ___ ___ / ___ ___ / ___ ___	___ ___ ___ ___	___ ___ ___ • ___	___ ___ ___ ___	___ ___ ___ ___	___ ___ ___	___ ___ ___
17. ___ ___ / ___ ___ / ___ ___	___ ___ ___ ___	___ ___ ___ • ___	___ ___ ___ ___	___ ___ ___ ___	___ ___ ___	___ ___ ___
18. ___ ___ / ___ ___ / ___ ___	___ ___ ___ ___	___ ___ ___ • ___	___ ___ ___ ___	___ ___ ___ ___	___ ___ ___	___ ___ ___
19. ___ ___ / ___ ___ / ___ ___	___ ___ ___ ___	___ ___ ___ • ___	___ ___ ___ ___	___ ___ ___ ___	___ ___ ___	___ ___ ___
20. ___ ___ / ___ ___ / ___ ___	___ ___ ___ ___	___ ___ ___ • ___	___ ___ ___ ___	___ ___ ___ ___	___ ___ ___	___ ___ ___
21. ___ ___ / ___ ___ / ___ ___	___ ___ ___ ___	___ ___ ___ • ___	___ ___ ___ ___	___ ___ ___ ___	___ ___ ___	___ ___ ___
22. ___ ___ / ___ ___ / ___ ___	___ ___ ___ ___	___ ___ ___ • ___	___ ___ ___ ___	___ ___ ___ ___	___ ___ ___	___ ___ ___

23. Comments (in particular, on any anomalous and/or extreme environmental conditions, e.g. snow/ice cover, wind, temperature): _____

_____

* For appropriate codes see Part III, Section 2 of the *CEMP Standard Methods* manual

Use capital letters and dark pencil or black ink

E/*A7* V5

page _____   of _____

CCAMLR Data Submission

CEMP METHOD A8: Penguin Chick Diet – General Composition

CATEGORY A – ALL ITEMS MUST BE COMPLETED

1. Standard Method Version A8 • ___

2. Date of preparation   (Y/M/D) ___ ___ ___ ___ / ___ ___ / ___ ___

3.* Member ___ ___ ___

4. Researcher contact ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___

5. Data collected according to standard method protocol?   Y ☐   N ☐

6.* Area/subarea/division ___ ___ ___ ___

7. Split-year ___ ___ ___ ___

8. Site designator ___ ___ ___

9. Colony or beach designator ___ ___ ___ ___

10.* Species ___ ___ ___

CATEGORY B – COMPLETE AS APPROPRIATE

	Collection Date (Y/M/D)	Collection Time[1] (h/m)	Total pre-sorting weight[2] (g)	Squid (g)	Fish (g)	Total crustaceans (g)	Superba[3] (g)	Crystal's[4] (g)	Other euphausiids (g)	Other crustaceans (g)	Other material (g)
11.	___/___/___	___/___	___	___	___	___	___	___	___	___	___
12.	___/___/___	___/___	___	___	___	___	___	___	___	___	___
13.	___/___/___	___/___	___	___	___	___	___	___	___	___	___
14.	___/___/___	___/___	___	___	___	___	___	___	___	___	___
15.	___/___/___	___/___	___	___	___	___	___	___	___	___	___
16.	___/___/___	___/___	___	___	___	___	___	___	___	___	___
17.	___/___/___	___/___	___	___	___	___	___	___	___	___	___
18.	___/___/___	___/___	___	___	___	___	___	___	___	___	___
19.	___/___/___	___/___	___	___	___	___	___	___	___	___	___

[1] Greenwich Mean Time
[2] Include empty stomachs
[3] *Euphausia superba*
[4] *Euphausia crystallorophias*

* For appropriate codes see Part III, Section 2 of the *CEMP Standard Methods* manual

E/A8/A V5   Page 1

PLEASE TURN THE PAGE FOR CONTINUATION OF FORM

Use capital letters and dark pencil or black ink

page _____ of _____

Form E/A8/A V5

(Colony _ _ _ _ Species _ _ _)

	Collection Date (Y/M/D)	Collection Time[1] (h/m)	Total pre-sorting weight[2] (g)	Squid (g)	Fish (g)	Total crustaceans (g)	*Superba*[3] (g)	*Crystal's*[4] (g)	Other euphausiids (g)	Other crustaceans (g)	Other material (g)
20.	_ _/_ _/_ _	_ _/_ _									
21.	_ _/_ _/_ _	_ _/_ _									
22.	_ _/_ _/_ _	_ _/_ _									
23.	_ _/_ _/_ _	_ _/_ _									
24.	_ _/_ _/_ _	_ _/_ _									
25.	_ _/_ _/_ _	_ _/_ _									
26.	_ _/_ _/_ _	_ _/_ _									
27.	_ _/_ _/_ _	_ _/_ _									
28.	_ _/_ _/_ _	_ _/_ _									
29.	_ _/_ _/_ _	_ _/_ _									
30.	_ _/_ _/_ _	_ _/_ _									
31.	_ _/_ _/_ _	_ _/_ _									
32.	_ _/_ _/_ _	_ _/_ _									
33.	_ _/_ _/_ _	_ _/_ _									
34.	_ _/_ _/_ _	_ _/_ _									
35.	_ _/_ _/_ _	_ _/_ _									
36.	_ _/_ _/_ _	_ _/_ _									
37.	_ _/_ _/_ _	_ _/_ _									

38. Comments (in particular, on any anomalous and/or extreme environmental conditions, e.g. snow/ice cover, wind, temperature):

[1] Greenwich Mean Time
[2] Include empty stomachs
[3] *Euphausia superba*
[4] *Euphausia crystallorophias*

* For appropriate codes see Part III, Section 2 of the *CEMP Standard Methods* manual

E/A8/A V5 Page 2

Use capital letters and dark pencil or black ink

page _____ of _____

CCAMLR Data Submission

CEMP METHOD A9: Penguin Breeding Chronology

CATEGORY A – ALL ITEMS MUST BE COMPLETED

1.   Standard Method Version A9 • ___

2.   Date of preparation   (Y/M/D) ___ ___ ___ ___ / ___ ___ / ___ ___

3.* Member ___ ___ ___

4.   Researcher contact ___ ___ ___ ___ ___ ___ ___ ___ ___

5.   Data collected according to standard method protocol?   Y ☐   N ☐

6.* Area/subarea/division ___ ___ ___ ___ ___

7.   Split year ___ ___ ___ ___

8.   Site designator ___ ___ ___

9.   Colony designator ___ ___ ___ ___

10.* Species ___ ___ ___

CATEGORY B – RATES OF EVENTS (COMPLETE AS APPROPRIATE)

| First day of 5-day period (Y/M/D) | Number of adults arriving in colony in this period | <- - - - - Sample of 100 nests - - - - -> | | | Number of chicks fledging from colony in this period |
		Number of nests with egg laid in this period	Number of nests with first chick hatching this period	Number of nests ceasing to brood in this period	
11. ___ ___ ___ ___ / ___ ___ / ___ ___	___ ___ ___ ___	___ ___ ___	___ ___ ___	___ ___ ___	___ ___ ___
12. ___ ___ ___ ___ / ___ ___ / ___ ___	___ ___ ___ ___	___ ___ ___	___ ___ ___	___ ___ ___	___ ___ ___
13. ___ ___ ___ ___ / ___ ___ / ___ ___	___ ___ ___ ___	___ ___ ___	___ ___ ___	___ ___ ___	___ ___ ___
14. ___ ___ ___ ___ / ___ ___ / ___ ___	___ ___ ___ ___	___ ___ ___	___ ___ ___	___ ___ ___	___ ___ ___
15. ___ ___ ___ ___ / ___ ___ / ___ ___	___ ___ ___ ___	___ ___ ___	___ ___ ___	___ ___ ___	___ ___ ___
16. ___ ___ ___ ___ / ___ ___ / ___ ___	___ ___ ___ ___	___ ___ ___	___ ___ ___	___ ___ ___	___ ___ ___
17. ___ ___ ___ ___ / ___ ___ / ___ ___	___ ___ ___ ___	___ ___ ___	___ ___ ___	___ ___ ___	___ ___ ___
18. ___ ___ ___ ___ / ___ ___ / ___ ___	___ ___ ___ ___	___ ___ ___	___ ___ ___	___ ___ ___	___ ___ ___
19. ___ ___ ___ ___ / ___ ___ / ___ ___	___ ___ ___ ___	___ ___ ___	___ ___ ___	___ ___ ___	___ ___ ___
20. ___ ___ ___ ___ / ___ ___ / ___ ___	___ ___ ___ ___	___ ___ ___	___ ___ ___	___ ___ ___	___ ___ ___
21. ___ ___ ___ ___ / ___ ___ / ___ ___	___ ___ ___ ___	___ ___ ___	___ ___ ___	___ ___ ___	___ ___ ___
22. ___ ___ ___ ___ / ___ ___ / ___ ___	___ ___ ___ ___	___ ___ ___	___ ___ ___	___ ___ ___	___ ___ ___
23. ___ ___ ___ ___ / ___ ___ / ___ ___	___ ___ ___ ___	___ ___ ___	___ ___ ___	___ ___ ___	___ ___ ___

PLEASE TURN THE PAGE FOR CONTINUATION OF FORM
Use capital letters and dark pencil or black ink

page _____ of _____

* For appropriate codes see Part III, Section 2 of the *CEMP Standard Methods* manual

(Colony _ _ _ _   Species _ _ _ _)

	First day of 5-day period (Y/M/D)	Number of adults arriving in colony in this period	<- - - - - Sample of 100 nests - - - - ->			Number of chicks fledging from colony in this period
			Number of nests with egg laid in this period	Number of nests with first chick hatching this period	Number of nests ceasing to brood in this period	
24.	_ _/_ _/_ _	_ _ _	_ _ _	_ _ _	_ _ _	_ _ _
25.	_ _/_ _/_ _	_ _ _	_ _ _	_ _ _	_ _ _	_ _ _
26.	_ _/_ _/_ _	_ _ _	_ _ _	_ _ _	_ _ _	_ _ _
27.	_ _/_ _/_ _	_ _ _	_ _ _	_ _ _	_ _ _	_ _ _
28.	_ _/_ _/_ _	_ _ _	_ _ _	_ _ _	_ _ _	_ _ _
29.	_ _/_ _/_ _	_ _ _	_ _ _	_ _ _	_ _ _	_ _ _
30.	_ _/_ _/_ _	_ _ _	_ _ _	_ _ _	_ _ _	_ _ _
31.	_ _/_ _/_ _	_ _ _	_ _ _	_ _ _	_ _ _	_ _ _
32.	_ _/_ _/_ _	_ _ _	_ _ _	_ _ _	_ _ _	_ _ _
33.	_ _/_ _/_ _	_ _ _	_ _ _	_ _ _	_ _ _	_ _ _
34.	_ _/_ _/_ _	_ _ _	_ _ _	_ _ _	_ _ _	_ _ _
35.	_ _/_ _/_ _	_ _ _	_ _ _	_ _ _	_ _ _	_ _ _

36. Total monitored _ _ _

37. Total failures _ _ _

CATEGORY C – SUMMARY DATES (Y/M/D) (COMPLETE AS APPROPRIATE)

	Arriving	Laying	Hatching	Creching	Fledging
38. Calculated median[1] dates	_ _/_ _/_ _	_ _/_ _/_ _	_ _/_ _/_ _	_ _/_ _/_ _	_ _/_ _/_ _
39. Calculated modal dates	_ _/_ _/_ _	_ _/_ _/_ _	_ _/_ _/_ _	_ _/_ _/_ _	_ _/_ _/_ _
40. Date of first	_ _/_ _/_ _	_ _/_ _/_ _	_ _/_ _/_ _	_ _/_ _/_ _	_ _/_ _/_ _
41. Date of completed		_ _/_ _/_ _	_ _/_ _/_ _	_ _/_ _/_ _	_ _/_ _/_ _
42. Date when 95% of nests have eggs		_ _/_ _/_ _			
43. Date one third of eggs have hatched		_ _/_ _/_ _			
44. Date two thirds of chicks are in creche		_ _/_ _/_ _			

45. Comments (in particular, on any anomalous and/or extreme environmental conditions, e.g. snow/ice cover, wind, temperature):

_____

[1] Calculate medians only for nests which were successful within a period

* For appropriate codes see Part III, Section 2 of the *CEMP Standard Methods* manual

Use capital letters and dark pencil or black ink

CCAMLR Data Submission
CEMP METHOD B1: Black-browed Albatross
Breeding Population Size and Success

CATEGORY A – ALL ITEMS MUST BE COMPLETED

1. Standard Method Version B1/2 • __

2. Date of preparation   (Y/M/D) __ __ __ __ / __ __ / __ __

3.* Member __ __ __

4. Researcher contact __ __ __ __ __ __ __ __ __ __ __ __ __ __ __

5. Data collected according to standard method protocol?   Y ☐   N ☐

6.* Area/subarea/division __ __ __ __

7. Split-year __ __ __ __

8. Site designator __ __ __

9. Colony designator __ __ __ __

10. Procedure A (repeated visits and ringing) ☐   Procedure B (single visits) ☐

CATEGORY B - COMPLETE EITHER A OR B AS APPROPRIATE

Procedure A Only

11. Total number of breeding pairs __ __ __ __

12. Number hatching __ __ __ __

13. Number banded __ __ __ __

14. Number dying after banding __ __ __

15. Number surviving to fledge __ __ __ __

16. % breeding success (#14 ÷ #10) __ __ • __ __

17. % hatching success (#11 ÷ # 10) __ __ • __ __

18. % fledging success (#14 ÷ # 11) __ __ • __ __

Procedure B Only

	Date of count (Y/M/D)	Mean no.	Std. deviation (S_{n-1})	Sample size (n)
19. Total number of breeding pairs	__ __/__ __/__ __	__ __ __ • __	__ __ __ • __	__
20. Number of nests brooding	__ __/__ __/__ __	__ __ __ • __	__ __ __ • __	__
21. Number surviving to pre-fledging	__ __/__ __/__ __	__ __ __ • __	__ __ __ • __	__

22. % breeding success (#20 ÷ #18) __ __ • __ __

23. % hatching success (#19 ÷ #18) __ __ • __ __

24. % brooding success (#20 ÷ #19) __ __ • __ __

25. Comments (in particular, on any anomalous and/or extreme environmental conditions, e.g. snow/ice cover, wind, temperature):

_____

_____

_____

* For appropriate codes see Part III, Section 2 of the *CEMP Standard Methods* manual

CCAMLR Data Submission

CEMP METHOD B4: Petrel Chick Diet – General Composition

CATEGORY A - ALL ITEMS MUST BE COMPLETED

1. Standard Method Version B4 • __

2. Date of preparation (Y/M/D) __ __ __ __ / __ __ / __ __

3.* Member __ __

4. Researcher contact __ __ __ __ __ __ __ __ __ __ __

5. Data collected according to standard method protocol? Y ☐ N ☐

6.* Area/subarea/division __ __ __ __

7. Split-year __ __ __ __

8. Site designator __ __

9. Colony or beach designator __ __ __ __

10.* Species __ __ __

CATEGORY B - COMPLETE AS APPROPRIATE: Procedure   A ☐   B ☐

	Collection Date (Y/M/D)	Collection time[1] (h/m)	Total pre-sorting weight (g)	Squid+ (g)	Fish+ (g)	Total Crustaceans (g)	*Euphausia Superba*+ (g)	Other euphausiids (g)	Other crustaceans (g)	Other material (g)
11.	__ / __ / __	__ / __	__ __	__ __	__ __	__ __	__ __	__ __	__ __	__ __
12.	__ / __ / __	__ / __	__ __	__ __	__ __	__ __	__ __	__ __	__ __	__ __
13.	__ / __ / __	__ / __	__ __	__ __	__ __	__ __	__ __	__ __	__ __	__ __
14.	__ / __ / __	__ / __	__ __	__ __	__ __	__ __	__ __	__ __	__ __	__ __
15.	__ / __ / __	__ / __	__ __	__ __	__ __	__ __	__ __	__ __	__ __	__ __
16.	__ / __ / __	__ / __	__ __	__ __	__ __	__ __	__ __	__ __	__ __	__ __
17.	__ / __ / __	__ / __	__ __	__ __	__ __	__ __	__ __	__ __	__ __	__ __
18.	__ / __ / __	__ / __	__ __	__ __	__ __	__ __	__ __	__ __	__ __	__ __
19.	__ / __ / __	__ / __	__ __	__ __	__ __	__ __	__ __	__ __	__ __	__ __

+ Estimated total weights using standard equations for Procedure B only

[1] Greenwich Mean Time

* For appropriate codes see Part III, Section 2 of the *CEMP Standard Methods* manual

PLEASE TURN THE PAGE FOR CONTINUATION OF FORM
Use capital letters and dark pencil or black ink

E/B4/A V2 Page 1   page ____ of _____

(Colony _ _ _ _   Species _ _ _)

Collection Date (Y/M/D)	Collection time[1] (h/m)	Total pre-sorting weight (g)	Squid[+] (g)	Fish[+] (g)	Total Crustaceans (g)	Euphausia Superba[+] (g)	Other euphausiids (g)	Other crustaceans (g)	Other material (g)
20.									
21.									
22.									
23.									
24.									
25.									
26.									
27.									
28.									
29.									
30.									
31.									
32.									
33.									
34.									
35.									
36.									
37.									

38.   Comments (in particular, on any anomalous and/or extreme environmental conditions, e.g. snow/ice cover, wind, temperature):

_____

[+]   Estimated total weights using standard equations for Procedure B only

[1]   Greenwich Mean Time

* For appropriate codes see Part III, Section 2 of the *CEMP Standard Methods* manual

E/B4/A V2 Page 2

Use capital letters and dark pencil or black ink

page _____ of _____

CCAMLR Data Submission
CEMP METHOD B5: Antarctic Petrel Breeding Population Size and Success

CATEGORY A – ALL ITEMS MUST BE COMPLETED

1. Standard Method Version B5 • __

2. Date of preparation   (Y/M/D)   __ __ __ __ / __ __ / __ __

3.* Member __ __ __

4. Researcher contact __ __ __ __ __ __ __ __ __ __ __ __ __ __ __

5. Data collected according to standard method protocol?   Y ☐   N ☐

6.* Area/subarea/division __ __ __ __

7. Split-year __ __ __ __

8. Site designator __ __ __

9. Colony designator __ __ __ __

10. Procedure A (repeated visits and ringing) ☐   Procedure B (infrequent visits) ☐

     Procedure C (single visits) ☐

CATEGORY B – COMPLETE EITHER A OR B AS APPROPRIATE

Procedure A Only

11. Total number of breeding pairs __ __ __ __   15. Number surviving to fledge __ __ __ __

12. Number hatching __ __ __ __   16. % breeding success (#14 ÷ #10) __ __ • __ __

13. Number banded __ __ __ __   17. % hatching success (#11 ÷ # 10) __ __ • __ __

14. Number dying after banding __ __ __   18. % fledging success (#14 ÷ # 11) __ __ • __ __

Procedure B Only	Date of count (Y/M/D)	Mean no.	Std. deviation (S_{n-1})	Sample size (n)
19. Total number of breeding pairs	__ __/__ __/__ __	__ __ __ __ • __	__ __ __ • __	__
20. Number of nests brooding	__ __/__ __/__ __	__ __ __ __ • __	__ __ __ • __	__
21. Number surviving to pre-fledging	__ __/__ __/__ __	__ __ __ __ • __	__ __ __ • __	__

22. % breeding success (#20 ÷ #18)   __ __ • __ __

23. % hatching success (#19 ÷ #18)   __ __ • __ __

24. % brooding success (#20 ÷ #19)   __ __ • __ __

Procedure C Only	After laying	After hatching	Pre-fledging
25. Date of count (Y/M/D)	__ __/__ __/__ __	__ __/__ __/__ __	__ __/__ __/__ __
26. Total number of breeding pairs	__ __ __ __	__ __ __ __	__ __ __ __
27. Number of nests brooding	__ __ __ __	__ __ __ __	__ __ __ __
28. Number surviving to pre-fledging	__ __ __ __	__ __ __ __	__ __ __ __

29. Comments (in particular, on any anomalous and/or extreme environmental
     conditions, e.g. snow/ice cover, wind, temperature):

_____

_____

_____

* For appropriate codes see Part III, Section 2 of the *CEMP Standard Methods* manual

Use capital letters and dark pencil or black ink

CCAMLR Data Submission
CEMP METHOD C1: Fur Seal Cow Foraging

CATEGORY A - ALL ITEMS MUST BE COMPLETED

1. Standard Method Version C1 • __

2. Date of preparation   (Y/M/D) __ __ __ __ / __ __ / __ __

3.* Member __ __ __

4. Researcher contact __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __

5. Data collected according to standard method protocol?   Y ☐   N ☐

6.* Area/subarea/division __ __ __ __

7. Split-year __ __ __ __

8. Site designator __ __ __

9. Colony designator __ __ __ __

CATEGORY B – REPORT FOR THE FIRST SIX PERINATAL TRIPS BY FEMALES

10. Date of start of first trip   (Y/M/D)   __ __ / __ __ / __ __   time (h/m) __ __ / __ __

11. Date of end of last trip   (Y/M/D)   __ __ / __ __ / __ __   time (h/m) __ __ / __ __

All females pooled

Trip No.	Mean duration (hours)	Std. deviation (S_{n-1})	Sample size (n)	Minimum (hours)	Maximum (hours)
1.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
2.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
3.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
4.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
5.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
6.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __

All trips pooled

Female No.

