

# **Practical Guidelines for Developing and Designing Environmental Monitoring Programmes in Antarctica**

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This document has been developed for the Council of Managers of National Antarctic Programs (COMNAP) by its Antarctic Environmental Officers Network (AEON). Up-to-date versions of this document can be found on the COMNAP web site at <http://www.comnap.aq>

## **FOREWORD**

Environmental monitoring has been an important focus of the Council of Managers of National Antarctic Programmes' (COMNAP) work since the mid-1990s. Recent initiatives within the Antarctic Treaty system and within the Scientific Committee on Antarctic Research (SCAR) and COMNAP, as well as ongoing experience in the practical implementation of the Environmental Protocol to the Antarctic Treaty, have each advanced the understanding of the issues related to environmental monitoring in Antarctica.

During the 1999 meeting of COMNAP in Goa, India, the Antarctic Environmental Officers Network (AEON) arranged a workshop with the aim of following up and facilitating discussions on the issue of environmental monitoring of science and operational activities in Antarctica.

This workshop identified several steps in the process of developing, designing and implementing environmental monitoring programmes, and looked at areas where there may be gaps in the current documentation and information available to operators. Although information exists on these matters the workshop noted that much of it is not widely available, and is not written as practical guidelines that are readily understandable by operators.

Following the discussion, the workshop recommended that practical guidelines for developing and designing an environmental monitoring programme be prepared. Terms of Reference were then prepared, and the document developed reflects the intentions of these Terms of Reference.

The document has passed through several drafts in its development. The drafts have been circulated and reviewed by members of AEON. Comments have been incorporated to arrive at the final format and content.

This coordinated effort to provide practical monitoring guidelines should assist all national programmes, but particularly those with more limited resources and who do not currently have a systematic monitoring programme in place. Ultimately, a unified approach to environmental monitoring will assist the continued protection of resources and values, and in minimising human impacts on the Antarctic continent.

G rard Jugie  
Chair, Council of Managers of National Antarctic Programmes (COMNAP)  
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## LIST OF ACRONYMS

AEON	Antarctic Environmental Officers Network
ASMA	Antarctic Specially Managed Area
ASPA	Antarctic Specially Protected Area
ATCM	Antarctic Treaty Consultative Meeting
BOD	Biological Oxygen Demand
CEP	Committee for Environmental Protection
COD	Chemical Oxygen Demand
COMNAP	Council of Managers of National Antarctic Programmes
DO	Dissolved Oxygen
EIA	Environmental Impact Assessment
GIS	Geographical Information System
IAATO	International Association of Antarctica Tour Operators
PAH	Polycyclic Aromatic Hydrocarbon(s)
PCB	Polychlorinated Biphenyls
PM <sub>10</sub>	Particulate up to 10 microns in diameter
SCAR	Scientific Committee on Antarctic Research
SS	Suspended Solids
TOC	Total Organic Carbon
TSS	Total Suspended Solids
TPH	Total Petroleum Hydrocarbons

## GLOSSARY OF TERMS

**Action:** Any step taken as part of an activity.

**Activity:** An event or process resulting from, or associated with, the presence of humans in Antarctica, and/or which may lead to the presence of humans in Antarctica.

**Baseline monitoring:** Collection of data and information from a particular site, ahead of an activity taking place that is predicted to have certain impacts on the site.

**Cumulative Impact:** The combined impact of past, present and reasonably foreseeable activities. These activities may occur over time and space and can be additive, interactive or synergistic.

**Direct Impact:** A change in environmental components that results from direct cause-effect consequences of interaction between the exposed environment and outputs.

**Exposure:** The process of interaction between an identified potential output and an environmental element or value.

**Impact:** A change in the values or resources attributable to a human activity. It is the consequence of an agent of change, not the agent itself.

**Indicator:** Indicators are measures of physical, chemical, biological or socio-economic factors which best represent the key elements of the environment. They capture, focus and condense information about complex environments for management, monitoring and reporting purposes. To be effective indicators must be scientifically credible.

**Indirect indicator:** Signs or symptoms of changes in features not directly related to the environmental feature, but which potentially may impact the environmental features. Output indicators indicate changes in outputs (emission, fuel spills, noise) that may impact the environment. Compliance indicators indicate changes in compliance with environmental legislation, which then indirectly may have consequences for the environment.

**Indirect Impact:** A change in environmental components that results from interactions between the environment and other impacts (direct or indirect).

**Mitigation:** The use of practice, procedure or technology to minimise or prevent impacts associated with proposed activities.

**Monitoring:** Consists of standardised measurements or observations of key parameters (outputs and environmental variables) over time, their statistical evaluation and reporting on the state of the environment in order to define quality and trends.