	Mean duration (hours)	Std. deviation (S_{n-1})	Sample size (n)	Minimum (hours)	Maximum (hours)
1.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
2.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
3.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
4.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
5.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
6.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
7.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
8.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
9.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
10.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __

* For appropriate codes see Part III, Section 2 of the *CEMP Standard Methods* manual

PLEASE TURN THE PAGE FOR CONTINUATION OF FORM
Use capital letters and dark pencil or black ink

(Colony __ __ __ __ Species __ __ __)

Female No.	Mean duration (hours)	Std. deviation (S_{n-1})	Sample size (n)	Minimum (hours)	Maximum (hours)
11.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
12.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
13.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
14.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
15.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
16.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
17.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
18.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
19.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
20.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
21.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
22.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
23.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
24.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
25.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
26.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
27.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
28.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
29.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
30.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
31.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
32.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
33.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
34.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
35.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
36.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
37.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
38.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
39.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __
40.	__ __ __ • __ __	__ __ • __ __	__ __	__ __ __ • __ __	__ __ __ • __ __

41. Comments (in particular, on any anomalous and/or extreme environmental conditions, e.g. snow/ice cover, wind, temperature):

_____

_____

_____

* For appropriate codes see Part III, Section 2 of the *CEMP Standard Methods* manual

Use capital letters and dark pencil or black ink

page _____ of _____

CCAMLR Data Submission

CEMP METHOD C2: Fur Seal Pup Growth – Procedure A

CATEGORY A – ALL ITEMS MUST BE COMPLETED

1. Standard Method Version C2 • __

2. Date of preparation   (Y/M/D) __ __ __ / __ __ / __ __

3.* Member __ __ __

4. Researcher contact __ __ __ __ __ __ __ __ __ __

5. Data collected according to standard method protocol?   Y ☐   N ☐

6.* Area/subarea/division __ __ __ __

7. Split-year __ __ __ __

8. Site designator __ __ __

9. Colony designator __ __ __ __

10. Sex: Male ☐   Female ☐

CATEGORY B – COMPLETE AS APPROPRIATE
Procedure A Only – report for each pup

	Birth date (Y/M/D)	Regression coefficient $b_{y.x}$ (kg/day)	Standard error S_b	Intercept a (kg)	Standard error S_a	F ratio for regression	Sample size (n)	Deviant growth pattern
11.	__ / __ / __	0 • __	__ • __	__ • __	__ • __	__ • __	__	☐
12.	__ / __ / __	0 • __	__ • __	__ • __	__ • __	__ • __	__	☐
13.	__ / __ / __	0 • __	__ • __	__ • __	__ • __	__ • __	__	☐
14.	__ / __ / __	0 • __	__ • __	__ • __	__ • __	__ • __	__	☐
15.	__ / __ / __	0 • __	__ • __	__ • __	__ • __	__ • __	__	☐
16.	__ / __ / __	0 • __	__ • __	__ • __	__ • __	__ • __	__	☐
17.	__ / __ / __	0 • __	__ • __	__ • __	__ • __	__ • __	__	☐
18.	__ / __ / __	0 • __	__ • __	__ • __	__ • __	__ • __	__	☐
19.	__ / __ / __	0 • __	__ • __	__ • __	__ • __	__ • __	__	☐
20.	__ / __ / __	0 • __	__ • __	__ • __	__ • __	__ • __	__	☐

21. Comments (in particular, on any anomalous and/or extreme environmental conditions, e.g. snow/ice cover, wind, temperature):

_____

* For appropriate codes see Part III, Section 2 of the *CEMP Standard Methods* manual

Use capital letters and dark pencil or black ink

page _____   of _____

E/C2/A V4

CCAMLR Data Submission
CEMP METHOD C2: Fur Seal Pup Growth – Procedure B

CATEGORY A – ALL ITEMS MUST BE COMPLETED

1. Standard Method Version C2 • __
2. Date of preparation   (Y/M/D) __ __ __ __ / __ __ / __ __
3.* Member __ __ __
4. Researcher contact __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __ __
5. Data collected according to standard method protocol?   Y ☐   N ☐
6.* Area/subarea/division __ __ __ __
7. Split-year __ __ __ __
8. Site designator __ __ __
9. Colony designator __ __ __ __
10. Sex: Male ☐   Female ☐   Unknown/Unsexed ☐

CATEGORY B – COMPLETE AS APPROPRIATE

PROCEDURE B ONLY

11. Date of first observation   (Y/M/D) __ __ / __ __ / __ __
12. Date of last observation   (Y/M/D) __ __ / __ __ / __ __
13. Date of first birth   (Y/M/D) __ __ / __ __ / __ __
14. Date of last birth   (Y/M/D) __ __ / __ __ / __ __

SUMMARY STATISTICS

15. Regression coefficient (kg/day)   0 • __ __ __
     Standard error   __ • __ __ __
16. Intercept (kg)   __ __ • __ __
     Standard error   __ • __ __ __
17. F ratio for regression   __ __ • __ __
18. Number of measurements   __ __

Date (Y/M/D)	Mean weight (kg)	Std. deviation (S_{n-1})	Sample size (n)
19. __ __ / __ __ / __ __	__ __ __ • __ __	__ __ • __ __	__ __ __
20. __ __ / __ __ / __ __	__ __ __ • __ __	__ __ • __ __	__ __ __
21. __ __ / __ __ / __ __	__ __ __ • __ __	__ __ • __ __	__ __ __
22. __ __ / __ __ / __ __	__ __ __ • __ __	__ __ • __ __	__ __ __
23. __ __ / __ __ / __ __	__ __ __ • __ __	__ __ • __ __	__ __ __
24. __ __ / __ __ / __ __	__ __ __ • __ __	__ __ • __ __	__ __ __
25. __ __ / __ __ / __ __	__ __ __ • __ __	__ __ • __ __	__ __ __
26. __ __ / __ __ / __ __	__ __ __ • __ __	__ __ • __ __	__ __ __

27. Comments (in particular, on any anomalous and/or extreme environmental conditions, e.g. snow/ice cover, wind, temperature):

_____

_____

_____

* For appropriate codes see Part III, Section 2 of the *CEMP Standard Methods* manual

Use capital letters and dark pencil or black ink

CCAMLR Data Submission
CEMP List of Colonies

1.*   Member __ __ __

2.   Date of preparation (Y/M/D) __ __ __ __ / __ __ / __ __

3.   Researcher contact __ __ __ __ __ __ __ __ __ __ __ __ __ __ __

4.*   Area/subarea/division __ __ __ __

5.   Data collected according to standard method protocol?   Y ☐   N ☐

6.   Site name _____ (30)

7.   Colony name _____ (30)

8.*   Colony species   1 __ __ __

                       2 __ __ __

                       3 __ __ __

9.   Colony centre at   latitude degrees   __ __

10.   latitude minutes   __ __

11.   latitude seconds   __ __

12.   longitude degrees   __ __ __

13.   longitude minutes   __ __

14.   longitude seconds   __ __

15.   Hemisphere   E ☐   W ☐

16.   Colony extent   N/S   (m) __ __ __ __

17.   E/W   (m) __ __ __ __

A map must be attached to this form

To be supplied by the Secretariat:

18.   Site designator __ __ __

19.   Colony designator __ __ __ __

* For appropriate codes see Part III, Section 2 of the *CEMP Standard Methods* manual

Use capital letters and dark pencil or black ink

SECTION 2

GUIDELINES FOR THE SUBMISSION OF CEMP DATA

GUIDELINES FOR THE SUBMISSION OF CEMP DATA

DATA SUBMISSION FORMATS

1. Data should be submitted to the Secretariat using CCAMLR data submission forms. Submissions should be accompanied by a covering letter giving the name and address of a contact person responsible for the data.

2. Submission of data on computerised media (magnetic tape and disk) is not encouraged at this stage of the CEMP program. Submission in these media will involve descriptions of the record format required for individual method reporting. Although this is a relatively simple task, it is recommended that whilst the CEMP standard methods are still being developed, all data be reported on the paper forms described below.

3. The forms are named after the CEMP standard method that they address, and given a code which contains details of the method number, the procedure type within that method and the version number of the form. This has a form similar to:

    'E/C2/B V1', meaning:

    'Ecosystem monitoring program / (Method number) / (Procedure number) V (form version number)', i.e. Method C2 (Fur seal pup growth), Procedure B (Random samples), Form Version 1.

    'E' is required to distinguish this form from other CCAMLR data submission forms. Procedure number is used when there are two or more procedures identified in the 'Data Collection' section of a single standard method, each of which necessitates a different analysis. Note that the version number in this code is <u>not</u> the version number of the CEMP standard method but the <u>version number of the form</u>. Thus methods may be changed without changing the reporting form and vice versa.

4. The following form codes are used:

E/A1	Penguin adult weight on arrival
E/A2	Duration of penguin incubation shift
E/A3	Penguin breeding population size
E/A4	reserved for penguin age-specific annual survival and recruitment
E/A5	Duration of penguin foraging
E/A6/A	Penguin breeding success – Procedure A
E/A6/B	Penguin breeding success – Procedure B
E/A6/C	Penguin breeding success – Procedure C
E/A7	Penguin chick weight at fledging
E/A8/A	Penguin chick diet – general composition
E/A8/B	reserved for penguin chick diet – detailed composition
E/A9	Penguin breeding chronology
E/B1	Black-browed albatross breeding population size and success
E/B3	reserved for black-browed albatross survival
E/B4/A	Petrel chick diet – general composition
E/B5	Antarctic petrel breeding population size and success
E/C1	Fur seal cow foraging
E/C2/A	Fur seal pup growth – Procedure A
E/C2/B	Fur seal pup growth – Procedure B

E/D	reserved for crabeater seals	
E/E	reserved for minke whales	
E/F	reserved for environmental parameters	
E/G1	List of Colonies	

5. All data submission forms consist of a number of items divided into two or more categories. Category A contains information about the collection of the data, and all items in this category must be completed. Category B contains the summary data and often contains items and fields that are optional, depending on the data collected. The following paragraphs give details of the formats for completion of the data submission forms.

6. All data must be entered in the spaces provided. Integer numerical data must be right justified. If a numeric data item is required but unknown enter '99' or '9999'.

Category A

Item 1.   Standard Method Version: this is the version described in Part I (e.g. A1.2).

Item 2.   Date of preparation: the date the sheet was prepared, in year/month/day (e.g. 1992/06/23).

Item 3.   Member: the nationality code of the Member submitting the data, as described by the following table:

Member	Code	Member	Code
Argentina	ARG	New Zealand	NZL
Australia	AUS	Norway	NOR
Belgium	BEL	Poland	POL
Brazil	BRA	Russian Federation	RUS
Chile	CHL	South Africa	ZAF
European Community	EEC	Spain	ESP
France	FRA	Sweden	SWE
Germany	DEU	Ukraine	UKR
India	IND	United Kingdom	GBR
Italy	ITA	United States of America	USA
Japan	JPN	Uruguay	URY
Korea, Republic of	KOR		

Item 4.   Researcher contact: enter any 15-character identifier for the contact person. This may be a name (e.g. AGNEW) or an institution code recognised by the contact person of the Member country (e.g. BAS-CEMPCO = British Antarctic Survey CEMP coordinator).

Item 5.   Area/subarea/division: the code for the CCAMLR area/subarea/division in which the study site is found, according to the following table (e.g. 4810 for the Peninsula subarea).

Name	Area/Subarea/Division	Code
Atlantic Antarctic Area	48	4800
Peninsula Subarea	48.1	4810
South Orkney Subarea	48.2	4820
South Georgia Subarea	48.3	4830
South Sandwich Subarea	48.4	4840
Weddell Subarea	48.5	4850
Bouvet Subarea	48.6	4860
Indian Ocean Antarctic Area	58	5800
Enderby-Wilkes Subarea	58.4	5840
Enderby-Wilkes Division I	58.4.1	5841
Enderby-Wilkes Division II	58.4.2	5842
Enderby-Wilkes Division III	58.4.3	5843
Enderby-Wilkes Division IV	58.4.4	5844
Kerguelen Subarea	58.5	5850
Kerguelen Division	58.5.1	5851
Heard-McDonald Division	58.5.2	5852
Crozet Subarea	58.6	5860
Marion-Edward Subarea	58.7	5870
Pacific Antarctic	88	8800
Eastern Ross Sea Subarea	88.1	8810
Western Ross Sea Subarea	88.2	8820
Amundsen Sea Subarea	88.3	8830
Unknown		9999

Item 6. Split-year: split-years are identified by the last year of the split-year (e.g. for the 1988/89 season enter '1989').

Item 7. Site designator: this is the site designator as defined by the Secretariat following submission of the CEMP List of Colonies. This list is not yet completed: please contact the Secretariat for more information on which sites are listed.

Item 8. Colony designator: this is the colony designator as defined by the Secretariat following submission of the CEMP List of Colonies. This list is not yet completed: please contact the Secretariat for more information on which colonies are listed before listing a new colony. On some forms the colony designator(s) are requested as part of Category B, when data from several colonies, but one site, may be reported on one form.

Members are referred to the instructions for listing colonies for details of these procedures. It should be noted that where data on a new colony is being submitted, that colony should be described in the list and assigned a site and colony designator by the Secretariat before data on any of the standard methods is submitted.

Item 9. Species: species codes are given below.

Species Name	Common Name	Code
Aves	Birds	BIZ
Diomedeidae	Albatrosses	ALZ
Diomedea chrysostoma	Grey-headed albatross	DIC
Diomedea epomophora	Royal albatross	DIP

…continued

Species Name	Common Name	Code
Diomedea melanophrys	Black-browed albatross	DIM
Diomedea exulans	Wandering albatross	DIX
Macronectes giganteus	Southern giant petrel	MAI
Macronectes halli	Northern giant petrel	MAH
Phoebetria palpebrata	Light-mantled sooty albatross	PHE
Phoebetria fusca	Sooty albatross	PHU
Procellariidae	Petrels and shearwaters	PTZ
Daption capense	Cape petrel	DAC
Procellaria aequinoctialis	White-chinned petrel	PRO
Thalassoica antarctica	Antarctic petrel	TAA
Oceanitidae		
Oceanites oceanicus	Wilson's storm petrel	OCO
Spheniscidae	Penguins	PYZ
Eudyptes chrysolophus	Macaroni penguin	EUC
Pygoscelis adeliae	Adélie penguin	PYD
Pygoscelis antarctica	Chinstrap penguin	PYN
Pygoscelis papua	Gentoo penguin	PYP
Lobodon carcinophagus	Crabeater seal	SET
Arctocephalus gazella	Antarctic fur seal	SEA
Balaenoptera acutorostrata	Minke whale	MIW
Pisces	Finfish	MZZ
Crustacea	Crustaceans	FCX
Euphausia crystallorophias	Ice krill	KRC
Euphausia spp.	Euphausids	KRX
Euphausia superba	Antarctic krill	KRI
Salpidae	Salps	SPX
Ommastrephidae	Flying squids	SQU
Loligo spp.	Common squids	SQC

Item 10.   Method: mark the box as appropriate to describe which method/procedure was used to collect the data.

Category B

Detailed descriptions of data entry will not be considered here. There is no coded entry of data in Category B. The following conventions apply for data formats:

Dates and times: all dates and times must be in Greenwich Mean Time.

Dates (Y/M/D)	= year/month/day	e.g. 92/02/24 for 24 February 1992
Time (h/m)	= hour/minute	e.g. 14/23 for 23 minutes past 2 pm
Duration of an event (hours)	= hours/fractions	e.g. for 14.6 hours (0.6 h = 36 minutes)

First day of five-day period (y/m/d) = the date of the first day of a standard five-day period used for calculation of summary data. The following table lists standard five-day periods.

CEMP standard five-day period starting dates:

Normal Year		Leap Year 1991/92, 1999/2000	
05-Jul	01-Jan	05-Jul	01-Jan
10-Jul	06-Jan	10-Jul	06-Jan
15-Jul	11-Jan	15-Jul	11-Jan
20-Jul	16-Jan	20-Jul	16-Jan
25-Jul	21-Jan	25-Jul	21-Jan
30-Jul	26-Jan	30-Jul	26-Jan
04-Aug	31-Jan	04-Aug	31-Jan
09-Aug	05-Feb	09-Aug	05-Feb
14-Aug	10-Feb	14-Aug	10-Feb
19-Aug	15-Feb	19-Aug	15-Feb
24-Aug	20-Feb	24-Aug	20-Feb
29-Aug	25-Feb	29-Aug	25-Feb
03-Sep	02-Mar	03-Sep	01-Mar
08-Sep	07-Mar	08-Sep	06-Mar
13-Sep	12-Mar	13-Sep	11-Mar
18-Sep	17-Mar	18-Sep	16-Mar
23-Sep	22-Mar	23-Sep	21-Mar
28-Sep	27-Mar	28-Sep	26-Mar
03-Oct	01-Apr	03-Oct	31-Mar
08-Oct	06-Apr	08-Oct	05-Apr
13-Oct	11-Apr	13-Oct	10-Apr
18-Oct	16-Apr	18-Oct	15-Apr
23-Oct	21-Apr	23-Oct	20-Apr
28-Oct	26-Apr	28-Oct	25-Apr
02-Nov	01-May	02-Nov	30-Apr
07-Nov	06-May	07-Nov	05-May
12-Nov	11-May	12-Nov	10-May
17-Nov	16-May	17-Nov	15-May
22-Nov	21-May	22-Nov	20-May
27-Nov	26-May	27-Nov	25-May
02-Dec	31-May	02-Dec	30-May
07-Dec	05-Jun	07-Dec	04-Jun
12-Dec	10-Jun	12-Dec	09-Jun
17-Dec	15-Jun	17-Dec	14-Jun
22-Dec	20-Jun	22-Dec	19-Jun
27-Dec	25-Jun	27-Dec	24-Jun
	30-Jun		29-Jun

Where time is referred to this is understood to be GMT.

Statistical terms: means, standard deviations and *n* are required for most methods.

Std deviation (S_{n-1}) = standard deviation in the same units as the mean to which it refers.

Standard deviation of Y $(S_{n-1}) = \sqrt{\dfrac{\left(\sum y^2 - \left(\sum y \right)^2 \right)}{n-1}}$

n = number in a sample used to calculate mean and standard deviation.
b = regression coefficient (slope)
s_b = standard error of regression coefficient
a = intercept of regression
s_a = standard error of intercept
$\bar{Y}$ = mean of Y
$s_{\bar{Y}}$ = standard error of Y

Units
No. = 'number'
g = grams
kg = kilograms
h = hours

Position:
Colony designator: see above under Category A.

Comments:
A comment of up to 79 characters may be added to the form.

CCAMLR DATA CENTRE LIST OF CEMP COLONIES

Operation of the Official List

1. The Official List of CEMP Colonies is maintained by the CCAMLR Data Centre at the Secretariat. The purposes of the list are:

   (i) to identify colonies clearly so as to avoid confusion among investigators and to facilitate analysis of data taken at the same colony by different investigators; and

   (ii) to assign to each colony a unique colony descriptor to be used in submitting data to the CCAMLR Data Centre.

2. In this section the following definitions are used:

   (i) CEMP site: an area within which monitoring at one or more colonies is carried out; and

   (ii) CEMP colony: a naturally discrete aggregation of breeding animals stable in space and time, chosen by an investigator for monitoring of a parameter using the CEMP standard methods.

3. All colonies where monitoring is being carried out as part of CEMP, in accordance with the CEMP standard methods must be included on the Official List and be given a colony code and site designator. To list a colony a Member must complete a form E/G1 and submit it to the Secretariat.

4. If the colony has been listed previously by another Member, or this is suspected from the locational information, the Secretariat will consult with all Members involved to arrive at an agreed description of the colony.

5. Because submission of data forms requires inclusion of a colony designator it is necessary for those intending to report data to consult the Secretariat in order to obtain a colony designator prior to data submission. Descriptions of colonies on the list will be distributed to Member institutions so the inter-institution and between-year comparisons of parameters are facilitated.

SECTION 3

CEMP INDICES: THEIR CALCULATION
AND COMPARISON BY THE SECRETARIAT

CEMP INDICES: THEIR CALCULATION
AND COMPARISON BY THE SECRETARIAT

INTRODUCTION

This document describes in detail the methods used to calculate indices, from CEMP data submitted to the CCAMLR Data Centre, giving examples and FORTRAN listings of the programs used (Annex A). In most cases the rationale for choice of an index is straightforward, but in some cases further explanations are required; these are given in Annex B. This section of the *CEMP Standard Methods* is developed from Agnew (1992).

In Agnew (1991), the following criteria for the choice and computation of indices of CEMP parameters were defined:

(a)   an index should accurately summarise the data specified in the standard methods;

(b)   changes in the parameter under consideration should be reflected in changes in the index at the temporal scale of interest (in this case the temporal scale is one or more years);

(c)   the index should be insensitive to temporal variability at scales less than that identified in (b); if a parameter is known to change within a season, indices should be chosen that are capable of accurately reflecting or eliminating this variation;

(d)   where the standard method allows calculation of the variance of a parameter the variance or an estimate of the variance of the index should be reported;

(e)   the index and its variance would lend itself to statistical analysis;

(f)   comparison between indices should be possible without recourse to the original data; and

(g)   the index should be as concise as possible to facilitate interpretation by the reader.

Normally there are a number of records for a particular year from different sites, colonies, species, and sometimes different sexes. Most often, data from different colonies (and/or sexes) are combined into a single index, so that the amount of data presented is reduced to a concise index (item (a) above). Much of the detail involved in calculating the indices therefore deals with the methodology of combining data into a single index. These data are reported to the Secretariat usually containing only mean, standard deviation (SD) and sample size.

Further consideration is given to the presentation of the index and its associated statistics so that statistical comparisons between indices are possible from the data presented (item (e) above). Calculation of the index is different for each method, and therefore indices will be referred to by method (e.g. $I_{(A3)}$ is the index derived from Method A3).

Three methods are not represented here: A4, B1 and B2. There is no agreed reporting format for A4 yet and there are currently few data for B1 and B2 in the CCAMLR Data Centre. When data from these methods becomes available, suitable indices will be developed.

CEMP Data Reporting and Processing

PROGRAMS

Annex A gives listings of all programs referred to in this document. Many of the programs calculate values from the t- , ^{2}- and F- distributions using calls to the subroutines BETAI and GAMMQ. These subroutines extract values from incomplete Beta and Gamma functions and were obtained from Press et al. (1989); listings of all the subroutines given in Press et al. in FORTRAN, on IBM disk, may be purchased for a small fee (about US$27) from Cambridge University Press, 110 Midland Avenue, Port Chester, New York 10573, USA.

The programs listed in Annex A are the most basic formulation of those used to calculate the indices, and require manual data entry. Copies of the latest versions of these programs can be obtained from the Secretariat on request.

D.J. Agnew
Data Manager
1 November 1992

METHOD A1

Indices:

$I_{(A1,1)}$: Mean weight at arrival for a number of colonies weighted by the percentage arriving within a period. Standard deviation (SD) and n are also given.

Program: COMBSAMP.

Calculation: A report for a single colony contains the mean weight, SD, n and percentage arriving for each of a number of five-day periods. To calculate the index, mean arrival weight for each period must be combined using the percentage arriving in the period as a weighting factor. If arrival weights from different colonies are being combined, this is done using the same methodology as for a single colony, with weighting factors (% arriving per period) being in the same units and scale. In the following explanation, there are a records (n_c colonies of n_p periods) containing $\bar{x}_i$, s_i^2, n_i and w_i.

Firstly, find $\sum^n x_i$ and $\sum^n x^2_i$ for each i of the a records,

$$\sum^n x_i = n_i \bar{x}_i,$$

$$\sum^n x^2_i = s_i^2 (n_i - 1) + \frac{\left(\sum^n x_i\right)^2}{n_i} \qquad \text{for } i = 1, a$$

Then, applying weighting factors to find $w_i \sum^n x_i$ and $w_i \sum^n x^2_i$ the mean and SD of the combined populations are found by:

$$\overline{X} = \frac{\sum_{i=1}^a w_i \left(\sum^n x\right)_i}{\sum_{i=1}^a w_i n_i} \tag{1}$$

$$S_X = \sqrt{\frac{\sum_{i=1}^a w_i \left(\sum^n x^2\right)_i - \frac{\left(\sum^a w_i \left(\sum^n x\right)\right)^2}{\sum^a w_i n_i}}{\sum^a w_i n_i - 1}} \tag{2}$$

Example: Site SPS, colony SP1, species PYD, nationality ARG, year 1988, sex unknown.

Date	Mean Weight	SD	n	w_i *	$\sum_{i}^{n} x_i$	$\sum_{i}^{n} x_i^2$
1987/10/28	4314.10	605.10	32	1	1.38E5	6.07E8
1987/09/23	4650.40	746.70	5	1	2.33E4	1.10E8
1987/10/03	5807.80	550.80	51	1	2.96E5	1.73E9
1987/10/08	5327.60	505.80	29	1	1.55E5	8.30E8
1987/10/13	5233.30	506.70	33	1	1.73E5	9.12E8
1987/10/18	5300.00	100.00	2	1	1.06E4	5.62E7
1987/10/23	4764.70	602.10	17	1	8.10E4	3.92E8
Totals			169		8.76E5	4.64E9

$$I_{(A1)} = \overline{X} = 8.76E5/169 = 5185.2$$

and because all $w_i = 1$, $\sum_{i=1}^{a} w_i \sum_{i}^{n} x_i = 8.76E5$ and $\sum_{i=1}^{a} w_i \sum_{i}^{n} x_i^2 = 4.64E9$

and $\sum_{i=1}^{a} w_i n_i = 169$. Therefore,

$$S_x = \sqrt{\left(4.64E9 - \left(8.76E5\right)^2 / 169\right) / \left(169 - 1\right)} = 768.101$$

Comments: When more than one colony is being considered, care must be taken that the weighting factors are all in the same units (percentages, proportions or arbitrary). In the above example, if data from another colony were added with percentage weighting factors, the factors in this example should be adjusted to 100/7 each. There is an example of the use of % weighting factors under Method A7.

Note: In future references to the program COMBSAMP, it will be referred to as 'weighted by ......' or 'unweighted'. If unweighted, the calculation is performed setting all weighting factors to 1, as in the example above.

METHOD A2

Index:

$I_{(A2,1)}$: First incubation shift length for a number of colonies (mean, SD and n).
$I_{(A2,2)}$: Second incubation shift length for a number of colonies (mean, SD and n).

Program: COMBSAMP.

Calculations: Similar calculations to A1, unweighted.

---

* Percentage arriving in each five-day period, which makes up the weighing factor, has not been reliably reported for this method yet. The equations show how it should be incorporated, either as a proportion or as a percentage. In this example, the weighing factor has been set to 1 (unweighted).

METHOD A3

Index:

$I_{(A3,1)}$: Total population size for a number of colonies.

Program: None required.

Calculation: Simple sum of all colonies counted. At the moment errors in counting may or may not be reported but are not included in the calculation of the index.

Colony	Number of Nests Occupied	Date
JN01	1600	1989/11/05
MC99	2849	1989/11/05
SQ01	0527	1989/10/22

Therefore, $I_{(A3)} = \sum^{a} x_i = 4976$.

METHOD A5

Indices:

$I_{(A5,1)}$: Mean foraging duration at start of brooding (also SD and n).
$I_{(A5,2)}$: Mean foraging duration at start of creching (also SD and n).

Program: COMBSAMP.

Calculation: Calculation of this index requires knowledge of the times of peak hatching and creching because of variations in foraging duration throughout the season (Agnew, 1991). Two indices are calculated:

$I_{(A5,1)}$: 'Foraging duration at start of brooding': Periods 3, 4, 5 where period 1 = period of peak hatching; and

$I_{(A5,2)}$: 'Foraging duration at start of creching': Periods 3, 4, 5 where period 1 = period of peak creching.

median hatch / creche

A9 i

A5 ii

A B C D E

iii
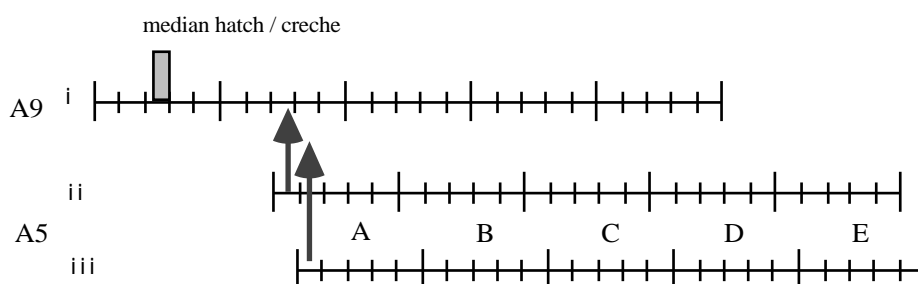
Figure A5: Calculation of indices $I_{(A5,1)}$ and $I_{(A5,2)}$. Part (i) shows five, five-day periods from Method A9, with median peak hatching or creching on day 3 of the first A9 period. In part (ii) the start of A5 period A falls less than six days after the median day and so the index is calculated using A5 periods B, C and D (the start of D is day 20). In part (iii) the start of A5 period A falls six days after the median day so the index is calculated using A5 periods A, B and C.

The rationale for the choice of these two indices is given in Agnew (1991) and reproduced in Annex B. Five-day periods are chosen from the A5 data if they fall as periods 3, 4 and 5 where period 1 is that with peak hatching or creching. In practice, allocation of A5 periods is done with reference to calculated median hatch or creche dates. Firstly, the median hatching and creching dates are identified from the data reported under Method A9: penguin breeding chronology (Figure A5) using linear interpolation. Counting this day as A9 day 1, data from Method A5 are used if the first day of the five-day period falls between 6 and 20 days after the median date of hatching or creching (Figure A5).

Following allocation of A5 periods the indices are calculated in the usual way by combining data from the relevant periods and colonies (Equations 1 and 2).

Example: Site SES colony 71 species EUC, nationality USA, year 1990, sex female.

A9 data

Date – First Day of Period	Number of Nests with First Chick Hatching in this Period	Number of Nests Ceasing to Brood in this Period
22/12/89	18	0
27/12/89	12	0
1/1/90	1	0
6/1/90	1	0
11/1/90	0	3
16/1/90	0	19
21/1/90	0	5
26/1/90	0	5
31/1/90	0	0

A5 data

Date – First Day or Period	Mean Foraging Duration	SD	n	w_i	$\sum^{n} x_i$	$\sum^{n} x_i^2$
8/1/90	26.4	13.8	5	1	132	4246.6
13/1/90	38.2	10.9	5	1	191	7771.4
18/1/90	50.5	18.5	5			
23/1/90	26.8	15.6	4			
28/1/90	37.1	0	1	1	37.1	1376.4
2/2/90	57.5	0	1	1	57.5	4682.7

The A9 periods for hatching are period (1) 22 to 26 December, (2) 27 to 31 December, (3) 1 to 5 January, (4) 6 to 10 January, (5) 11 to 15 January. A5 period 8 to 12 January has its midpoint on 10 January, within A9 period (4) and thus the index $I_{(A5,1)}$ is made up from the periods beginning 8 and 13 January.

$$I_{(A5,1)} = \overline{X} = 32.3, \; S_X = 13.27, \; n = 10.$$

Similarly the A9 period of peak creching is 16 to 20 January, and A9 period 3 starts on 26 January. The midpoint of the A5 period that starts on 23 January is 25 January which does not lie within A9 period 3. Therefore, for calculation of index $I_{(A5,2)}$ only the last two A5 periods can be used, giving

$$I_{(A5,2)} = \overline{X} = 47.3, \; S_X = 14.43, \; n = 2.$$

METHOD A6

There are three procedures for this method:

    A: On one day a year count the number of chicks and number of adults present.

    B: Monitor a sample of nests and calculate the mean number of chicks raised to creche per nest.

    C: Count the number of nests occupied and the number of chicks in the creche.

<u>Indices</u>:

$I_{(A6,1)}$:   Number of nests occupied.

$I_{(A6,2)}$:   Number of chicks (Procedure A) or the number of chicks to creche (Procedure C).

$I_{(A6,3)}$:   Normalised <u>number of chicks reared per nest</u>. This is the final index of success rate, and normalisation by the potential number of chicks is necessary for the reasons given in Annex B.

$I_{(A6,4)}$:   Number of adults at count time (Procedure A).

$I_{(A6,5)}$:   Number of chicks reared per adult present (Procedure A).

<u>Program</u>: As yet no program required.

<u>Calculation</u>:

Procedure A: For all colonies to be accumulated, add all counts of the number of nests with chicks, obtained from Method A3, if this has been reported, to get $I_{(A6,1)}$. Add all counts of the number of chicks, obtained from Method A6, to get $I_{(A6,2)}$. A final index of success rate, normalised by the potential number of chicks, is calculated for the reasons given in Annex B.

Calculate

$$I_{(A6,1)} = \sum^{a} n_i \quad \text{and} \quad I_{(A6,2)} = \sum^{a} c_i$$

where n and c are the number of nests with chicks and the number of chicks respectively, for a colonies, and then calculate the final index

$$I_{(A6,3)} = \frac{\sum^{a} c_i}{k \sum^{a} n_i} = \frac{I_{(A6,2)}}{k I_{(A6,1)}}$$

where k is the potential number of chicks per nest (e.g. for chinstrap penguins $k = 2$, for macaroni penguins $k = 1$).

Alternatively, if n has not been reported under Method A3, the number of adults present in the colony, reported under procedure A, may be used to calculate a substitute index for $I_{(A6,1)}$,

$$I_{(A6,4)} = \sum^{a} d_i$$

where d is the number of adults present, and a further index $I_{(A6,5)}$ is calculated from

$$I_{(A6,5)} = \frac{\sum^{a} c_i}{k \sum^{a} d_i} = \frac{I_{(A6,2)}}{k I_{(A6,4)}}$$

Procedure B: $I_{(A6,1)}$ and $I_{(A6,2)}$ are calculated as above: n_i is reported with Procedure B, but c_i is only reported as the number of pairs that rear one and two chicks to creche ($p1$ and $p2$), and therefore $c_i = p2_i + p1_i$. $I_{(A6,3)}$ may be obtained directly from the data but must be normalised in the same way as given above.

Procedure C: c and n are reported so calculations are as with Procedure A.

Example: Site SES, colonies as given, species PYD, nationality USA, year 1990.

Procedure C reported

Colony	Number of Nests with Chicks at End of Hatching	Number of Chicks in Creche when all Chicks in Creche
54	223	147
24	13	1
51	39	7
42	187	241
31	233	354
66	192	313
9	250	351
32	80	109
33	119	182
21	60	87
Totals	1 396	1 792

$I_{(A6,1)} = 1\ 396$
$I_{(A6,2)} = 1\ 792$
$I_{(A6,3)} = 1\ 792/(1\ 396 \times 2) = 0.642$

<u>Comments</u>: No estimate of error is given for these indices, although with A and C three counts of colonies are usually done and the variance associated with these counts (measurement error) is reported. Because the counts are merely added together, it is difficult to include this variance; however, one solution might be to report the mean coefficient of variation (CV) for $I_{(A6,1)}$ and $I_{(A6,2)}$.

A more useful variance is available for Procedure B, associated with the mean number of chicks reared per nest, rather than measurement error.

METHOD A7

<u>Indices</u>:

$I_{(A7,1)}$: Mean weight at fledging (also SD, n).

<u>Program</u>: COMBSAMP.

<u>Calculation</u>: Calculations are the same as for Method A1.

<u>Example</u>: Site SES, colony 102, species PYN, nationality USA, year 1991.

Date – First Day of Period	Mean Weight	SD	n	w_i	$\sum_{i}^{n} x_i$	$\sum_{i}^{n} x_i^2$
1991/03/02	2926.00	348.84	25	6	7.32E4	2.17E8
1991/02/15	2827.00	302.40	44	30	1.24E5	3.56E8
1991/02/20	2894.00	272.58	95	41	2.75E5	8.03E8
1991/02/25	2880.00	325.58	90	15	2.59E5	7.56E8
Totals			254		7.312E5	2.13E9

and $\sum_{i=1}^{a} w_i \sum_{i}^{n} x_i = 1.93E7$ and $\sum_{i=1}^{a} w_i \sum_{i}^{n} x_i^2 = 5.62E10$

and $\sum_{i=1}^{a} w_i n_i = 6715$. Therefore

$I_{(A7)} = \overline{X} = 1.93E7/6715 = 2878.73$

$$S_x = \sqrt{\left(5.62E10 - (1.93E7)^2 / 6715\right)/(6715 - 1)} = 290.89$$

METHOD A8

Indices:

$I_{(A8,1)}$: Mean weight of stomach contents (also SD, n).

$I_{(A8,2)}$: Mean proportion of crustaceans (arcsin transformed) (also SD, equivalent proportion - reverse arcsin transformation).

Program: ARCSIN.

Calculation: The mean weight and SD of stomach contents are found for $I_{(A8,1)}$. Crustacean weight (Wc) is expressed as a proportion of the weight of stomach contents (Ws) and this proportion is then transformed by

$$T = \arcsin \sqrt{\frac{Wc}{Ws}}$$

Then

$I_{(A8,2)} = \bar{T}$, SD.

The inverse arcsin transform of the mean, $\left(\sin\bar{T}\right)^2$, is also given to enable visual comparison, but the index itself is used for statistical comparison between samples.

Stomach Weight Ws (g)	Crustacean Weight Wc (g)	Proportion	Arcsin Transform T (degrees)
1 098	1098.000	1.000	90.000
.	.	.	.
.	.	.	.
545	544.0	0.998	87.545
716	682.6	0.953	77.527
640	640.0	1.000	90.000
700	700.0	1.000	90.000
411	405.3	0.986	83.237
519	440.6	0.849	67.129
724	724.0	1.000	90.000
798	798.0	1.000	90.000
788	788.0	1.000	90.000
497	439.5	0.884	70.115
538	504.5	0.938	75.550
752	752.0	1.000	90.000
703	703.0	1.000	90.000
20 637			2 786.7

$I_{(A8,1)}$ = 644.906 g, SD = 178.759.
$I_{(A8,2)}$ = 87.083 degrees, SD = 6.017 degrees (inverse arcsin transform: relative proportion = 0.997).

METHOD A9

Indices:

$I_{(A9,1)}$: Median hatching date.
$I_{(A9,2)}$: Median creching date.
$I_{(A9,3)}$: Median fledging date.

Program: MEDIAN.

Calculations: Data are reported as counts of nests/birds per five-day period. To enable calculation of medians for pooled colonies, each count is allocated equally between the five days of the period from which it is reported. The daily estimates of counts are then combined for each colony and a combined median is calculated. This method allows calculation (estimation) of medians where the five-day periods used are not identical.

Example: Site SES, colonies 4, 25, species PYD, nationality USA, year 1990; number hatching is reported. In this case both colonies were reported with the same five-day periods.

Date – First Day of Period	Colony 4 – Number of Nests with First Chick Hatching	Colony 25 – Number of Nests with First Chick Hatching	Date – Days	Assumed Number of Nests with First Chick Hatching	Cumulative	
22/12/89	51	50	22	20.2	20.2	
			23	20.2	40.4	
			24	20.2	60.6	
			25	20.2	80.8	<--- 79
			26	20.2	101.0	
27/12/89	27	24	27	10.2	111.2	
			28	10.2	121.4	
			29	10.2	131.6	
			30	10.2	141.8	
			31	10.2	152.0	
1/1/90	3	1	1	0.8	152.8	
			2	0.8	153.6	
			3	0.8	154.4	
			4	0.8	155.2	
			5	0.8	156.0	
6/1/90	2	0	6	0.4	156.4	
			7	0.4	156.8	
			8	0.4	157.2	
			9	0.4	157.6	
			10	0.4	158.0	

$I_{(A9,1)}$ = 25 December 1989

METHOD C1

Indices:

$I_{(C1,1)}$: Mean foraging duration of first six trips by females (also SD, *n*)

Program: COMBSAMP.

Calculation: Mean duration for each of the first six trips is reported for a number of females at one colony. The index is calculated by combining the data from all trips for a number of colonies, following the methods of A1 (unweighted).

METHOD C2

Indices:

$I_{(C2,1)}$: Growth rate: standard error of rate, correlation coefficient, n.

Program: REG.

Calculation: Reported data – the time of sampling, mean weight of pups and SD of weight – are used to obtain sums and sums of squares (ss) as follows: given a samples, each with X_i (time of sample i), $\overline{Y}_i$ (mean weight of pups for sample i) and s_i (SD of weight), calculate

$$\sum^{n_i} X_i = n_i X_i$$

$$\sum Y_i = n_i \overline{Y}_i$$

$$\sum X^2_i = n_i X^2_i$$

$$\sum Y^2_i = s_i^2 (n_i - 1) + \frac{\left(\sum Y_i\right)^2}{n_i} = s_i^2 (n_i - 1) + n_i \left[\overline{Y}_i\right]^2$$

$$\sum XY_i = n_i X_i \overline{Y}_i$$

then add all these expressions for $i = 1$ to a to obtain $\sum^{a} \sum^{n_i} X_i$ etc., and use the method of Sokal and Rohlf (box 14.4 p. 480–482) to calculate the regression coefficients.

Example: Site SES, colony 501, species SEA, nationality USA, sex female.

Time (days) X_i	Mean Weight (kg) $\overline{Y}_i$	SD s_i	n_i	$\sum^{n_i} X_i$	$\sum^{n_i} Y_i$	$\sum^{n_i} X^2_i$	$\sum^{n_i} Y^2_i$	$\sum^{n_i} XY_i$	$\sum^{n_i} \frac{Y_i^2}{n_i}$
1	7.23	0.95	24	24	173.5	24.0	1275.3	173.5	1254.5
3	7.24	1.14	24	72	173.8	216.0	1287.9	521.3	1258.0
14	8.79	1.63	14	196	123.1	2744.0	1116.2	1722.8	1081.7
15	9.34	1.01	31	465	289.5	6975.0	2734.9	4343.1	2704.3
29	10.4	1.4	24	696	249.6	20184.0	2640.9	7238.4	2595.8
30	11.06	1.08	22	660	243.3	19800.0	2715.6	7299.6	2691.1
31	10.15	1.88	4	124	40.6	3844.0	422.7	1258.6	412.1
43	11.44	1.82	24	1032	274.6	44376.0	3217.2	11806.1	3141.0
44	11.69	1.43	18	792	210.4	34848.0	2494.6	9258.5	2459.8
56	12.32	1.63	24	1344	295.7	75264.0	3703.9	16558.1	3642.8
Totals			209	5405	2074.1	208275.0	21609.2	60180.0	21241.2

From these, the following can be calculated following the procedure set out by Sokal and Rohlf (box 14.4), the details of which will not be given here:

* Number of groups $a = 10$

* $\overset{a}{n_i} = 209$

SS_{total}	1026.786
SS_{groups}	658.760
$SS_{within\ groups}$	368.026

Sum of squares of X, x^2 68494.98

Sum of products, xy 6542.21

Explained sum of squares $\hat{y}^2$ 624.87

Unexplained sum of squares $d^2_{Y.X}$ 33.8898

* Mean squared deviation $\overset{2}{y.x} = 33.89/_{(10\text{-}2)} = 4.2361$

The sums of squares and their degrees of freedom (DF) are thus:

	DF	SS
Among groups	$a\text{-}1 = 9$	658.760
Linear regression	1	624.871
Deviations from regression	$a\text{-}2 = 8$	33.890
Within groups	190	368.026
Total	208	1026.786

* Regression coefficient (slope), $b_{Y.X} = \dfrac{xy}{x^2} = 0.0955$

Mean square $s^2_{Y.X} = \dfrac{d^2_{Y.X}}{a-2} = 4.2362$

* Standard error $s_b = \sqrt{\dfrac{s^2_{Y.X}}{x^2}} = 0.0079$

Correlation coefficient R, $= \dfrac{xy}{\sqrt{x^2\ y^2}}$, where $y^2 = Y^2 - \dfrac{(Y)^2}{n}$

All the quantities marked (*) are reported,

$I_{(C2,1)} = 0.955$ kg/day, with standard error $s_b = 0.0079$ and sum of squares of X, $x^2 = 68494.98$, correlation coefficient R = 0.780, number of samples $a = 10$ and number of animals $\overset{a}{n_i} = 209$.

Note: the quantity x^2 is reported to enable comparisons to be made between k regression coefficients. Although the 95% confidence limits of the regression coefficients (= growth rate in kg/day) are reported, comparisons of slope should further be made using program REGCO, which follows the method of Sokal and Rohlf (Box 14.8).

COMPARISONS

In order to identify trends in indices over time, or between sites and species, it is necessary to perform statistical comparisons between them. All the indices described above are reported with sufficient detail (of variance, sample size etc.) to allow statistical comparisons between them. The following section gives details of the routine statistical comparisons used within the document reporting trends.

MEANS

Uses: A1, A2, A5, A7, A8 (on transformed data), C1.

Program: TTEST.

Calculation: T-tests are performed according to the methods of Press et al. (1989); first an F-test for similar variances is performed, and depending on the result the program uses either a t-test for distributions with the same variance,

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2 + s_2^2}{n_1 + n_2 - 2}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

distributed as $t_{[n1+n2-2]}$, or a t-test for distributions with different variances

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

distributed approximately as t

$$\frac{\left[s_1^2/n_1 + s_2^2/n_2\right]^2}{\frac{\left[s_1^2/n_1\right]^2}{n_1 - 1} + \frac{\left[s_2^2/n_2\right]^2}{n_2 - 1}}$$

ANOVA could also be used for these comparisons.

Example: no example is given for this standard statistic.

REGRESSION COEFFICIENTS

Uses: C2.

Program: REGCO.