**Output:** A physical change or an entity imposed on or released to the environment as a result of an action or an activity.

**Parameter:** A measurable variable for an indicator.

**Remediation:** The steps taken after impacts have occurred to promote, as much as possible, the return of the environment to its original condition.

**Unavoidable Impact:** An impact for which no further mitigation is possible.

**Value:** The worth, merit or importance of something (**environmental value:** the worth, merit or importance of an environmental feature).

## **SECTION 1: Introduction to the Guidelines**

### **1.1 Why Monitor in Antarctica?**

The primary obligations for undertaking monitoring in Antarctica are set out in the Protocol on Environmental Protection to the Antarctic Treaty (the Protocol). These requirements are summarised in Appendix 1, and include the verification of predicted impacts linked to specific activities and monitoring for unforeseen impacts and environmental change in Antarctica generally.

The issue of environmental monitoring was substantively discussed at ATCM XV (1989) and Recommendation XV-5 was the result (reproduced at Appendix 1). Further consideration of the issue at ATCM XVI (1991) led to the convening of a Meeting of Experts in Buenos Aires in June 1992. ATCM XVII considered the report of the Meeting of Experts and adopted Recommendation XVII-1 (reproduced at Appendix 1). ATCM XVII also proposed the convening of a workshop to pursue the issue of environmental monitoring further. In July 1996 the Scientific Committee on Antarctic Research (SCAR) and the Council of Managers of National Antarctic Programmes (COMNAP) published the results of two workshops entitled “Monitoring of Environmental Impacts from Science and Operations in Antarctica” (Kennicutt *et al*, 1996).

As a result of those workshops two further documents were proposed:

- a technical handbook of standardised monitoring methods, and
- a practical guide to monitoring in Antarctica.

The technical handbook was published by COMNAP and SCAR in May 2000 as the “COMNAP/SCAR Antarctic Environmental Monitoring Handbook”.

The present “Practical Guidelines for Developing and Designing Environmental Monitoring Programmes in Antarctica” fulfil the second proposal of preparing a practical guide to monitoring in Antarctica. It is recommended that it be used in conjunction with the handbook.

### **1.2 Objectives of these Guidelines**

The objective of these guidelines is to provide practical advice to national Antarctic operators in developing and designing environmental monitoring programmes, by:

- a. Setting out a practical approach to designing environmental monitoring programmes in Antarctica, with examples;
- b. Bringing together various sources of monitoring information into a single reference document; and
- c. Providing clear and understandable advice.

### **1.3 How to use these Guidelines**

These Guidelines have been structured so as to provide a common approach to the design of monitoring programmes in Antarctica that can be used by national Antarctic operators that are:

- New signatories to the Environmental Protocol;
- Wishing to review existing or long-term monitoring programmes;

- Looking to establish new monitoring programmes for specific activities.

The guidelines can be used for a range of monitoring needs including:

- Meeting the monitoring requirements of the Environmental Protocol;
- Monitoring of activities in response to environmental impact assessment requirements;
- Reporting on the state of the Antarctic environment.

The guidelines have been prepared in a deliberately generic format to enable application to both simple and complex monitoring needs; though the basic process for designing monitoring programmes is likely to be the same in each case.

It is important to note that these guidelines have no mandatory status and are available for use by national Antarctic programmes at their own discretion.

## SECTION 2: A Three-Step Approach to Environmental Monitoring

This section outlines a three-step approach to designing and developing an environmental monitoring programme in Antarctica. Figure 1 summarises these steps.