Calculation: For the comparison of two regression coefficients (where the number of treatments, $k = 2$) (for instance male pup growth rate in 1990 and 1992),

given that $s_b = \sqrt{\dfrac{s_{Y.X}^2}{x^2}}$ and $s_{Y.X}^2 = \dfrac{d_{Y.X}^2}{a-2}$ (above), it is easy to calculate the weighted average of $s_{Y.X}^2$, $\bar{s}_{Y.X}^2$ for both groups given the method of Sokal and Rohlf (box 14.8):

$$\bar{s}_{Y.X}^2 = \frac{\sum\limits^{k} d_{Y.X}^2}{\sum\limits^{k} a - 2k} \quad \text{(Sokal and Rohlf)}$$

$$= \frac{\sum\limits^{k} (a-2)s_{Y.X}^2}{\sum\limits^{k} a - 4} \quad \text{(expressed in terms reported by program REG)}.$$

And then test for the differences among regression coefficients, b, by

$$F_s = \frac{(b_1 - b_2)^2}{\dfrac{\sum x_1^2 + \sum x_2^2}{(\sum x_1^2)(\sum x_2^2)} \bar{s}_{Y.X}^2}$$

comparing F_s with $F_{[1, a_1 + a_2 - 4]}$

Example: Site SES, colony 501, species SEA, nationality USA, compare male, female.

	Males	Females
Regression coefficient, $b_{Y.X}$	0.1124	0.0955
Stand. error s_b	0.00929	0.00786
Mean square dev. $s_{Y.X}^2$	5.2675	4.2361
No. of samples a	10	10
Calculated $\sum x^2$	61034	68568

$\bar{s}_{Y.X}^2 = 4.7518$
$F_{(1,16)} = 1.9409$
$P = 0.1826$

POWER − NORMAL DISTRIBUTIONS

Uses: A1, A2, A5, A7, A8 (on transformed data), C1.

Program: POWER.

Calculations: The power of the data to detect changes in the index, where this is derived as a mean of a normally distributed population, is calculated using the method of Sokal and Rohlf (1981). The minimum sample size n required to detect a change

in the mean at a significance level (probability of a type I error) and with a power P (where $P = 1-$ and is the probability of a type II error) is given as

$$n \geq 2 \sigma^2 \left\{ t_{\alpha[v]} + t_{2(1-P)[v]} \right\}^2$$

where σ is the true standard deviation, v is the degrees of freedom $= a(n\text{-}1)$ where $a = $ number of years over which the detection is desired, and t values are from a two-tailed t distribution. Since n appears on both sides of this equation, fitting proceeds iteratively.

Example: This calculation has been used by CEMP extensively and is not further elaborated here (see Boveng and Bengtson, 1989; Whitehead, 1989; Croxall, 1989).

POWER - PROPORTIONS

Uses: A6.

Program: POWERPERC.

Calculation: The power of the data to detect changes in the index, where this is derived as a proportion, is calculated using the method of Sokal and Rohlf (1981). The number of observations in each of two samples required to detect a difference between proportions p_1 and p_2 is

$$n \geq \frac{A\left[1 + \sqrt{1 + 4(p_1 - p_2)/A}\right]^2}{4(p_1 - p_2)^2}$$

where $A = \left[t_{a[v]}\sqrt{2\bar{p}(1 - \bar{p})} + t_{b[v]}\sqrt{p_1(1 - p_1) + p_2(1 - p_2)} \right]^2$

where a and b are as above and $\bar{p} = (p_1 + p_2)/2$.

PROPORTIONS

Uses: Method A6 ($I_{(A6,2)}$, $I_{(A6,3)}$).

Program: CHI.

Calculation: The number of chicks reared to creche is the number of successes, s, and the normalised success rate is r. Then the number of fails is calculated as $f = \frac{s}{r}(1 - r)$, and the standard one-tailed χ^2 formula for a 2 x 2 contingency table is used:

$$\chi^2_{[1]} = \frac{n\left(f_1 s_2 - f_2 s_1\right)^2}{\left(f_1 + f_2\right)\left(s_1 + s_2\right)\left(f_1 + s_1\right)\left(f_2 + s_2\right)}$$

where $n = \left(f_1 + f_2 + s_1 + s_2 \right)$. In most cases within Method A6, f and s are likely to be high and therefore Yates' adjustment for continuity is not applied (see also Sokal and Rohlf, p. 743).

Example: Site SES, colonies (9, 66), species PYN, nationality USA

	$I_{(A6,2)}$ (s)	$I_{(A6,3)}$ (r)	Calculated f
1990	1792	0.642	1 000
1991	1008	0.627	600

$$\chi^2_{[1]} = 0.9879$$

REFERENCES

Agnew, D.J. 1991. A proposal for CEMP predator parameter indices. Document *WG-CEMP-91/8*. CCAMLR, Hobart, Australia.

Agnew, D.J. 1992. CEMP indices: their calculation and comparison by the Secretariat. In: *Selected Scientific Papers, 1992 (SC-CAMLR-SSP/9)*. CCAMLR, Hobart, Australia: 81–97.

Boveng, P. and J.L. Bengtson. 1989. On the power to detect changes using the standard methods for monitoring parameters of predatory species. In: *Selected Scientific Papers, 1989 (SC-CAMLR-SSP/6)*. CCAMLR, Hobart, Australia: 377–397.

Croxall, J.P. 1989. Reference tables for the CEMP sensitivity analysis. Document *WG-CEMP-89/23*. CCAMLR, Hobart, Australia.

Press, W.H., B.P. Flannery, S.A. Teukolsky and W.T. Vetterling. 1989. *Numerical Recipes. The Art of Scientific Computing (FORTRAN Version)*. Cambridge University Press, Cambridge.

Sokal, R.R. and F.J. Rolf. 1981. *Biometry: the Principles and Practice of Statistics in Biological Research.* 2nd Edition. Freeman, New York.

Whitehead, M.D. 1989. Sensitivity analysis for parameters of predatory species CCAMLR Ecosystem Monitoring Program. In: *Selected Scientific Papers, 1989 (SC-CAMLR-SSP/6)*. CCAMLR, Hobart, Australia: 411–432.

The following program listings are those necessary to run each index calculation on its own. In order to calculate the indices presented in WG-CEMP-92/8 these programs were incorporated as subroutines into further programs that directly access output from the database. Listings of functions GAMMQ and BETAI are not given as they are copyright of Press et al. (1989) and can be obtained from that publication.

```
      PROGRAM ARCSIN
C
C  Designed for Method A8
C
C  processes proportional data with arcsine transform
C  returns mean and s.d. of transformed data, and the
C  proportion relative to the transformed mean.
C
C  INPUTS: total (weight) and parameter (weight) which together
C       make up the proportion.
C
C  D J Agnew, May 1991
C
      CHARACTER*20 IN
      NSAMP=0

      WRITE (*,*) 'program FEEDING. computes indices for A8'
      WRITE (*,*)
      WRITE (*,'(1x,A,$)') 'input file name :'
      READ (*,'(A20)') IN
      OPEN (UNIT=2,FILE=IN,STATUS='OLD',
    &   CARRIAGECONTROL='LIST',ERR=20)
      GOTO 45
C data input if no file (this method safeguards data in a crash)
20    CONTINUE
      WRITE (*,*) '***** new file *****'
      CLOSE(2)
      OPEN (UNIT=2,FILE=IN,STATUS='NEW',CARRIAGECONTROL='LIST')
C read the data
25    NSAMP=NSAMP+1
      WRITE (*,'(1X,A,I3,A,$)') 'total wt ',NSAMP,' (END=9999) :'
      READ (*,*) WT1
      IF (WT1.EQ.9999.) GOTO 30
      WRITE (*,'(1X,A,I3,A,$)') 'crust/superba wt ',NSAMP,' :'
      READ (*,*) WT2
      WRITE (2,'(1X,F8.2,2X,F8.2)') WT1,WT2
      GOTO 25
30    CLOSE (2)
      OPEN (UNIT=2,FILE=IN,STATUS='OLD')
c  setup count zeros
45    N=0
      SUMW=0
      SUMWW=0
      SUMR=0
      SUMRR=0
      SUMT=0
      SUMTT=0
      CONV=3.14159/180
      OPEN (UNIT=5,FILE='OUT.PRN',CARRIAGECONTROL='LIST',STATUS='NEW')
c  loop to read data and calculate sums
50    READ (2,*,END=100) WT1,WT2
      IF(WT2.GT.WT1) THEN
        WRITE (*,*) '****** ERROR ******'
        WRITE (*,'(1X,A,F8.2,A,F8.2)') 'crustacean wt',
    &       WT2,' > stomach wt',WT1
        WRITE (*,*) ' at line', N+1
```

```
      GOTO 200
    ENDIF
    RATIO=WT2/WT1
    TRAN=(ASIN(SQRT(RATIO)))/CONV
     WRITE (5,51) WT1,WT2,RATIO,TRAN
51   FORMAT (1X,4F9.3)
    N=N+1
    SUMW=SUMW+WT1
    SUMWW=SUMWW+WT1**2
    SUMR=SUMR+RATIO
     SUMRR=SUMRR+RATIO**2
    SUMT=SUMT+TRAN
    SUMTT=SUMTT+TRAN**2
    GOTO 50
c   calculate results and print
100  CONTINUE
    AVGW=SUMW/N
    AVGR=SUMR/N
    AVGT=SUMT/N
    SDEVW=SQRT((SUMWW-(SUMW**2)/N)/(N-1))
    SDEVR=SQRT((SUMRR-(SUMR**2)/N)/(N-1))
    SDEVT=SQRT((SUMTT-(SUMT**2)/N)/(N-1))
    EQUIVT=(SIN(AVGT*CONV))**2
    WRITE (*,*)
     WRITE (*,*) '-------------------------------'
    WRITE (*,101) AVGW,SDEVW,AVGR,SDEVR,AVGT,SDEVT,EQUIVT,N
101  FORMAT (1X,'combined feeding results',
    &//,1x,'mean stomach weight =',F8.3,'  s.d. =',F8.3,
    &/,1x,'mean proportion crust/superba =',F8.3,'  s.d. =',F8.3,
    &/,1x,'mean transformed proportion =',F8.3,'  s.d. =',F8.3,
    &/,1x,'relative proportion converted back =',F8.3,
    &/,1X,'N =',I4)
200  CONTINUE
    END


---------------------------------------------------------------------------------------
    PROGRAM CHISQ
C
C this simple chi squared program takes numbers of chicks and
C the normalised success from 2 samples to calculate the 2x2
C contingency table of chisquared calculation.
C
    REAL S(2),F(2)
    SUM=0
    DO 10 I=1,2
     WRITE (*,'(1X,A,I2,A,$)') 'Sample ',I,' chicks to creche :'
    READ (*,*) S(I)
     WRITE (*,'(1X,A,I2,A,$)') 'Sample ',I,' normalised rate  :'
    READ (*,*) F(I)
    F(I)=(1-F(I))*S(I)/F(I)
    SUM=SUM+F(I)+S(I)
10   CONTINUE
    ADD=(F(1)+F(2))*(S(1)+S(2))*(F(1)+S(1))*(F(2)+S(2))
    CH=(SUM*(F(1)*S(2)-F(2)*S(1))**2)/ADD
    DF=1.
    PROB=GAMMQ(0.5*DF,0.5*CH)
     WRITE (*,20) (S(I),I=1,2),(F(I),I=1,2),CH,PROB
20   FORMAT (1X,'         SAMPLE 1  SAMPLE 2',/,
    &1X,'Success ',2F7.1,/,
    &1X,'Fail    ',2F7.1,/,
    &1X,'CHISQUARED = ',F9.4,/,
    &1x,'PROBABILITY= ',F9.4)
    END
-----------------------------------------------------------------------
```

```
      PROGRAM COMBSAMP

C
C combines samples given mean, s.d. and n to a new sample mean, sd and n
C
C Author: D J Agnew 19 March 1992
C
C
      LOGICAL WEIGHT
      WEIGHT=.FALSE.

      WRITE (*,*) 'Program COMBSAMP: combines samples using mean, sd'
      WRITE (*,*)
      WRITE (*,'(1X,A,$)') 'Are you weighting mean by numbers
     & other than N? Y/N  [N] :'
      READ (*,'(A)') WEIGHT


      SUMWTM=0.
      SUMW=0.
      SUMX=0.
      SUMXX=0.
      SUMN=0.
      NN=0.

      NSAMP=1
50    WRITE (*,'(1X,A,I2,A,$)') 'sample ',NSAMP,' mean (9999=end): '
      READ (*,*) SMEAN2
       IF (SMEAN2.EQ.9999.) GOTO 100
      WRITE (*,'(1X,A,I2,A,$)') 'sample ',NSAMP,' s.d.: '
      READ (*,*) SDEV2
      WRITE (*,'(1X,A,I2,A,$)') 'sample ',NSAMP,' n: '
      READ (*,*) N2
       IF (WEIGHT) THEN
        WRITE (*,'(1X,A,I2,A,$)') 'sample ',NSAMP,' weighting: '
        READ (*,*) W2
       ELSE
        W2=1.
       ENDIF
C
C calculation of sums for mean and s.d.
      X2=SMEAN2*N2
      SUMX=SUMX+W2*X2
       XX2=(SDEV2**2)*(N2-1)+(X2**2)/N2
      SUMXX=SUMXX+W2*XX2
      SUMN=SUMN+W2*N2
       WRITE (*,*) W2,X2,XX2
      NN=NN+N2
      NSAMP=NSAMP+1
      GOTO 50

100   CONTINUE
      WRITE (*,*) SUMX,SUMN,SUMXX
      SMEAN=SUMX/SUMN
      SDEV=SQRT((SUMXX-(SUMX**2)/SUMN)/(SUMN-1))
      N=NINT(SUMN)

      WRITE (*,'(/,1X,A)') '----------------------------'
      IF (WEIGHT) THEN
      WRITE (*,20) NSAMP-1,SMEAN,SDEV,NN
20    FORMAT (1X,'Stats for ',I2,' combined weighted samples ... ',
     &//,1x,'true mean (applying sample sizes and weights) =',F10.3,
     &/,1x,'standard deviation =',F10.3,
     &/,1x,'NN, total measurements =',I4)
      ELSE
      WRITE (*,22) NSAMP-1,SMEAN,SDEV,N
```

```
22    FORMAT (1X,'Stats for ',I2,' combined unweighted
      &samples ... ',//,1x,'mean =',F10.3,
      &/,1x,'standard deviation =',F10.3,/,1x,'NN =',I4)
      ENDIF

      END
```

```
      PROGRAM MEDIAN

C
C finds median hatch/fledge/creche dates
C this program is able to combine several colonies all starting
C on different days because it allocates counts to individual julian
C days, starting from November 1st.
C
C Thus it is set up to deal with dates from 1 Nov - May, eg.
C WARNING; to change the start date for julain day calculation you must
C change the DATA and MONSTART
C
C split-year is required for leap year calculations
C
C Author: D J Agnew 19 March 1992
C
      real X(200)
c set this array to start November 1
      INTEGER DAY, ENDDAY,D,M,DAYS(12)
c number of days per month with Month 1 = November
      DATA DAYS  /30,31,31,28,31,30,31,30,31,31,30,31/
      MONSTART=10

      DO 10 I=1,200
      X(I)=0.
10    CONTINUE

      WRITE (*,*) 'Program MEDIAN: application to A9'
      WRITE (*,*)
      WRITE (*,'(1X,A,$)') 'Enter split-year '
      READ (*,*) IYEAR
      IF ((IYEAR/4)*4.EQ.IYEAR) DAYS(4)=29
      WRITE (*,'(1X,A,$)') 'How many colonies to combine ? '
      READ (*,*) ICOL

      SUM=0.
c loop for each colony to be combined
      DO 55 I= 1,ICOL
      WRITE (*,'(1X,A,I2,A,$)') 'Colony ',I,
      &' start day and month of first period D,M : '
      READ (*,*) D,M
c convert to julian day where 1 = 1st Nov (start day = DAY)
      MON=M-MONSTART
      IF(MON.LT.1) MON=MON+12
      DAY=0
      IF (MON.GT.1) THEN
        DO 30 N=1,MON-1
        DAY=DAY+DAYS(N)
30      CONTINUE
      ENDIF
      DAY=DAY+D
c
c request data and allocate to each day
      DO 50 NSAMP = 1,20
        WRITE (*,'(1X,A,I2,A,$)') 'count in period ',NSAMP,' (9999=end):'
        READ (*,*) C
        IF (C.EQ.9999.) GOTO 100
        STRTDAY=DAY+5*(NSAMP-1)
```

```
      DO 40 N=STRTDAY,STRTDAY+4
      X(N)=X(N)+C/5
40    CONTINUE
c SUM is used to calculate the median
      SUM=SUM+C
50    CONTINUE
100   CONTINUE
55    CONTINUE
      CMED=SUM/2.
      SUM=0.
c loop through to find the median day
      DO 150 I = 1,200
      SUM=SUM+X(I)
      IF (SUM.GT.CMED) GOTO 200
150   CONTINUE
200   CONTINUE
c having found the median, convert back to days and months
      ENDDAY=I
      DO 210 I=1,12
      ENDDAY=ENDDAY-DAYS(I)
      IF (ENDDAY.LT.1) GOTO 220
210   CONTINUE
220   ENDDAY=ENDDAY+DAYS(I)
      MON=I+MONSTART
      IF (MON.GT.12) MON=MON-12
c
      IF(MON.GT.7) IYEAR=IYEAR-1
      WRITE (*,222) ENDDAY,MON,IYEAR
222   FORMAT (/,1X,'Median is D/M/Y : ',I2,'/',I2,'/',I4)

      END


-----------------------------------------------------------------------

      PROGRAM POWER
C
C finds sample size required from given SDEV, Alpha, Power and Change
C
C   calls TVAL function by DJA which finds T value for given Alpha an DF
C
C  also uses functions from "Numerical Recipies", Press et al
C
C
      WRITE (*,*) 'Program POWER: find sample size required for power P'
      WRITE (*,*)
      WRITE (*,'(1X,A,$)') 'enter standard deviation:'
      READ (*,*) SDEV
      WRITE (*,'(1X,A,$)') 'enter alpha (required probability):'
      READ (*,*) ALPHA
      WRITE (*,'(1X,A,$)') 'enter P  (power):'
      READ (*,*) P
      WRITE (*,'(1X,A,$)') 'enter DETECTABLE CHANGE:'
      READ (*,*) CH
      WRITE (*,'(1X,A,$)') 'enter number of repeats (years):'
      READ (*,*) RPT

40    CHANGE=2.*(SDEV/CH)**2.
      WRITE (*,*) 'SDEV/CH',SDEV/CH
      PNN=50.

50    DF=RPT*(PNN-1)
      TALPH=TVAL(ALPHA,DF)
      TP=TVAL(2*(1-P),DF)
      TEST=CHANGE*(TALPH+TP)**2.
      NDIFF=ABS(TEST-PNN)
      WRITE (*,*) TEST
      IF (NDIFF.LT.0.001) GOTO 100
```

```
    PNN=TEST
    GOTO 50
100  CONTINUE
    NN=NINT(PNN)
    WRITE (*,*)
    WRITE (*,11) ALPHA,P,CH,NN
11   FORMAT (1X,'alpha=',F6.3,' power=',F6.3,
    & ' change=',F8.3,'  Sample size NN = ',I4)
C
C  allow for changing any of the inputs within this run
C
110  WRITE (*,*)
    WRITE (*,*) ' ******** MENU ***********'
    WRITE (*,*) ' Enter number for changing'
    WRITE (*,*) ' St. deviation...........1'
    WRITE (*,*) ' Alpha..................2'
    WRITE (*,*) ' Power..................3'
    WRITE (*,*) ' Detectable change.......4'
    WRITE (*,*) ' Replicates.............5'
    WRITE (*,*) ' See current values .....6'
    WRITE (*,*) ' Exit...................7'
    WRITE (*,*)
    WRITE (*,'(1X,A,$)') 'enter: '
    READ (*,*) J
    IF (J.LT.1) GOTO 110
    WRITE (*,'(1X,A,$)') 'enter new value: '
    IF (J.EQ.1) READ (*,*) SDEV
    IF (J.EQ.2) READ (*,*) ALPHA
    IF (J.EQ.3) READ (*,*) P
    IF (J.EQ.4) READ (*,*) CH
    IF (J.EQ.5) READ (*,*) RPT
    IF (J.EQ.6) THEN
      WRITE (*,12) SDEV,ALPHA,P,CH,RPT,NN
12     FORMAT (1X,'Standard Deviation = ',F8.3,/,
    & ' Alpha = ',F8.3,/,
    & ' Power = ',F8.3,/,
    & ' Change= ',F8.3,/,
    & ' Repeat= ',F8.3,/,
    & ' Sample= ',I4)
      GOTO 110
    ENDIF
    IF (J.GE.7) GOTO 500
    GOTO 40
C
500    END




    FUNCTION TVAL(A,V)
          Author D.J. Agnew, March 1991
    TOP=50.
    BOT=0.
    TVAL=2
    COUNTER=1
10   CONTINUE
    PROB=BETAI(0.5*V,0.5,V/(V+TVAL**2))
    DIFF=ABS(PROB-A)
    IF (DIFF.LE.0.00001) GOTO 20
    IF (PROB.LT.A) THEN
     TOP=TVAL
    ELSE
     BOT=TVAL
    ENDIF
    TVAL=(TOP+BOT)*.5
    COUNTER=COUNTER+1
    IF (COUNTER.GT.1000) THEN
```

```
        WRITE (*,*) 'error; counter exeeded TVAL; T=',T
      RETURN
    ENDIF
    GOTO 10
20  CONTINUE
    RETURN
    END


----------------------------------------------------------------------

    PROGRAM POWERPERC
C
C finds sample size required from 2 given percentages
C
C   calls TVAL function by DJA which finds T value for given Alpha an DF
C
C  also uses functions from "Numerical Recipies", Press et al
C
C
    DATA V/999./

    WRITE (*,*) 'Program POWERPERC
   &: find sample size required for power P'
    WRITE (*,*)
    WRITE (*,'(1X,A,$)') 'enter proportion 1:'
    READ (*,*) P1
    WRITE (*,'(1X,A,$)') 'enter alpha (required probability):'
    READ (*,*) ALPHA
    WRITE (*,'(1X,A,$)') 'enter P  (power):'
    READ (*,*) P
    WRITE (*,'(1X,A,$)') 'enter DETECTABLE CHANGE (proportion):'
    READ (*,*) CH

40   P2=P1-CH
    PBAR=(P1+P2)/2
    T1=TVAL(ALPHA,V)
    T2=TVAL(2*(1-P),V)
    TMP=T2*SQRT(P1*(1-P1)+P2*(1-P2))
    A=(T1*SQRT(2*PBAR*(1-PBAR))+TMP)**2
    TMP=A*(1+SQRT(1+4*(P1-P2)/A))**2
    NN=NINT(TMP/(4*(P1-P2)**2))

    WRITE (*,*)
    WRITE (*,11) P1,ALPHA,P,CH,NN
11   FORMAT (1X,'percent=',F6.3,' alpha=',F6.3,' power=',F6.3,
   & ' change=',F8.3,/,1x,'  Sample size NN = ',I4)
C
C   allow for changing any of the inputs within this run
C
110  WRITE (*,*)
    WRITE (*,*) ' ******** MENU ***********'
    WRITE (*,*) ' Enter number for changing'
    WRITE (*,*) ' Percentage..............1'
    WRITE (*,*) ' Alpha...................2'
    WRITE (*,*) ' Power...................3'
    WRITE (*,*) ' Detectable change.......4'
    WRITE (*,*) ' See current values .....6'
    WRITE (*,*) ' Exit....................7'
    WRITE (*,*)
    WRITE (*,'(1X,A,$)') 'enter: '
    READ (*,*) J
    IF (J.LT.1) GOTO 110
    WRITE (*,'(1X,A,$)') 'enter new value: '
    IF (J.EQ.1) READ (*,*) P1
    IF (J.EQ.2) READ (*,*) ALPHA
    IF (J.EQ.3) READ (*,*) P
    IF (J.EQ.4) READ (*,*) CH
```

```
       IF (J.EQ.6.OR.J.EQ.5) THEN
          WRITE (*,12) P1,ALPHA,P,CH,NN
12        FORMAT (1X,'Percentage = ',F8.3,/,
      & ' Alpha = ',F8.3,/,
      & ' Power = ',F8.3,/,
      & ' Change= ',F8.3,/,
      & ' Sample= ',I4)
          GOTO 110
       ENDIF
       IF (J.GE.7) GOTO 500
       GOTO 40
C
500    END
```

```
       FUNCTION TVAL(A,V)
       TOP=50.
       BOT=0.
       TVAL=2
       COUNTER=1
10     CONTINUE
       PROB=BETAI(0.5*V,0.5,V/(V+TVAL**2))
       DIFF=ABS(PROB-A)
       IF (DIFF.LE.0.00001) GOTO 20
       IF (PROB.LT.A) THEN
        TOP=TVAL
       ELSE
        BOT=TVAL
       ENDIF
       TVAL=(TOP+BOT)*.5
       COUNTER=COUNTER+1
       IF (COUNTER.GT.1000) THEN
          WRITE (*,*) 'error; counter exeeded TVAL; T=',T
        RETURN
       ENDIF
       GOTO 10
20     CONTINUE
       RETURN
       END
```

```
       PROGRAM REG
C
C    Written for method C2
C
C    Calculates regression coefficients given mean and s.d. of
C    a series of samples.
C
C    see pages 480-485 Sokal & rohlf for calculation method
C
C    Called function TVAL finds a t value given alpha and v
C    Called funtions BETAI, BETACF, GAMMLN are taken from
C     Numerical Recipes, by Press, Flannery, Teukolsky & Vetterling (1989)
C
C    D J Agnew, May 1991
C
       CHARACTER*20 IN
       REAL MSREG,MSYX
C
C blimit is the % confidence limits required
       BLIMIT=95.
       ALPHA=1-BLIMIT/100

       NSAMP=0
```

```
       WRITE (*,*) 'program REG. computes indices for C2'
       WRITE (*,*)
       WRITE (*,'(1x,A,$)') 'input file name :'
       READ (*,'(A20)') IN
        OPEN (UNIT=2,FILE=IN,STATUS='OLD',
      &    CARRIAGECONTROL='LIST',ERR=20)
        GOTO 45
C data input if no file
20   CONTINUE
       WRITE (*,*) '***** new file *****'
       CLOSE(2)
       OPEN (UNIT=2,FILE=IN,STATUS='NEW',CARRIAGECONTROL='LIST')
25   NSAMP=NSAMP+1
       WRITE (*,'(1X,A,I3,A,$)') 'day ',NSAMP,' (END=9999) :'
       READ (*,*) DAY
       IF (DAY.EQ.9999.) GOTO 30
       WRITE (*,'(1X,A,I3,A,$)') 'mean weight ',NSAMP,' :'
       READ (*,*) WT
       WRITE (*,'(1X,A,I3,A,$)') 's.d. weight ',NSAMP,' :'
       READ (*,*) SD
       WRITE (*,'(1X,A,I3,A,$)') 'n ',NSAMP,' :'
       READ (*,*) N
       WRITE (2,'(1X,3(F10.5,2X),I5)') DAY,WT,SD,N
       GOTO 25
30   CLOSE (2)
       OPEN (UNIT=2,FILE=IN,STATUS='OLD')
c  setup count zeros
45   NSN=0
       SY=0
       SYN=0
       SY2=0
       SX=0
       SX2=0
       SXY=0
       NSAMP=0
c  loop to read data and calculate sums
50   READ (2,*,END=100) DAY,WT,SD,N
       NSN=NSN+N
       NSAMP=NSAMP+1
       SWT=WT*N
       SWT2=(SD*SD)*(N-1)+(SWT*SWT)/N
       SY=SY+SWT
       SYN=SYN+WT*WT*N
       SY2=SY2+SWT2
       SX=SX+DAY*N
       SX2=SX2+DAY*DAY*N
       SXY=SXY+DAY*SWT
       GOTO 50

c  calculate results and print
100  CONTINUE
       CTY=SY*SY/NSN
       SSTOTAL=SY2-CTY
       SSGROUP=SYN-CTY
       SSWITHIN=SSTOTAL-SSGROUP
       CTX=SX*SX/NSN
       SSQX=SX2-CTX
       SPXY=SXY-SX*SY/NSN
       EXSS=SPXY*SPXY/SSQX
       SDYX=SSGROUP-EXSS
       DFDYX=NSAMP-2
       DFREG=1
       MSREG=EXSS/DFREG
       MSYX=SDYX/DFDYX
       F=MSREG/MSYX
       DF1=DFREG
       DF2=DFDYX
```

```
C single tailed F test
      PROB=BETAI(.5*DF2,.5*DF1,DF2/(DF2+DF1*F))
    B=SPXY/SSQX
    A=(SY-B*SX)/NSN
    ERROR=SQRT(MSYX/SSQX)
    T=TVAL(ALPHA,DF2)
    BLOWER=B-ERROR*T
    BUPPER=B+ERROR*T
C calculation of correlation coefficient by Sokal & Rohlf method
C   R=ABS(SPXY/(SQRT(SSTOTAL*SSQX)))
C or using equation p 84 of Clarke
    R=(NSN*SXY-SX*SY)
    R=R/(SQRT((NSN*SX2-SX*SX)*(NSN*SY2-SY*SY)))
    R2=R*R
C
C

    WRITE (*,*) '-----------------------'
    WRITE (*,*) 'Abbreviated anova table'
    WRITE (*,*) ' variation  df      SS
    &  MS      F     P'
    WRITE (*,10) NINT(DFREG),EXSS,MSREG,F,PROB,
    &NINT(DFDYX),SDYX,MSYX
10  FORMAT (1X,'  REGRESSION',I3,4F10.4,/,1X,'DEV. FROM REG',
    &I3,2F10.4)
    WRITE (*,*)
    WRITE (*,11) B,ERROR,
    &BLIMIT,BLOWER,BUPPER,
    &MSYX,
    &NSAMP,NSN,R,R2,A
11  FORMAT (1X,'REPORTED VALUES',/,
    &/,1x,' by.x  slope =',F8.4,
    &/,1x,' Sb standard error of slope =',F8.5,
    &/,1x,F5.1,'% limits: ',F8.4,' & ',F8.4,
    &/,1x,' S2y.x  mean square dev =',F10.4,
    &/,1X,' number of samples =',I3,', number of animals =',I5,
    &/,1x,' correlation coefficient r =',F7.4,
    &//' OTHERS ',/,' r squared =',F7.4,
    &/,1X,'intercept =',F8.4)


    END

--------------------------------------------------------------------
    PROGRAM REGCO
C
C performs statistical comparison between two regression coefficients
C given the coefficient, its standard error, the mean square standard
C deviation S2y.x and the number of samples. These are all output from
c the program REG. Method for 2 samples follows Sokal & Rohlf
C Box 14.8, page 505.
C
C Author: D J Agnew, 25 March 1992
C
C
    REAL B(2),SB(2),S2YX(2),A(2),MSYX,SSQX(2)
    SUMS=0.
    SUMA=0.
    DO 10 I=1,2
    WRITE (*,'(1X,A,I2,A,$)') 'Sample ',I,' reg. coeff. b:'
    READ (*,*) B(I)
    WRITE (*,'(1X,A,I2,A,$)') 'Sample ',I,' std. error. reg. coef Sb:'
    READ (*,*) SB(I)
    WRITE (*,'(1X,A,I2,A,$)') 'Sample ',I,' mean sq. dev S2y.x:'
    READ (*,*) S2YX(I)
    WRITE (*,'(1X,A,I2,A,$)') 'Sample ',I,' no. samples  a:'
    READ (*,*) A(I)
```

```
      SUMS=SUMS+(A(I)-2)*S2YX(I)
      SSQX(I)=S2YX(I)/(SB(I)**2)
      SUMA=SUMA+A(I)
10    CONTINUE
      MSYX=SUMS/(SUMA-4)
      SINT=MSYX*(SSQX(1)+SSQX(2))/(SSQX(1)*SSQX(2))
      F=((B(1)-B(2))**2)/SINT
      DF1=1
      DF2=SUMA-4
      PROB=BETAI(0.5*DF2,0.5*DF1,DF2/(DF2+DF1*F))
      WRITE (*,20) (B(I),I=1,2),(SB(I),I=1,2),
     &(S2YX(I),I=1,2),(A(I),I=1,2),F,PROB
20    FORMAT (1X,'        SAMPLE 1  SAMPLE 2',/,
     &1X,'Rate ',2F9.4,/,
     &1X,'Sb   ',2F9.5,/,
     &1X,'S2y.x',2F9.4,/,
     &1X,'A    ',2F9.4,//,
     &1X,'F =  ',F9.4,/,
     &1x,'PROBABILITY= ',F9.4)
      END
```

RATIONALE FOR CHOICE OF INDICES
FOR METHODS A5, A6 AND A8

(this is reproduced from Agnew, 1991[3])

Method A5:   Foraging Duration

Index:

Foraging duration is reported on Form A5 as a 'mean of means'. Examination of data on chinstrap and macaroni penguin foraging from USA submissions, pooled for both sexes, indicated that foraging duration changes with time and may be different during guard and creche stages (Figures 1 and 2)[4].
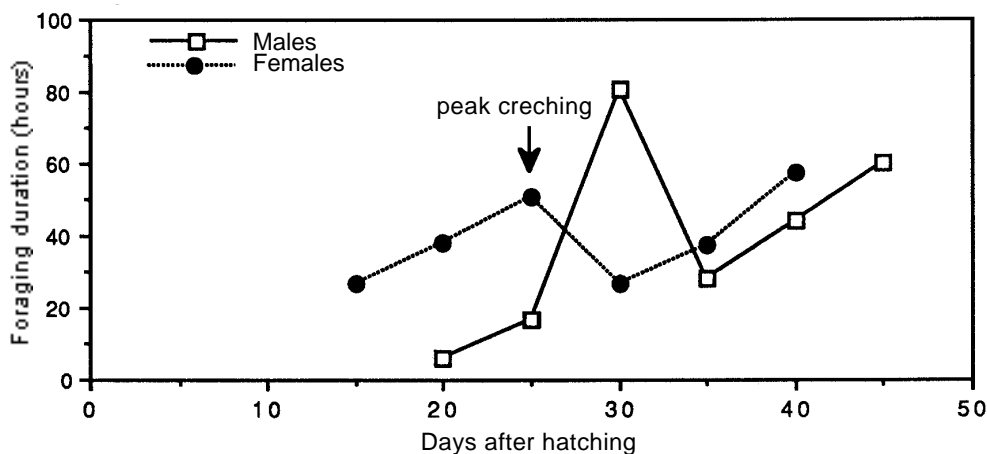
Figure 1:   Seal Island: chinstrap penguin mean foraging duration versus time for all five-day periods. Data from USA, 1990, all sexes combined. Standard errors are shown.

---

[3]   Agnew, D.J. 1991. A proposal for CEMP predator parameter indices. Document *WG-CEMP-91/8*. CCAMLR, Hobart, Australia.

[4]   Data note: For chinstrap penguins at Seal Island, although the decrease in foraging duration seen in Figure 1 was accompanied by a decrease in the mean number of chicks in a nest, an analysis of data for individual birds did not detect a significant difference between foraging duration of one- and two-chick birds. This analysis was only possible because of the detailed reporting of foraging duration by individual and by period. This type of reporting should be encouraged until the effect of the number of chicks has been thoroughly investigated.
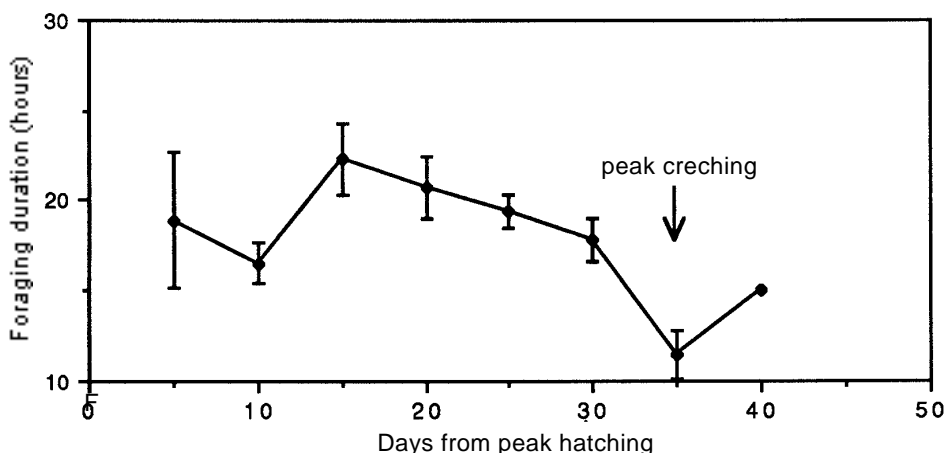
Figure 2:   Seal Island: macaroni penguin foraging duration for all five-day periods. Data from USA, 1990.

Accordingly, two indices are suggested, separated temporally with respect to key events during breeding: the times of peak hatching and creching. Two periods are left unused following the peak hatching and creching to ensure that most birds have entered the appropriate breeding stage:

Index 1:   Start of brooding: periods 3, 4 and 5 where period 1 = period of peak hatching; and

Index 2:   Start of creching: periods 3, 4 and 5 where period 1 = period of peak creching;

where the period alluded to is the five-day period of the CEMP standard methods.

The following diagram explains this allocation of indices: the bars are the start/end days of the five-day periods.

Peak
hatching

Peak
creching

These two indices are calculated for males and females separately.

Method A6: Breeding Success

Index:

Two indices, the total number of chicks reared to creche from a number of colonies, and the normalised success rate are used. Success rate is the number of chicks reared per nest normalised to the total potential number of chicks. For species laying two eggs per nest (chinstrap penguins), the potential number of chicks is therefore two times the number of nests.

The normalisation of this index is necessary because comparisons of these rates are most conveniently done using tests of independence on multiway tables; typical tests are the C^2 and G-statistic methods. All these methods require a success/failure rate calculation that produces a rate between 0 and 1. Thus the rate must be expressed as (number of chicks reared)/(total number of potential chicks).

Method A8: Chick Diet

Index:

Both weight of total stomach contents and the proportion of crustaceans in the stomach are used as indices. When more data becomes available, proportion of *Euphausia superba* or other foodstuffs may be used.

Proportional data are not usually normally distributed. In order to compare them, proportions may be normalised using an arcsin transformation.

$$x_T = \arcsin \sqrt{x}$$

where x_T is expressed in degrees. The efficacy of this method was tested using UK data for macaroni penguins from 1990. Figure 3 (shown on the following page) shows the probability plots and distributions of data before and after transformation.

The suggested indices are therefore given as mean weight of stomach contents and mean transformed proportion of crustacea in the stomach.
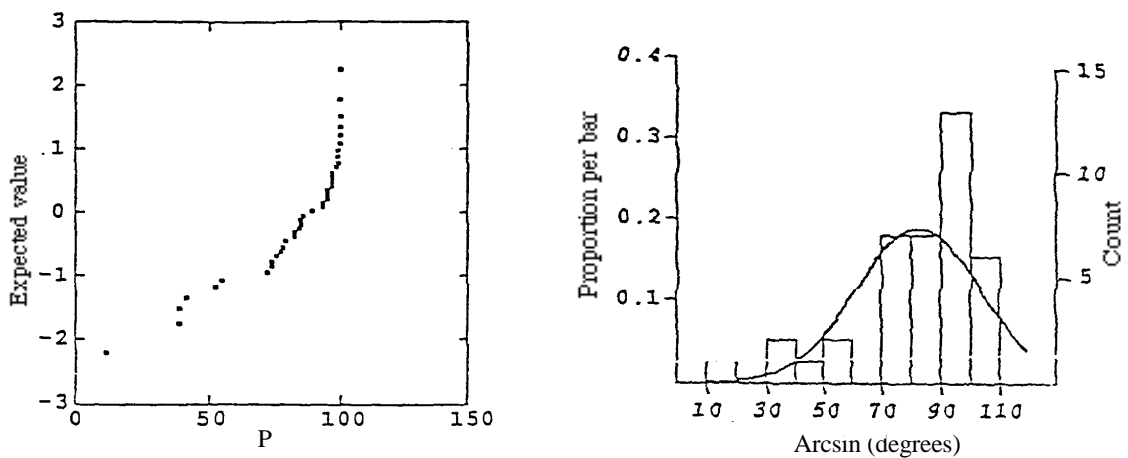
(a) before transformation p = percent by weight.
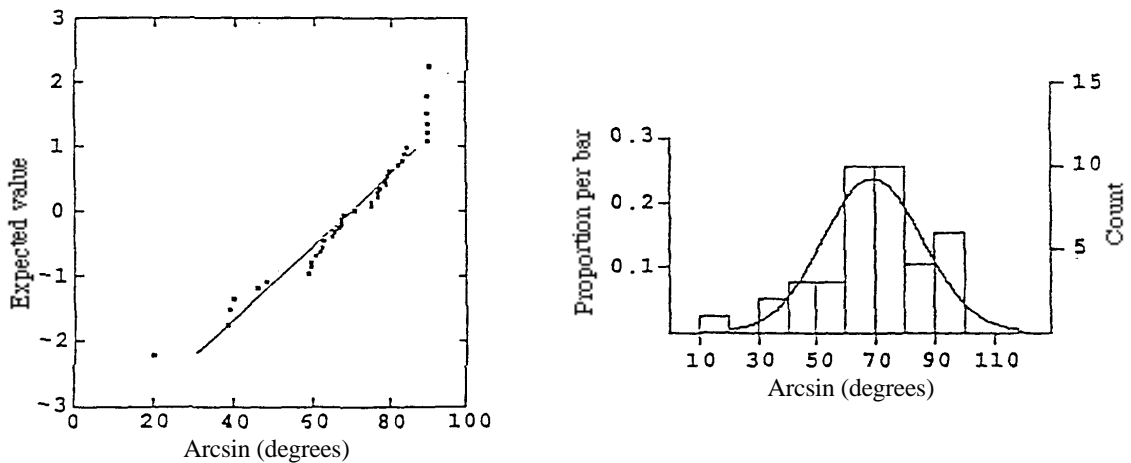
(b) after transformation $p^l = arcsin \sqrt{p}$

Figure 3:   Probability plots and bar graph with overlaid normal distributions for the percentage contribution of crustaceans to the stomach contents (weight) of macaroni penguins at Bird Island in 1990.

PART IV

OBSERVATION PROTOCOLS AND TECHNIQUES

SECTION 1

DETERMINING THE SEX OF PENGUINS

DETERMINING THE SEX OF PENGUINS

Sex determination is important for the measurement of several CEMP parameters, especially weight on arrival at breeding colony and age-specific annual survival and recruitment.

Determining sex in penguins can be performed by taking morphometric measurements (Scolaro et al., 1983; Scolaro, 1987) or, during the breeding season, by observing copulation and by cloacal examination (Sladen, 1978; Samour et al., 1983) and, at least in one species, sex-specific incubation routines (Kerry et al., 1993).

Morphometric measurement is the simplest method available which can be applied to adults of all species at all times. Details of the measurements required and of the discriminant functions which have been used to determine sex based on these measurements are given below. Agnew (1992) has shown that, in cases where the discriminant function used gives greater than 80% successful allocation of sex, determining sex by this method is preferable to not determining sex at all.

CHINSTRAP PENGUIN (*Pygoscelis antarctica*)

Amat et al. (1993) used discriminant analysis on chinstrap penguins from Deception Island, South Shetland Islands, validating their data by using birds sexed by observed copulation. They measured bill length (BL) and depth (BD), flipper length (FL) and body mass. Significant between-sex differences existed in all four variables. In the overall discriminant analysis, however, body mass did not make a positive contribution to the multivariate distance. The best discriminant function was:

$$Z = 0.213 \, BL + 4.360 \, BD + 0.137 \, FL.$$

Bill depth was the most important discriminant variable, contributing 85.4% to the multivariate distance (6.4% for BL and 8.3% for FL). Group centroids were 125.61 for males (range 120.68–130.16) and 116.09 (range 108.93–121.70) for females. Individuals with scores of >120.85 were considered males. This analysis correctly classified 94.6% of the 55 individuals. Identical classification success was also achieved using BL and BD alone:

$$Z = 0.409 \, BL + 4.113 \, BD.$$

Individuals with scores >99.77 were classified as males.

The authors also validated their discriminant function by using jacknife statistical procedures which also gave a classification success of 94.6%.

MACARONI PENGUIN (*Eudyptes chrysolophus*)

Sex determination of *Eudyptes* penguins from bill dimensions is straightforward (Downes et al., 1959; Warham, 1972, 1975; Williams and Croxall, 1991). The recommended measurements (shown in Figure 1) are:

bill length: from the tip of the proximal edge of the first ridge on the upper mandible;

bill depth: at the mandibular symphysis.

Observation Protocols and Techniques

The use of these two measurements will produce 100% discrimination of sexes in macaroni penguins. At South Georgia, where the measurements were validated on birds sexed by observed copulation and attendance pattern during incubation (Williams and Croxall, 1991), BD alone distinguished sexes in 100% of cases.

GENTOO PENGUIN (*Pygoscelis papua*)

Williams (1990, Table 1) used discriminant analysis to determine the sex of gentoo penguins at South Georgia. He used bill measurements and validated his data with birds sexed during observed copulation. Recommended measurements (shown in Figure 2) are:

bill length: from the tip to the point of feathering on the upper mandible;

bill depth: at the mandibular symphysis.

The discriminant function for birds from Bird Island, South Georgia is D = 0.922 length plus 3.885 depth. Mean discriminant score was 112.608 so that D >112.608 = male and D <112.608 = female. For the 112 known sex birds, 107 (95.5%) were correctly sexed.

ADÉLIE PENGUINS (*Pygoscelis adeliae*)

Scolaro et al. (1990) used discriminant analysis on Adélie penguins at King George Island, validating their data using birds sexed by reference to which bird took the first incubation shift. They took eight measurements, of which the most important in sex discrimination (shown in Figure 3) were:

bill depth: at nostrils from the point on the lower mandible to just behind the mandibular symphysis;

flipper breadth: maximum width near the cubitocarpal joint;

middle toe length: including nail.

For a combination of all three variables, the discriminant function was D = 0.348 flipper breadth + 1.46 bill depth + 0.311 middle toe length. The mean discriminant score was 70.52 (male >70.52; female <70.52). This correctly classified the sex of 87% of birds. For the best two variables, D = 0.428 flipper breadth + 1.40 bill depth. The mean discriminant score was 49.04, which correctly classified 80% of birds.

In an additional study, Kerry et al. (1991) were able to correctly determine the sex of 89% of Adélie penguins at Bechervaise Island, Mawson Base, using the discriminant function D = 0.582 (bill length) + 1.12 (bill depth) + 0.219 (flipper width) with a mean discriminant score of 55.39.

DETERMINING THE SEX OF ADÉLIE PENGUINS FROM INCUBATION SHIFT ROUTINE

Kerry et al. (1993) have shown that the sex of Adélie penguins can be determined by the observation of incubating birds. At Béchervaise Island they found that over a three-year period the peak presence of males alone on the nest occurred 15 to 21 days after the appearance of the first egg in the colony and the peak presence of females 33 to 36 days

from this date. In all three seasons male birds could be identified with 91.8% to 98.6% accuracy. This is better than that obtained by discriminant analysis of morphometric parameters.

This method, once calibrated for a particular region, may be applied to all birds in the colony with very little effort. Males should be marked with dye at the determined date (e.g. 15 to 21 days from first egg at Béchervaise Island) and the female using a different coloured dye when she returns to take the next incubation shift. Birds should then be banded or tagged as they leave the colony. If bands are placed on the left flipper for male and right for female the wrong assignment of sex can be identified when pairs are observed in subsequent seasons.
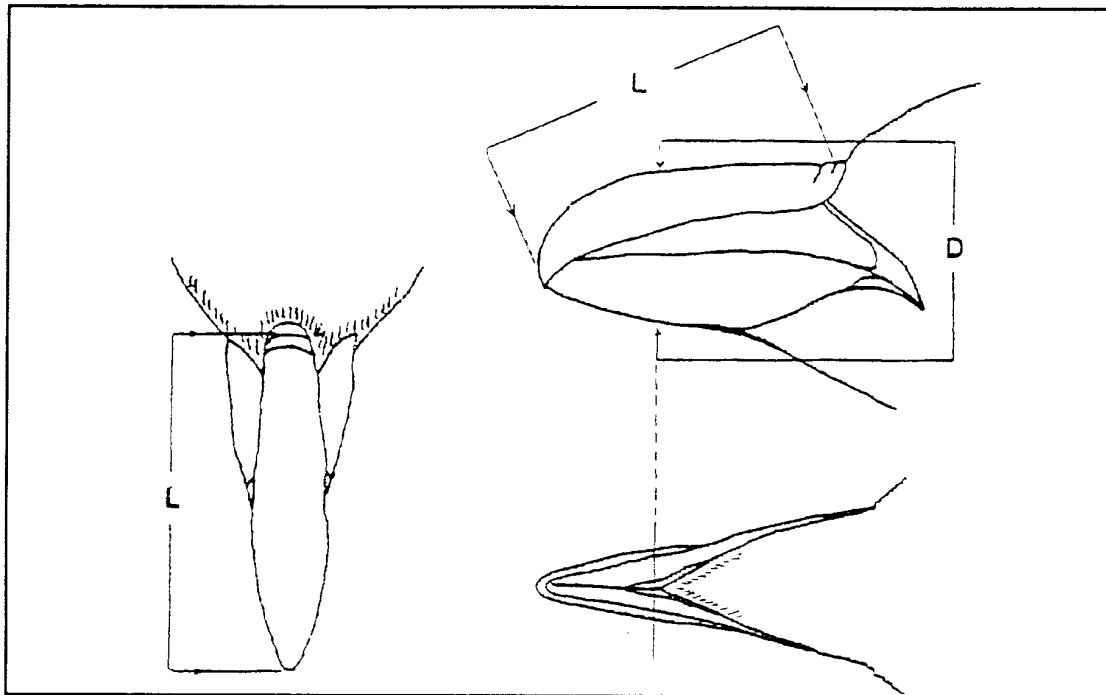
Figure 1: Macaroni penguin, *Eudyptes chrysolophus*, bill length (L) and depth (D).
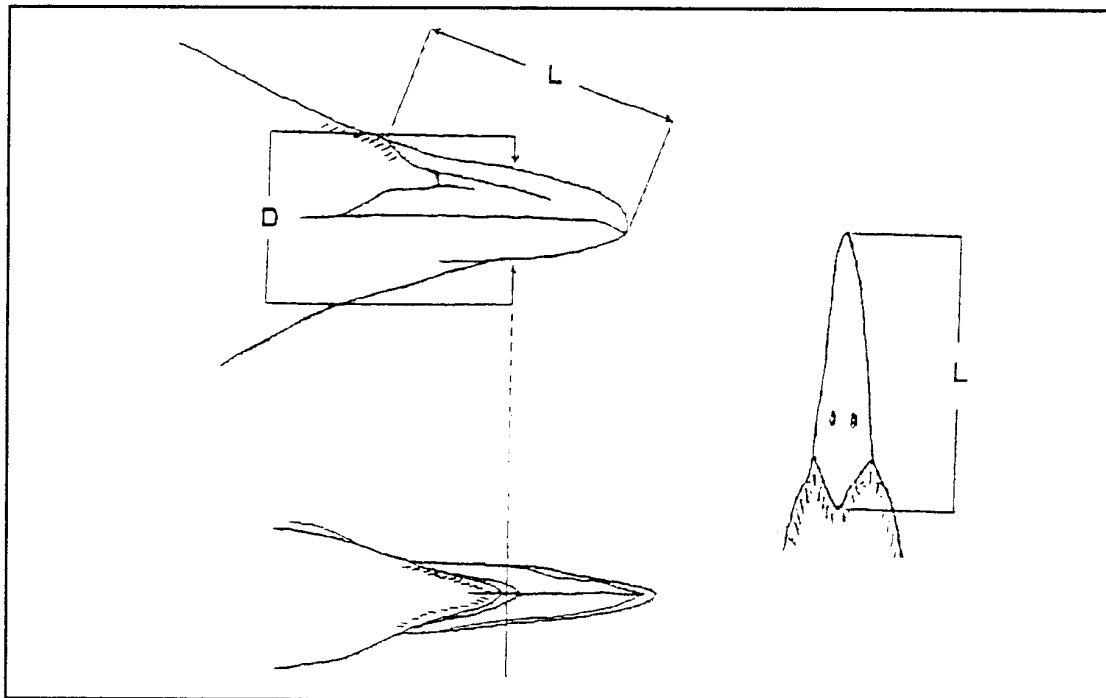
Figure 2: Gentoo penguin, *Pygoscelis papua*, bill length (L) and depth (D).
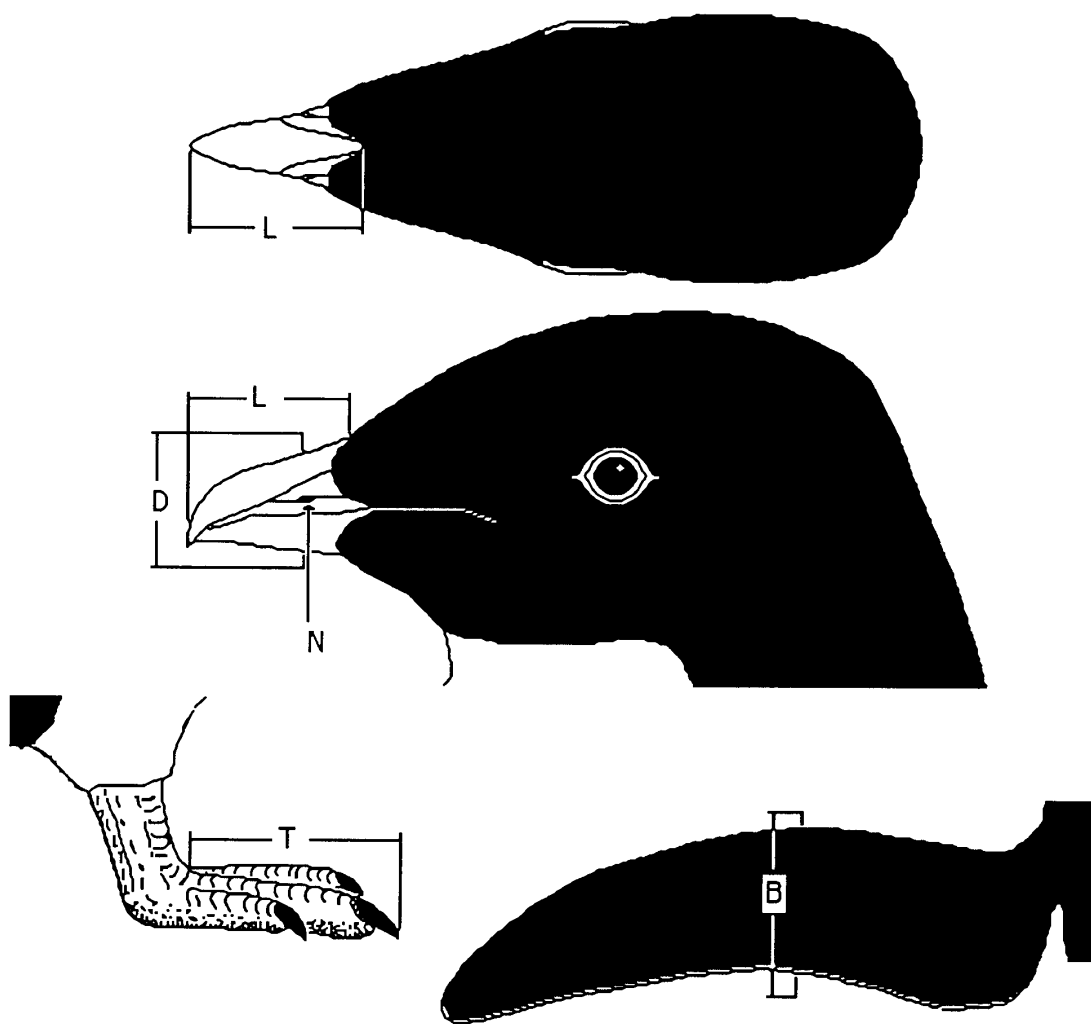
Figure 3:   Adélie penguin, *Pygoscelis adeliae*, bill depth (D), bill length (L), position of nostrils (N), flipper breadth (B) and middle toe length (T).

REFERENCES:

Agnew, D.J. 1992. Can we use discriminant function analysis to sex penguins prior to calculating an index of a morphometric characteristic? In: *Selected Scientific Papers, 1992 (SC-CAMLR-SSP/9)*. CCAMLR, Hobart, Australia: 259–272.

Amat, J.A., J. Vinuela and M. Ferrer. 1993. Sexing chinstrap penguins (*Pygoscelis antarctica*) by morphological measurements. *Colonial Waterbirds*, 16 (2): 213–215.

Downes M.C., E.H.M. Ealey, A.M. Gwynn and P.S. Young. 1959. The birds of Heard Island. *Anare Rep. Ser. B,* 1.

Kerry, K.R., R. Weatherly and G. Else. 1990. Standard Measurements on Adélie penguins. Document *WG-CEMP-90/25*. CCAMLR, Hobart, Australia.

Kerry, K.R., D.J. Agnew, J.R. Clarke and G.D. Else. 1992. The use of morphometric parameters for the determination of sex of Adélie penguins. *Australian Wildlife Research*, 19: 657–664.

Kerry, K.R., J.R. Clarke and G.D. Else. 1993. Identification of sex of Adélie penguins for observations of incubating birds. *Wild. Res.*, 20: 725–732.

Samour, H.J., M.F. Stevenson, J.A. Knight and A.J. Lawrie. 1983. Sexing penguins by cloacal examination. *Veterinary Record*, 113: 84–85.

Scolaro, J.A. 1987. Sexing fledglings and yearlings of magellanic penguins by discriminant analysis of morphometric measurements. *Colonial Waterbirds*, 10 (1): 50–54.

Scolaro, J.A., M.A. Hall and I.M. Ximenez. 1983. The magellanic penguin (*Sphenicus magellanicus*): sexing adults by discriminant analysis of morphometric character. *Auk*, 100: 221–224.

Scolaro, J.A., Z.B. Stanganelli, H. Gallelli and D.F. Vergani. 1990. Sexing of adult Adélie penguin by discriminant analysis of morphometric measurements. In: *Selected Scientific Papers, 1990* (*SC-CAMLR-SSP/7*). CCAMLR, Hobart, Australia: 543–549.

Sladen, W.J.L. 1978. Penguins: introduction. *Int. Zool. Yb.*, 18: 1–2.

Warham, J. 1972. Breeding seasons and sexual dimorphism in rockhopper penguins. *Auk*, 89: 86–105

Warham, J. 1975. The crested penguins. In: Stonehouse, B. (Ed.). *The Biology of Penguins.* Macmillan: p. 555.

Williams, T.D. 1990. Annual variation in breeding biology of gentoo penguins *Pygoscelis papua* at Bird Island, South Georgia. *J. Zool., Lond.*, 222.

Williams, T.D., and J.P. Croxall. 1991. Annual variation in breeding biology of the macaroni penguin, *Eudyptes chrysolophus*, at Bird Island, South Georgia. *J. Zool., Lond.*, 223: 189–202.

SECTION 2

RECOMMENDATIONS FOR A PENGUIN
STOMACH FLUSHING TECHNIQUE

RECOMMENDATIONS FOR A PENGUIN
STOMACH FLUSHING TECHNIQUE

This technique is relevant to CEMP Standard Method A8, procedure A, part 3.

A stomach pump or a funnel and tube are used to introduce water into the stomach to remove the contents. In both cases the tubing should be made of soft latex rather than rigid plastic, and tested at low temperatures to ensure that it remains flexible in cold conditions. The external diameter should be no more than 15 mm and any sharp edges on the end of the tube filed down.

Stomach contents are collected by pumping or pouring up to 1 000 ml of warm water (preferably fresh, though seawater can be used) via the stomach tube into the bird which is held standing or lying in ventral recumbency. Insert the stomach tube by opening the bill and gently feeding the tube down the throat to a distance equivalent to the base of the sternum (mark the tube beforehand to this length). If resistance to the passage of the tube is encountered remove it and try again. Never force the tube down. It is preferable to reject the bird and use a different individual if resistance to the tube persists.

Gently pump or pour water into the bird. Stop pumping after 1 000 ml has been introduced or once water starts to dribble from the beak. Stop sooner than this if the abdomen feels very distended in birds that were full of food to start with. Remove the tube and invert the bird over a bucket. Squeeze the abdomen firmly while holding the beak open and massaging the back of the throat with a finger. Shaking the bird in a vertical plane may help dislodge lumps of food. Once the bird has ceased to regurgitate it is returned to the starting position and the procedure repeated as many times as is necessary to remove all the stomach contents (i.e. until the regurgitated water is clear and the stomach feels empty on palpation).

It is sometimes difficult in very full birds to remove the food because it is compressed into lumps which do not pass easily from the stomach into the oesophagus. Excessive squeezing of the abdomen may risk rupturing the distended stomach. Rather than continuing to force the birds to vomit it is advisable to put the penguin into a fenced enclosure for up to 30 minutes to allow the introduced water to mix with the stomach contents and soften the compacted lumps. The birds will often vomit spontaneously if left alone full of water; following this the flushing processing can be continued. If the problem continues it is better to abandon the process and choose another individual than to risk injuring the bird.

Extracted food samples are poured into a sieve to drain off the water and then preserved in absolute ethanol or frozen until sorting takes place. The flushed birds should be marked with dye prior to release so that they can later be found at their nests to ensure that they are indeed breeding adults and that they have suffered no ill effects from the flushing procedure.

SECTION 3

POPULATION MONITORING IN LARGE
COLONIES OF ANTARCTIC PETRELS

POPULATION MONITORING IN LARGE
COLONIES OF ANTARCTIC PETRELS

This method is based on a modified version of the 'Star' system described by Anker-Nilssen and Røstad (1993) and documented in Lorentsen et al. (1993) for monitoring Antarctic petrels at Svarthamaren, Dronning Maud Land. The main advantages of this approach are that all areas of the colony are equally represented, and that the variance of the estimate can be calculated.

1. Establish a grid net of evenly-spaced sampling plots covering the whole colony area and count the number of nests within a specified area, study plot (e.g. 10 or 20 m²) in the centre of each grid cell. For a «flat» colony it is quite easy to lay out this grid net, but in a colony with a more pronounced topography, the methods described by Anker-Nilssen and Røstad (1993) should preferably be used (see Annex 1).

2. It is recommended that the number of study plots is a minimum of 100 and preferably up to 200. The distance between each study plot (horizontally and vertically) is calculated from the total area of the colony, and the number of study plots required. (For Svarthamaren a 40 m inter-plot distance was chosen for a colony of approximately 331 000 m² giving 207 study plots.) It is important that the grid net extends beyond the edge of the present colony area to allow for future population increases.

3. Mark the centre of each plot with an aluminium pole into which the plot number is engraved at the top, or marked with red paint in the case of plots situated on bedrock. Take a photograph of each plot to enable the replacement of marker poles which are missing or paint marks which have eroded from the rock.

4. Count every nest contained within a circle of 10 (or 20) m². To do this, it is convenient to use a 1.78-metre-long rope (or 2.52 m for a 20 m² study plot) attached to sweep the circle around the aluminium pole. A nest has to be counted if more than half of its area falls within the sampling area.

5. Calculate the total number of nests (P) by:

$$P = \frac{x^2 \; t_i}{a} \quad (i = 1,\mathrm{N})$$

and the standard error $SE(P)$ of the estimate:

$$SE(P) = \frac{x^2}{a} \sqrt{\frac{N \; t_i^2 - \left(\; t_i \right)^2}{N-1}} \quad (i = 1,N)$$

where x = inter-plot distance, t_i = number of nests in study plot, i and N = the number of inhabited study plots (study plots with a nest).

6. By using this method, density-dependent differences in population trends (e.g. recruitment) can be calculated together with density differences in different habitat strata of the colony. If the colony is divided into different habitat strata, the standard error of P within each stratum ($SE(P_j)$) is calculated in a similar way, and a new estimate of $SE(P)$ for the whole colony is found as:

$$SE(P) = \sqrt{ \; \left(SE(P_j) \right)^2 } \quad (j = 1,S)$$

REFERENCES

Anker-Nilssen, T., and O.W. Røstad. 1993. Census and monitoring of puffins *Fratercula arctica* on Røst, N Norway, 1979–1988. *Ornis Scand.*, 24: 1–9.

Lorentsen, S.-H., N. Røv and G. Bangjord. 1993. Documentation of the demography and population monitoring systems for Antarctic petrels at Svarthamaren, Dronning Maud Land. *NINA Oppdragsmelding*, 240: 1–75.

THE STAR SYSTEM

(extract from: Anker-Nilssen and Røstad, 1993)

In 1983, a new sampling method, here called *the star system*, was developed and introduced on Hernyken. The principle of the method is to spread many small sampling plots systematically all over the colony in such a way that the total surface of the island, taking its topography into account, is covered. The sampling plots are evenly spaced and thus represent surface areas of equal size. In a flat landscape the total surface area can easily be divided into equal squares. In areas with a more pronounced topography, as on Hernyken, the spacing method has to be quite different. We used a star-shaped model for spacing small circular sampling plots (Figure 2).
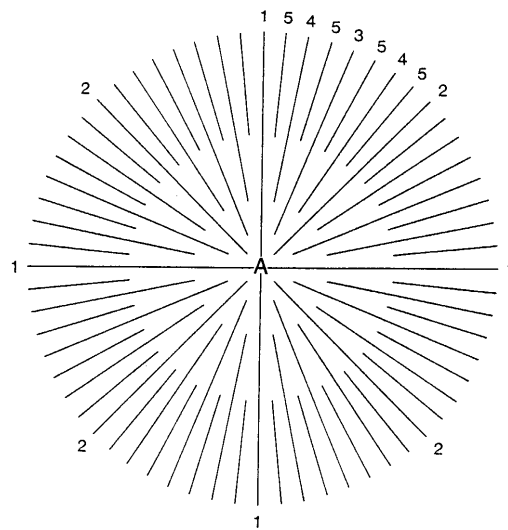
Figure 2:   The star-shaped spacing model used to localise sampling area centres. 1 denotes the four lines radiating in the main compass directions (1st order lines), 2 denotes lines in the first intermediate line set dividing the circle into eight equal sectors (2nd order lines), etc.

First, a point near the centre of the colony is chosen as the centre of the star-shaped model (*A*, Figure 2). The centre points of all the other sampling plots are situated on lines radiating from this point. The distance between two adjacent points on one line is denoted x. On the lines in the four main compass directions from *A* (called 1st order lines) the points are spread out with the first point on each line x m from *A*. In the field a rope of length x m is laid along the ground in the line direction to locate each centre point.

When the four 1st order lines with all their points are completed, the four 2nd order lines are laid out, then the eight 3rd order lines, etc. However, the distance from *A* to the first point on an intermediate line (i.e. a line of 2nd, 3rd or higher order) is not constant, but increases with increasing line order (*L*) and varies with the degree of topography. The first point on a 2nd order line is found by laying a rope of length $3x/2$ along the ground from *A*. For lines of higher order (*L*   3), the procedure is slightly more complicated. The first point is then located by using a rope of length:

$$\frac{x}{\cos\dfrac{180°}{2^L}} + \frac{x}{2}$$

The rope is laid along the ground, perpendicular to the L order line, and with the rope ends touching each neighbouring line. Where the rope cuts the new line, the first point on the line is found at a distance of $x/2$ m in the line direction away from point A. With increasing L value the expression above approaches $3x/2$, and for L 4, we used this approximation.

By simply choosing specific values for the distance x and the sampling area a surrounding each plot, the method can easily be adjusted for any colony. This way of spacing plots evenly over a topographically structured surface area may also be useful when sampling other biological or physical parameters.

Considering the size of the Puffin colony on Hernyken, the work capacity available, and the accuracy wanted, we chose $x = 20$ m and $a = 10$ m^2 in our study. This results in 2.5% of the colony area being within the sampling plots. The entire surface of Hernyken was considered as the study area, and the resulting total of 415 sampling plots were spaced out by two persons during a three-week period (Figure 3).
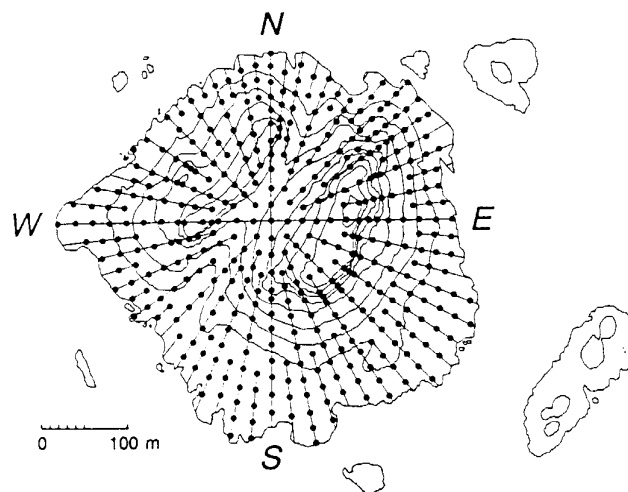
Figure 3: Map of Hernyken showing *the star system* lines and the distribution of sampling plots. The contour interval is 10 m.

In the field a theodolite was used to measure directions and angles. The centre point in each plot was numbered and marked either by a numbered metal stick stuck into the ground, or by a dot and the point number painted on a rock surface. In order to replace sticks removed by erosion, sheep or people, a photo of each plot was taken. To define the outer limit of a sample plot, we used a thin rope of length

$$r = \sqrt{\frac{a}{\pi}} = \sqrt{\frac{10 \text{ m}^2}{\pi}} = 1.784 \text{ m}$$

Every sampling point represents an area of size x^2 m^2, which was defined as being part of the colony if there was at least one occupied nest burrow within its sampling plot. In this way the total colony area, and hereby the burrow density, is dependent (but only weakly) on the sampling plot size.

SECTION 4

USING TDRS FOR THE COLLECTION OF DATA ON AT-SEA
BEHAVIOUR OF PENGUINS AND ANTARCTIC FUR SEALS

USING TDRS FOR THE COLLECTION OF DATA ON AT-SEA BEHAVIOUR OF PENGUINS AND ANTARCTIC FUR SEALS

SPECIES

Penguins: Adélie, chinstrap, macaroni (*Pygoscelis adeliae*, *Pygoscelis antarctica*, *Eudyptes chrysolophus*); and Antarctic fur seals (*Arctocephalus gazella*): lactating females.

PARAMETER

To determine the characteristics of at-sea behaviour in terms of the frequency, depth and groupings of dives.

BACKGROUND AND PRINCIPLES

1. In their simplest form, recorders of at-sea behaviour, known also as time-depth recorders (TDRs) are microelectronic data acquisition and storage devices which provide measurements of depth on a known or derived-time base. More advanced forms also provide measurements of swimming speed, temperature, direction and light level (from which very approximate positions can be calculated based on local apparent noon). These draft standard methods are exclusively concerned with bivariate measurements of depth with time.

2. The normal configuration of TDRs includes a central microelectronic controller which can be programmed to sample pressure from a pre-calibrated transducer to provide a measurement of depth. Each depth reading, which can be taken at intervals of between 1 and <255 seconds, is stored in volatile solid-state memory. On recovery of the TDR, the information which is stored in memory can be recovered to a computer. The time base is then restored from knowledge of the start-up time and the interval at which depth measurements were obtained.

3. Various parameters can then be derived from the data stream. These include:

    (i)   dive depth;
    (ii)   dive duration;
    (iii)   surface interval before or after the dive; and
    (iv)   time of day at which the dive took place.

4. The analyses normally involve making the assumption that records of below 2 m depth are dives. This depth has been used because the resolution of depth transducers in TDRs is normally 1 m down to depths of ~250 m (the normal depth range used for current CCAMLR monitoring species). Given this resolution and the potential effects of dynamic pressure changes during swimming, a minimum dive depth of twice the maximum resolution has typically been used.

5. An additional and important consideration is that the output from the pressure transducers can drift, even under constant pressure. This may cause inaccuracies in the detection of dives and the general approach has been to set the point of zero depth manually by inspection of the dive trace.

6. A further inaccuracy in the detection of dives can occur because of the sampling interval (Boyd, 1993) which is used to measure depth. If the behaviour of an animal

is such that it spends periods at the surface between dives which are shorter than the intervals between records of depth, then a proportion of dives will become concatenated, because some periods at the surface will be missed. This can result in a decline in the total number of dives recorded and an increase in the average dive duration. Therefore, the interval at which TDRs are programmed to measure depth can affect the number of dives which are detected and normally the interval used is less than one-half of the shortest behaviour to be measured.

7. The sampling interval which is used is critical both for the accuracy of the data obtained about diving and for the duration of the diving record. All TDRs have limited memory capacity and data collection protocols are, of necessity, a compromise between the accuracy of the dive record and the duration of that record. The suggested standard protocols for the deployment of TDRs place a priority on a short sampling interval rather than extended deployment.

GENERAL PROCEDURE

1. TDR specifications:

   The essential features that TDRs should have are:

   (i)   a minimum of 128 kbytes of volatile memory;

   (ii)   a battery life of more than one month;

   (iii)   pressure resistance to the equivalent of 300 m depth (CCAMLR monitoring species only);

   (iv)   a pressure transducer with a minimum resolution of 1 m over a range of 0 to 250 m; and

   (v)   pre-programmable sampling intervals.

   Desirable features are:

   (i)   a seawater switch to detect when the animal is ashore; and
   (ii)   internal software designed to conserve memory use when animals are ashore.

2. TDR setup:

   (i)   when appropriate, the TDR should be programmed to record only when the animal is at sea (i.e. the recorder is 'wet') and the periods ashore should be timed;

   (ii)   the interval at which depth is sampled should be a maximum of five seconds;

   (iii)   in some types of TDRs it is possible to set up different sampling protocols and duty cycles. In this case there should be no duty cycling and a single protocol should be used throughout the deployment; and

   (iv)   the start-up time should be set to local time.

3. Duration of deployment:

   Where possible, complete dive records for foraging trips should be obtained. As a general rule, TDRs which do not record a time base alongside the depth and which have 128 kbytes of memory have deployment durations of seven to eight days when a sampling interval of five seconds is used. This is increased to a period of 14 to 15 days for devices with 256 kbytes of memory. Amongst some species, such as during the chick-rearing period in penguins, it should be possible to obtain records for several consecutive foraging trips in a single deployment. For fur seals, a deployment of seven to eight days is usually sufficient for one complete foraging trip.

4. Number of foraging trips per individual:

   Antarctic fur seal: a minimum total of two foraging trips should be measured for each individual across a minimum of 10 individuals.

   Adélie, chinstrap and macaroni penguins: a complete record should be obtained of a minimum of two to three foraging trips for 10 individuals during the guard and/or rearing phases of the chick-rearing period.

MANDATORY DATA

1. Date and times of the beginning and end of each foraging trip.

2. Number of dives per foraging trip.

3. Mean ± standard deviation and median dive depth and duration.

4. Mean ± standard deviation and median surface interval duration between dives. This should only include surface intervals lasting less than five minutes. The sample size should also be included.

5. Mean ± standard deviation and median ratio of the surface interval to the duration of the previous dive. This should only include surface intervals lasting less than five minutes. The sample size should also be included.

6. Proportion of time spent diving during the foraging trip. This should include two values; the proportion of time spent submerged and the proportion of time spent in dive bouts (defined by any sequence of diving not separated by a surface interval greater than five minutes duration).

7. Proportion of dives occurring at night, between 2000 and 0400 local time.

ATTACHMENTS OF INSTRUMENTS

Background

The measurement of at-sea behaviour in marine mammals and penguins requires that TDR instruments are attached externally to the fur, hair or feathers. Ever since instruments began to be deployed on these animals there has been concern that, depending on the dimensions of the instrument, the way in which it has been attached, its location on the animal and its colour, the instrument could have a number of unknown and unquantified effects on the behaviour of the animal. In addition to ensuring the welfare of the animal

itself, it is important to minimise these effects so that the information which is obtained can be interpreted as representing the normal behaviour of the species concerned. Instrument size and position has been observed to influence dive depth, swimming speed, reproductive success and foraging-cycle duration (Wilson et al., 1986; Wilson and Culik, 1992; Walker and Boveng, 1994). With requirements to increase the number of deployments of instruments, duration of deployments on individuals and to ensure comparability across datasets collected in different locations and through time, there is a need to ensure best attachment practice and, as far as practicable, to standardise methods of attachment.

Shape and Size of Instruments

Advances in miniaturisation have significantly reduced the size and weight of externally-mounted devices such as TDRs over the last decade. The most-widely used TDR on the market (Wildlife Computers, Mk V) weighs 45 g and measures 6.5 x 3.5 x 1.0 cm. Instrument mass is of relatively minor importance for marine birds and mammals compared with the shape and external dimensions of the instrument. However, wherever possible, instruments should be made neutrally buoyant. This can be achieved by potting the instruments in buoyant epoxy.

The maximum mass of an instrument attached to penguins should be less than 5% of body mass (Wilson and Culik, 1992).

Shape and size have their impact through the creation of additional drag as the animal swims. Drag increases as a function of the cross-sectional area of the device but can be reduced by streamlining. A spindle shape is the most hydrodynamically-efficient form but a fineness ratio (length/diameter) of the device similar to that of the animal on which the device is being deployed should be used. A ratio of around 4.5 is probably optimal.

Attachment methods using tapes, epoxy resins and cable ties are well developed and tested on penguins and seals.

Tape (TESA) appears to have least impact on penguins (Wilson and Wilson, 1989) as the tape can be removed at the end of a sampling period without leaving any residue on the bird's feathers. However, it may not be adequate for deployments lasting weeks rather than days. It also requires that the instrument shape is moulded to allow tape attachment.

A combination of epoxy glue and cable ties is recommended as the standard method for attaching instruments to both seals and penguins.

Penguins: The instrument should be prepared by wrapping it in electrical tape. Instruments which are cast in epoxy can have small grooves (the same width as the cable ties) filed out of the corners of the instrument to provide added purchase for the cable ties. The cable ties are then wrapped around the instrument and feathers simultaneously and fast-setting epoxy resin is applied to the upper surfaces of the instrument to prevent slippage of the ties. Cable ties should be tightened with a cable tie 'gun'. Birds should be kept hooded for the 5 to 10 minutes that it takes the epoxy to cure.

Penguins and fur seals: Alternatively, fast-setting epoxy can be used on its own without cable ties. In this case the instrument is also wrapped in electrical tape but epoxy is placed on the lower surface of the instrument before it is placed on the bird or fur seal. Additional epoxy is then added around the sides of the instrument to ensure that the fur or feathers are well-keyed to the epoxy. This method has the disadvantage that the fur and feathers below the instrument normally have to be cut to remove the instrument. Therefore, the smallest possible area should be covered with epoxy.

Where larger instruments are used, or where longer deployment (a month or more) are required, it may be necessary to glue unwrapped instruments directly to an animal. The instruments are then removed by carefully cutting the feathers or pelage close to the instruments. Instruments not recovered in this way will fall off during moult.

Fur seals: In cases where large (>100 g) instruments are to be deployed or where there is a requirement to regularly recover and replace instruments on individual animals, the instrument should be attached with cable ties passed under nylon webbing (1–2 cm width) which is itself attached to the fur with epoxy glue. The webbing should be tacked to the fur with epoxy at intervals along its length thus allowing loops for the cable ties to pass through, flexibility of movement of the mount with the movement of the body of the seal and minimum disruption of the fur by epoxy. The smallest possible length of webbing (normally the same length as the instrument) should be used within the requirements of the study.

Some of the fast-setting glues are exothermic and the structural strength of the feathers or pelage and thus their ability to hold the instrument may be compromised if too much heat is generated. Care should be taken therefore to both delay the attachment of the instrument to the feathers or pelage by a few seconds to allow some of the initial heat to dissipate and to minimise the amount of glue which is used.

Penguins: Instruments should be attached as far caudally as possible on the dorsal midline of the back but anterior to the penguin's preen gland (Bannasch, 1994). Note that if the instrument is mounted off-centre then serious impairment of swimming can result.

Fur seals: Instruments should be positioned along the dorsal mid-line at the level of the scapulae.

Colour

Penguins: Wilson et al. (1990) suggest that, wherever possible, device colour should be similar to the background colour of the plumage because Adélie penguins tend to peck at brightly-coloured instruments. However, there is often an advantage in wrapping instruments in brightly-coloured electrical tape to aid identification at a distance. This may work well for some species but workers should be aware of the potential effects of colour because it may distract the bird carrying the instrument, attract the attention of other penguins in the colony (and thereby cause disturbance to the instrumented bird) or attract the attention of avian predators.

Fur seals: Colour is less important in this case. Fur seals do not appear to be attracted to or distracted by bright colours. However, red should be avoided because avian scavengers such as sheathbills and skuas tend to peck at the instrument and cause disturbance to the instrumented animal.

REFERENCES

Bannasch, R. 1994. Hydrodynamic aspects of design and attachment of a back-mounted device in penguins.

Bengtson, J.L., D.A. Croll and M.E. Goebel. 1993. Diving behaviour of chinstrap penguins at Seal Islands. *Antarctic Science*, 5: 9–16.

Boyd, I.L. 1993. Selecting sampling frequency for measuring diving behaviour. *Marine Mammal Science*, 9: 424–430.

Boyd, I.L., J.P.Y. Arnould, T. Barton and J.P. Croxall. 1994. Foraging behaviour of the Antarctic fur seal during periods of contrasting prey abundance. *Journal of Animal Ecology*, 63: 703–713.

Boyd, I.L. and J.P. Croxall. 1994. Diving behaviour of lactating Antarctic fur seals. *Canadian Journal of Zoology*, 70: 919–928.

Boyd, I.L., K. Reid and R.M. Bevan. 1995. Swimming speed and allocation of time during the dive cycles in Antarctic fur seals. *Animal Behaviour*, 50: 769–784.

Croll,, D.A., S.D. Osmek and J.L. Bengtson. 1991. An effect of instrument attachment on foraging trip duration in chinstrap penguins. *Condor*, 93: 777–779.

Croll, D.A., A.J. Gaston, A.J. Burger and D. Konnoff. 1992. Foraging behaviour and physiological adaptation for diving in thick-billed murres. *Ecology*, 73: 344–356.

Croxall, J.P., D.R. Briggs, A. Kato, Y. Naito, Y. Watanuki and T.D. Williams. 1993. Diving pattern and performance in the macaroni penguin *Eudyptes chrysolophus*. *Journal of Zoology, London*, 230: 31–47.

Croxall, J.P. and R.W. Davis. 1990. Metabolic rate and foraging behaviour of *Pygoscelis* and *Eudyptes* penguins at sea. In: Davis, L.S. and J.T. Darby (Eds). *Penguin Biology*: 207–228. Academic Press, London, New York.

Croxall, J.P., Y. Naito, A. Kato, P. Rothery and D.R. Briggs. 1991. Diving patterns and performance in the Antarctic blue-eyed shag *Phalacrocorax atriceps*. *Journal of Zoology, London*, 225: 177–199.

Culik, B., R. Bannasch and R.P. Wilson. 1994a. External devices on penguins: how important is shape? *Marine Biology*, 188: 353–357.

Culik, B.M., R.P. Wilson and R. Bannasch. 1994b. Underwater swimming at low energetic cost by Pygoscelid penguins. *Journal of Experimental Biology*, 197: 65–78.

Gentry, R.L., G.L. Kooyman and M.E. Goebel. 1986. Feeding and diving behaviour of northern fur seals. In: Gentry, R.L. and G.L. Kooyman (Eds). *Fur Seals: Maternal Srategies on Land and at Sea*. Princeton University Press, New Jersey: 61–78.

Feldkamp, S.D., R.L. DeLong and G.A. Antonelis. 1989. Diving patterns of California sea lions, *Zalophus californianus*. *Canadian Journal of Zoology*, 67: 872–883.

Hindell, M.A., D.J. Slip and H.R. Burton. 1991. The diving behaviour of adult male and female southern elephant seals, *Mirounga leonina* (Pinnipeds: Phocidae). *Australian Journal of Zoology*, 39: 595–619.

Pütz, K. and C.A. Bost. 1994. Feeding behaviour of free-ranging king penguins (*Aptenodytes patagonicus*). *Ecology*, 75: 489–497.

Walker, B.G. and P.L. Boveng. 1994. Effects of time-depth recorders on foraging behaviour of lactating Antarctic fur seals. Abstract, SCAR Sixth Biology Symposium, Venice, 30 May to 3 June 1994.

Watanuki, Y., A. Kato, Y. Mori and Y. Naito. 1993. Diving performance of Adélie penguins in relation to food availability in fast sea-ice areas: comparisons between years. *Journal of Animal Ecology*, 62: 634–646.

Williams, T.D., D.R. Briggs, J.P. Croxall, Y. Naito and A. Kato. 1992a. Diving pattern and performance in relation to foraging ecology in the gentoo penguin, *Pygoscelis papua*. *Journal of Zoology, London*, 227: 211–230.

Williams, T.D., A. Kato, J.P. Croxall, Y. Naito, D.R. Briggs, S. Rodwell and T.R. Barton. 1992b. Diving pattern and performance in non-breeding gentoo penguins (*Pygoscelis papua*) during winter. *Auk*, 109: 223–234.

Wilson, R.P. 1985. Seasonality in diet and breeding success of the jackass penguin. *Journal of Field Ornithology*, 126: 53–62.

Wilson, R.P. and M.P. Wilson. 1989. Tape: a package attachment technique for penguins. *Wildlife Society Bulletin*, 17: 77–79.

Wilson, R.P., H.J. Spairani, N.R. Coria, B.M. Culik and D. Adelung. 1990. Packages for attachment to seabirds: what colour do Adélie penguins dislike least? *J. Wildl. Manage.*, 54: 447–451.

Wilson, R.P. and B.M. Culik. 1992. Packages on penguins and device-induced data. In: Priede, I.G. and S.M. Swift (Eds). *Wildlife Telemetry*. Ellis Howard, Chichester: 580-673.

SECTION 5

PROTOCOLS FOR COLLECTING SAMPLES
FOR TOXICOLOGICAL ANALYSES

PROTOCOLS FOR COLLECTING SAMPLES
FOR TOXICOLOGICAL ANALYSES

The following procedure describes the methods for collecting and storing samples of animal tissues in the event that pollutants or toxic substances are suspected in species being monitored as part of CEMP.

Samples should be collected and analysed for organochlorine compounds such as polychlorinated biphenyls (PCBs), dichloro-diphenyl-trichloroethane (DDTs), lindane, polycyclic aromatic hydrocarbons (PAHs) and heavy metals (cadmium, mercury, lead, zinc and copper). It should also be appreciated that chemical content in seabirds may be related to diet and lifestyle and is naturally occurring.

It is recommended that all field teams conducting CEMP programs maintain stocks of sampling equipment at their monitoring site to allow adequate collection, storage and transport of samples for the following laboratory analyses.

The analyses of samples for contaminants involve sophisticated and expensive techniques and therefore require support from appropriate specialised centres.

SAMPLING GUIDELINES

Chlorinated Hydrocarbons

The body burden of chlorinated hydrocarbons can be evaluated from muscle and/or fatty tissue, skin biopsies, unhatched eggs, blood, preen gland oil and stomach contents. Collect a minimum of 2 g of tissue or skin and a few microlitres of preen gland oil. If the animal is dead, collect in addition liver, muscle and brain. Post-mortem sampling should be carried out on recently-dead individuals, with records of biometric parameters and times of death and sampling attached.

Heavy Metals

Ante-mortem collection of feathers, faeces and skin biopsies is suitable. Post-mortem sampling of recently-dead animals can also include liver and kidney.

Biochemicals

The modification of specific biochemical responses (i.e. enzymes and metabolites) may indicate the presence of pollutants in seabirds. These analyses can be correlated with those carried out on samples collected as described above. The following table summarises the biological samples suitable for specific biochemical tests:

Test	Sample
Porphyrin (COPRO-URO-PROTO)	Faeces, feathers, liver, blood (whole)
Mixed-function oxidases: Ethoxyresorufin-O-deethylase (EROD) Penthoxyresorufin-O-deethylase (PROD) Benzyloxyresorufin-O-deethylase (BROD)	Liver, skin biopsies
Benzopyrene-monooxygenase (BPMO) CYT-P450-reductase	
Esterases: Acetylcholinesterase (AChE) Butyrylcholinesterase (BChE)	Brain, blood (whole for mammals, and serum or plasma for birds and fish)

COLLECTION AND STORAGE OF SAMPLES

All samples should be collected into glass containers or tubes which can be sealed so they do not dehydrate in storage.

Samples for heavy metals and chlorinated hydrocarbon analyses should be stored as soon as possible at –20°C. Care should be taken to prevent contamination of samples – in the case of heavy metals, by metallic compounds in the sampling tubes (e.g. metal tops) and in the case of hydrocarbons, by plastics (e.g. plastic wrapping material).

Samples for biochemical analyses should be stored promptly in liquid nitrogen; it is very important for further successful laboratory analyses to freeze the samples immediately.

All samples should be labelled to provide details of sample, the identity of the individual animal and date of collection. It is important to ensure that tissue from the same animal may be matched in the laboratory. A detailed logbook should be maintained and forwarded with the samples.

SUMMARY TABLE

(Legend: OC = organochlorine compounds; HM = heavy metals; BR = biochemical responses; P = porphyrin; MFO = mixed function oxidases system; E = esterases; PE = polyethylene)

	Sample Type (Amount)	Collection	Storage	**Important**
OC	Fatty tissue, skin biopsies (>2 g) Preen gland oil (a few µL) Liver, brain (post mortem; >2 g)	Glass/PE Tubes/pots	–20°C (it is permitted to keep samples at about 0°C for >12 hours until storage at –20°C)	Do **not** use tube/pots made with **chlorine** materials
HM	Feathers, faeces, skin biopsies (2 g) Liver, kidley (post mortem; 2 g)	Glass/PE Tubes/pots	–20°C (it is permitted to keep samples at about 0°C for >12 hours until storage at –20°C)	Do **not** use aluminium foil or **metal** materials
BR: P	Feathers, faeces, liver, blood	Glass/PE Tubes/pots	Liquid nitrogen (after freezing they can be stored at – 80°C)	Do **not** keep samples at **room temperature**
MFO	Liver, skin biopsies	Glass/PE Tubes/pots	"	"
E	Brain, blood	Glass/PE Tubes/pots	"	"

SECTION 6

PROTOCOLS FOR COLLECTION OF SAMPLES FOR PATHOLOGICAL
ANAYLSIS IN THE EVENT OF DISEASE BEING SUSPECTED
AMONG MONITORED SPECIES OF BIRDS

PROTOCOLS FOR COLLECTION OF SAMPLES FOR PATHOLOGICAL ANALYSIS IN THE EVENT OF DISEASE BEING SUSPECTED AMONG MONITORED SPECIES OF BIRDS

INTRODUCTION

Disease and parasitism occur in all colonies of birds but in many cases they are not apparent. Instead, they can exist at subclinical levels and manifest in periods of stress or changes in circumstances in the colony. Overt disease, usually recognised by deaths, is obvious. Subclinical disease is unlikely to be recognised although it may be suspected in times of reduced chick production or generalised failure to thrive.

This section outlines the basis for a pathological assessment in the event of disease being suspected among monitored species of birds.

The following protocol is provided for collection of specimens in the field where primitive or no laboratory facilities are available and personnel undertaking the investigation may have little training in pathology. It is not expected that the cause of death or disease will be established at the time as microbiological analysis and follow-up investigations are generally required. Long delays in the diagnosis are expected. Detailed labelling and recording of the specimens, storage and description are of the utmost importance.

It is recommended that all field teams conducting CEMP programs receive instruction on the collection of specimens and on basic anatomy of birds and post-mortem techniques outlined in this document. Field teams should maintain stocks of sampling equipment at their monitoring site.

It is important to consult with a veterinary pathologist before going to Antarctica to ensure samples can be analysed. The laboratory may also have special requirements for the collection and storage of specimens.

BACKGROUND INFORMATION

Prevention of the Spread of Disease

While birds may die of non-infectious causes, the presence of an infectious agent should always be assumed. The potential to spread disease from colony to colony is ever present; the consequences of this may be devastating. Bacteria and viruses can survive at low temperatures, some are extremely resistant to adverse conditions. Pathogens can be spread mechanically by adhering to clothes, equipment and vehicles.

While it is important to establish how widespread the suspected outbreak of disease is, it is critical not to spread pathogens. Visits to other colonies should not occur unless measures to reduce microbial contamination such as cleaning and disinfection of equipment and clothing, especially boots, has been carried out.

Epidemiological Information

While a parasitic or microbial pathogen actually causes disease, there are usually many other factors that contribute to the outbreak of disease or the death of a bird. Factors such as stress, starvation, excessive predation, disruption by humans, inclement weather, etc. will contribute to the conditions in which clinical disease can occur. These factors are

important in determining the cause of an outbreak, its epidemiology and understanding the implications of disease on the breeding performance of a population. Such data need to be recorded in addition to the collection of pathological samples and carcasses.

It is important therefore to record such factors as:

- demographic factors: species, sex, age, reproductive status, stage of breeding cycle, colony size;

- environmental factors: location, weather, time, date, geography of the colony, human access and intervention, presence and activity of predators;

- number of ill and dead birds, age of affected birds, the location of affected birds in the colony: proportion of birds which recover or are affected clinically; and

- description of the symptoms of the disease.

Human Health and Hygiene

A number of avian diseases, some of which have been recorded in Antarctic birds, are contagious to humans and some can produce serious disease (e.g. *Chlamydia* spp. (Psittacosis), *Salmonella* spp., *Mycoplasma avium* (Tuberculosis) and avian influenza). On the other hand, a number of pathogenic and non-pathogenic organisms carried by humans cause disease in birds. Diseased or environmentally-stressed birds would be more susceptible to such pathogens and care should be taken to minimise the risk of introduction of diseases to birds. Precautions such as those listed below should be taken to prevent the transfer and spread of disease between humans and birds:

- wear rubber gloves;

- wear a surgical mask if in a poorly-ventilated room or if the person doing the dissection or in close contact with birds has a respiratory infection;

- wet down the feathers of the bird or fully dip the bird in water before examining the carcass or opening the abdomen;

- open the bird in a well-ventilated room or area, but not in windy conditions;

- cuts and scratches on personnel should be treated with disinfectants as soon as possible;

- wear protective clothing and change and wash clothes after handling ill or dead birds;

- observe sensible hygiene measures; and

- be aware of the occupational and safety measures applying to the use of formalin, liquid nitrogen and absolute alcohol.

The Investigation

An investigation of the death of a bird involves the observation and description of clinical symptoms (if present), the external examination of the bird and the collection of samples and performance and reporting of the post-mortem. It may not be necessary to conduct a

detailed post-mortem, but the following steps will allow a systematic approach to the collection of tissue samples and other samples for microbiological and parasitic assessment.

Examination of the internal organs should be performed in a systematic manner so as to avoid microbial contamination of organs and ensure that all organs are examined. To reduce the risk of cross-contamination, swabs and impression smears for microbial analyses should be taken progressively before any organs are removed or samples of tissue are taken. Tissues can be taken from most organs when the gastrointestinal tract and the thoracic organs are *in situ*. The gastrointestinal tract should be removed in order to investigate for parasites, to collect stomach and intestinal contents for dietary and bacteriological analyses and to examine the kidneys and gonads which are obscured by the intestines.

Detailed records supported by colour photographs, taken progressively, particularly before the tissues are collected, will greatly assist the investigation of the cause of illness and mortality in a colony. Description on audio tape and video may also be of value to the investigation.

External Examination of a Bird

Examination of a bird should commence with palpation to feel for broken bones or any other abnormalities. *Rigor mortis* and freezing of the carcass may hinder detection of this. Injury and other lesions (e.g. tumours, lumps, areas of feather loss and discharges) should be described. The description should include colour, consistency and size.

A systematic examination of the bird should be followed as suggested below:

- measure body weight;

- morphometric assessment – beak length and depth, wing and mid-toe length;

- integument – condition of the skin and plumage, signs of trauma, scabby lesions of the skin, look for external parasites;

- head – eyes, nares, beak, oral cavity and ears, look for discharges, note colour and consistency, colour of mucous membrane – lesions in the mouth, swellings;

- neck – swellings and any injuries;

- body condition – fat, normal, emaciated, dehydrated;

- abdomen – distension indicates that the bird has fed recently, flat indicates that the bird has not fed recently;

- brood patch – presence of scabby lesions; red and vascular as seen when the bird is brooding;

- vent – cloaca: soiled or caked-up; diarrhoea, blood, colour of excreta;

- preen gland (above the base of the tail);

- wings – injuries, deformities; and

- legs – injuries, deformities.

Observation Protocols and Techniques

Collection of Samples

Whole Bird Collection

In cases of serious outbreaks, with many birds sick and dying, entire carcasses should be collected. Specimens should represent a range of ages, sexes (if known), clinical symptoms and be as fresh as possible. Post-mortem changes reduce the quality of histological and microbiological analysis of the bird.

- Collect a minimum of three to five birds.

- Wrap individually in plastic if possible and place in plastic bags.

- Freeze (-20 to -70°C) as soon as possible.

- To identify individuals and relate samples to each other, number each bird.

- Label each bird with details of its number, its sex if known, age, from where it was collected, when and by whom.

- Prepare a full inventory of the specimens collected.

Tissue Collection

Choose birds which exhibit a range of symptoms of disease before they die or are euthanised. Collect tissue samples from all major organs from dead birds, specifically from those which show macroscopic lesions (e.g. white spots on the liver).

- Tissue samples should be collected from the intestine, pancreas, liver, kidneys, spleen, lung, heart, brain, thymus and bursa (in chicks) and any abnormal lesions; in the case of small birds leave the intestines coiled, make sections across the coil and fix; this avoids handling the delicate tissue.

- Use a scalpel blade to remove tissue samples.

- Each sample should be labelled with the type of tissue, the number/identity of the bird, the place of collection, the date and time and name of the person who collected it.

- Prepare a full inventory of the specimens collected.

Histopathology samples:

- Store tissues in 10% buffered formalin.

- Cut pieces of tissue no greater than 1 cm^3.

- Store 1:10 (tissue-preserving fluid) for two to three days.

- Transfer fixed tissue to another container containing only a small amount of formalin to keep the tissue moist.

- Do not let fixed tissue freeze.

Microbiology samples:

- For each sample of tissue collected for histopathology, collect another sample for virus isolation and identification.

- Freeze and store at -70°C.

Toxicology samples – (see Part IV, Section 5)

Intestinal contents:

- Stomach contents should be collected and fixed in 70% alcohol.

- Samples should be well labelled on the container in pencil or alcohol- and water-resistant pen. An additional label written in pencil should be placed inside the container.

Egg Collection

The failure of eggs to hatch can have a significant impact on the recruitment of birds into the breeding colony in the future. Several bacterial and viral diseases can affect the viability of the chick in the egg.

- Collect fresh or incubated eggs.

- Store frozen at -70°C if possible.

- Label in pencil on the shell and on attached paper the identity number and type of egg, the place of collection, the date and time and name of the person who collected it.

- Prepare a full inventory of the specimens collected.

Collection of Blood for Serology

An antibody titre indicates that a bird has, at some stage, been in contact with a specific disease. The level of the antibody titre can indicate whether there has been recent contact or active infection. Recently-infected birds will have the highest antibody titres.

- Using aseptic techniques collect 2 to 3 ml blood from the brachial or tibial veins into a glass tube or plain sterile blood collection tube.

- Avoid clotting of the blood during collection by obtaining a good blood flow.

- Avoid freezing of the blood during collection by performing venipuncture protected from the wind.

- Keep the blood collection tubes warm (e.g. on the inside of your jacket) and stand overnight in warm conditions to encourage clotting.

- Avoid freezing as this will lyse the red blood cells and discolour the serum.

Observation Protocols and Techniques

- Blood samples can be spun down by centrifugation to obtain more serum.

- Pipette off the serum, avoid contamination with cell fraction.

- Store serum and cell fraction in cryotubes. Cryotubes should have the thread on the outside of the tube to minimise the loss of serum when the cap is removed.

- Freeze serum at -20°C to -70°C. Store cell fraction at -70°C if possible, as it can be used for microbiological investigations.

- Label serum and cells with place and date of collection, identification number of the bird, species, chick or adult, sex if known and who collected the specimen.

- Prepare a full inventory of the specimens collected.

Collection and Preservation of Parasites

Ectoparasites

Lice and ticks are usually found where they cannot be removed by preening eg. under the bill, in the ear canals, on top of the head and along the back. The brood patch also may provide an ideal site for ectoparasites.

- Take skin scrapings of scaly areas, in the centre and on the edges of the lesion.

- Preserve specimens in a 70% ethyl alcohol and 5% glycerol solution.

- Label each container with place of collection, date, species, approximate age of the bird and sex if known and who collected the sample.

- Prepare a full inventory of the specimens collected.

Endoparasites

Round and tape worms and flukes are found in the gut and organs. The intestinal tract is opened from the stomach to the cloaca after removal from the abdominal cavity. The general procedure for the collection and preservation of endoparasites is as follows:

- Wash off excess intestinal contents, fluids and debris and gently remove parasites from the lumen.

- Dissect and handle endoparasites gently as they are fragile.

- Fix in 10% formol saline or in warm to hot 70% ethyl alcohol for later examination.

- Preserve transverse sections of parasitised tissue in 10% formol saline.

- Label samples with details of the collection site, time, species, identification number of the bird, age, sex if known and who collected the specimen.

- Prepare a full inventory of the specimens collected.

Nematodes (round worms)

These worms are found in the trachea, oesophagus (even under the lining), stomach and small intestine. Check the subcutaneous and visceral lining tissues for any cysts or walled-off lesions. Larval nematodes can encyst. Parasites in the lumen of the intestine or trachea can be collected as described above.

- Hold parasites in warm normal saline (0.9% NaCl) solution for several hours before fixing.

Trematodes (flukes)

Flukes are found in the small intestine, lower intestine, cloacal antrum, kidneys, gall bladder and liver and caused damage to the associated tissues and organs. Check the blood vessels of the gut mesentery and kidneys for vascular flukes if there are any abnormalities in these organs.

- Hold flukes in warm normal saline (0.9% NaCl) for several hours.

- If the flukes are very contracted, place in distilled water for a few hours. Osmosis will cause the fluke to swell and relax.

Cestodes (tape worms)

Adult tape worms are found in the lumen of the intestine. Larval cestodes can occur in subcutaneous fat or in body cavity as a cyst or a bladder-like sphere. The adults are fragile and often numerous.

- Collect a few whole specimens from head (scolex) to gravid terminal proglottis.

- Wash gently in distilled water for a few hours until they relax.

Haemoparasites

Haemoparasites can be identified in blood smears. The smears can be stored indefinitely and examined at a later date.

- Make a thin blood smear on a microscope slide. This may take some practice.

- Air dry. Avoid blowing heated air on the slide.

- Fix in 100% methanol.

- Store in a dry, dark place.

- Label slide with details of the collection site, time, species, identification number of the bird, age, sex if known and who collected the specimen.

- Prepare a full inventory of the specimens collected.

Collection and Preservation of Material for Investigation
of Bacterial, Viral and Fungal Infections

Infectious diseases occur in birds in Antarctica. Juvenile mortalities can be associated with infectious or opportunistic microbial diseases when birds are under stresses such as starvation, predation and crowding. Adults are rarely found dead in a colony. Viral or bacterial diseases may be suspected in cases of sudden death. Clinical symptoms may not be apparent. However, in less acute illness or less rapid mortality some clinical symptoms may be apparent. These could include: discharge from the eyes or mouth, coughing, sneezing, laboured breathing, nervous signs, tremors, convulsions and diarrhoea. Viral infections should also be considered when scabby lesions occur on unfeathered regions or in the mouth.

It is important to collect blood for antibody analysis, and to take swabs for culture from the palatine fissure, trachea and cloaca. Birds displaying a range of symptoms as well as birds showing no evidence of disease should be sampled.

- Collect material on a sterile swab.

- Do not use swab with a wooden stick to collect *Chlamydia* spp. as the timber can be toxic to the organism.

- Place swab in a sterile cryotube.

- Add chilled transport medium to the swab as soon as possible.

- Store swabs for viral and bacterial isolation at -70°C.

- Bacterial samples collected in Ames charcoal transport media tubes should be stored at 0°C to 4°C.

- Do not allow these swabs to freeze.

- These samples should be cultured as soon as possible.

- Media for sample storage:

  viral sample –
  brain heart infusion broth containing antibiotics;

  bacterial sample –
  brain heart infusion broth without antibiotics;

  mycoplasma and *Chlamydia* sample –
  brain heart infusion broth without antibiotics.

EXAMINATION AND DISSECTION OF DEAD BIRDS

Details of the dissection procedure (a post-mortem) are given as a guide to the collecting samples in such a way as to minimise contamination. This is not a priority and if undertaken is best conducted in a clean, comfortable environment. A detailed pathological assessment of a bird can take several hours to complete. Colour photographs of the opened bird and the organs will assist in diagnosis of the cause of death.

Post-mortem Dissection Technique and Examination

The procedures for carcass dissection and examination of the organs follow.

- Wet bird down, in warm running water containing detergent if bird is soiled.

- Place bird on its back on a well lit, dissection board covered with a disposable surface such as paper or plastic. Support may be needed either side of the bird to keep it upright. Dislocate hips in all birds except penguins, if necessary.

- Part the feathers and make a skin incision over the sternum or keel. Extend incision to the midline of the beak and to the vent, taking care not to cut through the abdominal wall. Peel skin back with fingers until the neck, all the chest (pectoral) and abdominal muscles are exposed, and extend down the thighs and legs where possible. This is necessary to avoid contamination of the abdominal and thoracic cavities with feathers. Extreme care is needed in small birds and birds which have been dead for some time as pressure can rupture the abdominal musculature.

Examination Note:
Make a subjective assessment of the bulk and the colour of the muscles; the presence of haemorrhage in the muscle and under the skin should be described. Haemorrhages can appear as red spots, splashes or bruises.

- Open the abdominal cavity with scissors, cutting along the midline and the posterior border of the thoracic cavity while holding up the abdominal wall with rat-tooth forceps. Care must be taken not to pierce the gall bladder, liver or intestinal tract. Fold back the abdominal muscles so that the abdominal contents are exposed.

Examination Note:
Colour of liver, size of gall bladder, presence of fluid in the abdominal cavity – quantity, colour and consistency; colour and distension of loops of intestine; the presence of food in the stomach and intestine.

- Cut the pectoral muscles with a scalpel blade along either side of the sternum, across the surface of the ribs. Use bone cutters or sturdy scissors, depending on the size and maturity of the bird, to cut through the sternal ribs and lever the sternum up to expose the thoracic and anterior abdominal contents. The air sacs are exposed. Cut through the clavicles to remove the sternum.

- Alternatively, to maximise exposure of the thoracic cavity most of the ribcage can be removed by cutting across the ribs as dorsal as possible. This will disturb the air sacs but examination of them is still possible.

Examination Note:
Air sacs are transparent membrane sacs located in the thorax and abdomen and should contain no fluids. Note the presence of any fluid, its colour and consistency. Take swabs of fluid or material. Abnormalities in the membrane thickness and transparency of the air sac wall should also be recorded. Record the colour and consistency of fluid and other unusual material in the thoracic cavity and pericardial sac – the membranous sac containing the heart. In addition, describe any tumours or other lesions in the lungs.

- Cut through the right mandible and hyoid apparatus and open the oral cavity. Examine and take samples and swabs from the tongue, palatine fissure, oropharynx, glottis, larynx and thymus (in young birds) where applicable. Open the oesophagus and take swabs and samples as necessary.

Observation Protocols and Techniques

Examination Note:
Look for evidence of swelling, discharges, discolouration, lesions, etc.

- To remove the gastrointestinal tract, transect the oesophagus between two ties which occlude the lumen, low in the thoracic cavity and the large intestine, close to the cloaca. The intestine can be lifted out while gently breaking the mesentery and suspensory ligaments. Care should be taken not to rupture the gall bladder as the bile will discolour tissues.

- The bursa of Fabricius is located near the vent in young birds – examine and take samples.

- Open the trachea, syrinx and pericardial sac. It is generally not necessary to take out thoracic organs.

Examination Note:
Note the presence of fluid, froth, its consistency and colour in the lumen of the trachea. The sac is normally translucent and has a shiny surface. Record any thickening of the membrane, the presence of any fluid and or material in the pericardial sac.

- Skin the head before removing the brain. The head can be removed from the neck at this stage. Cut through the skull using scissors or bone cutters. The brain should be removed with minimal handling. Drop the brain out under gravity, tipping in an anterior to posterior direction.

- Open wing and leg joints.

Examination Note:
The joint fluid is normally clear and the cartilage white and smooth. Take swabs of fluid or material in any joint that is not clear.

- Bone marrow can be obtained from the medullary cavities of the femur and tibia. If no marrow can be found, submit ribs for histology.

LIST OF RECOMMENDED EQUIPMENT

The equipment listed below is sufficient to enable a detailed collection of samples. Items marked with a single asterisk are the minimum required to collect specimens from birds in the field for further study. Collection of samples for identification of microorganisms from sick birds is a priority.

Ancillary equipment:

storage containers*
clothes – overalls*
hand warmers
hot-water bottles*
insulated containers or boxes to prevent freezing of material*
liquid nitrogen cylinder or freezer*
plastic sheeting for ground cover*
vacuum flasks
plastic bags – large and small*

Chemicals:

alcohol – absolute
disinfectants*
10% buffered or saline formalin
formalin – chemicals to make up 10% buffered formalin
methanol – absolute
normal saline – 0.9% NaCl
stains – e.g. Diff-Quick, new methylene blue or giemsa
sterile water
glycerol

Data recording equipment:

camera with 35 mm and 50 mm macro lenses*
cassette tape recorder
counters – to do counts in colonies
field note books – preferably water resistant paper*
film – colour slide is preferable*
freezer bag pens
labels for bodies*
labels for specimens*
pencils*
permanent marker pens*
rubber bands*
erasers
video camera

Microbiological equipment:

cryotubes – 2 ml, 5 ml, 10 ml*
culture media for bacteria culture and storage*
culture media for virus storage*
swabs – sterile plain wood stick, plastic stick for *Chlamydia**
transport media swabs – Ames charcoal transport tubes*

Post-mortem equipment:

adhesive tape*
alcohol or isopropanol tissues*
aluminium foil
bone cutters
bone saw
bottles 20, 50, 100 ml*
centrifuge
cover slips
diamond pencil
dissection boards – plastic*
disposable overalls*
drawing pins or tacks
forceps: plain and rat-toothed
glass containers

glass slides*
gloves – latex, powder-free*
knives – plastic handles*
labels
large garbage bags*
needle disposal container*
paper towels
plastic bags – freezer resistant various sizes
rubber gloves – various sizes, long, thick*
ruler*
scalpels – blades and handles, number 22 and 11
scissors – fine and sturdy blade
screw top, wide-mouthed plastic containers*
string*
surgical masks
tape measure*

Serology and haematology:

blood collection tubes – heparin and plain, 2.5 ml, 5 ml, 10 ml*
blood tubes holders*
needles 21, 23, 27 gauge 1 inch*
Nunc tubes for storage of serum
slide box
syringes 3 cc, 5 cc, 10 cc*

REFERENCES

Fowler, M.E. (Ed.). 1986. *Zoo and Wild Animal Medicine*, Second Edition. W.B. Saunders Co., Philadelphia.

Friend, M. (Ed.). 1987. *Field Guide to Wildlife Diseases: General Field Procedures and Diseases of Migratory Birds.* United States Department of the Interior Fish and Wildlife Service, Washington DC, Resource Publication, 167.

Geering, W.A, A.J. Forman and M.J. Nunn. 1995. *Exotic Diseases of Animals: a Field Guide for Australian Veterinarians.* Australian Government Publishing Service, Canberra.

Harrison, G.J. and L. Harrison (Eds). 1986. *Clinical Avian Medicine and Surgery.* W.B. Saunders Co., Philadelphia.

Ritchie, B.W., G.J. Harrison and L.R. Harrison (Eds). 1994. *Avian Medicine: Principles and Application.* Wingers Publishing Inc.