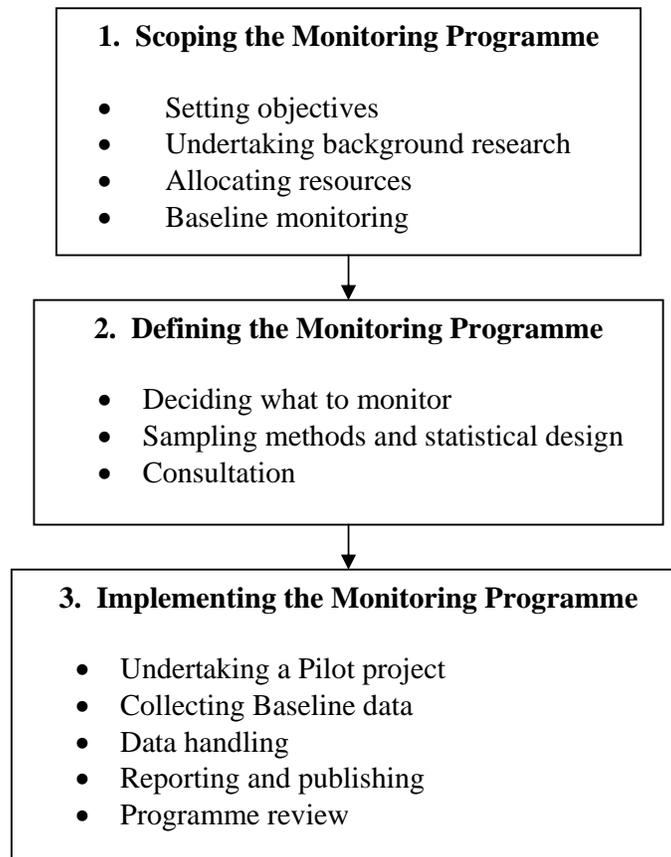


Figure 1. A flow diagram summarising the three-step approach to designing a monitoring programme.

### 2.1 STEP 1: Scoping the monitoring programme

This section describes the preparatory work that is necessary prior to undertaking any monitoring programme. It is important to undertake this step in a thorough manner to ensure that an effective monitoring programme can be developed.

#### 2.1.1 Setting objectives

All monitoring programmes should have clearly defined objectives, which must be agreed at the outset. Objectives should be meaningful, achievable, and concise. They need to identify what is to be achieved and over what time period. Objectives also need to make sense to those responsible for designing and implementing the monitoring programme, and to senior managers who may need to take action as a result of the findings of the monitoring programme.

### *Example for Setting Objectives*

*National Programme Alpha has decided to undertake an environmental monitoring programme for its Alpha Station. Having been assigned the task of developing and designing a monitoring programme, the Alpha Environmental Manager implemented the following process to set the objectives of the programme:*

- 1. A review of all environmental policy documents and reports relevant to the Alpha National Programme was conducted.*
- 2. A small brainstorming meeting of relevant personnel (managers and operators) was held to identify possible objectives of the environmental monitoring programme at Station Alpha.*
- 3. Based on outcomes from the brainstorming meeting the Environmental Manager developed a set of draft objectives.*
- 4. The draft objectives were reviewed and revised by relevant personnel (managers and operators) and were revised accordingly.*
- 5. The following objectives were established for the environmental monitoring programme:*
  - To demonstrate compliance with the requirements of the Environmental Protocol*
  - To capture information that may show environmental changes/impacts around the Alpha Station that may result from station and related field activities*
  - To undertake the monitoring for a period of five years before conducting a major review of the programme*
  - To utilise existing equipment, station personnel and scientists as much as possible without appointing additional staff to minimise costs*
  - To amend the structure and processes in the organisation to ensure monitoring information is used as a part of management decisions.*

### **2.1.2 Background Research**

Having defined the objectives for monitoring it is essential to gather relevant information that will assist with the design of the monitoring programme. The following sets out the key issues that need to be addressed.

#### *Existing data and research*

A key issue will be to determine what is already known about the area to be monitored. The following questions may assist in meeting this need:

- Is there any scientific or environmental research being conducted in the area to be monitored that may provide useful data?
- What information and data has been, or is being collected at, or near to the area to be monitored?
- Are there any existing environmental monitoring programmes with similar aims being conducted by other national Antarctic programmes?
- Is there any data available prior to any human activity in the region that could be useful baseline data?
- What are the information gaps? What is not known about the area?

- Is there a need for baseline data collection to be undertaken? Will it be important to collect basic information about the site before implementing a larger-scale monitoring programme?
- Are there any environmental reports, or environmental impact assessments for the area to be monitored?

*Environmental features within the monitoring area*

When collecting background information about the area to be monitored it is particularly important to build up a picture of the key environmental features that are found in the area of interest. This information will be essential when considering what to monitor (Step 2 of these guidelines). Figure 2 highlights key environmental features that might typically be found either singularly or in combination.

<p><i>Flora and Fauna (including marine species)</i></p> <p>Consider if:</p> <ul style="list-style-type: none"> <li>• there are species or species assemblages that are rare or unique in Antarctica.</li> <li>• there are species or species assemblages that are rare or unique in the area.</li> <li>• there are species or species assemblages that are important for on-going or planned science.</li> <li>• the flora is particularly undisturbed.</li> </ul> <p><i>Atmospheric, freshwater, marine or terrestrial environments including ice-shelves and ice-free ground</i></p> <p>Consider if:</p> <ul style="list-style-type: none"> <li>• there are any unique or special physical, chemical or biological features related to these environments.</li> <li>• the environment is important for on-going or planned science.</li> <li>• the environment is undisturbed or pristine.</li> <li>• the environment is protected as part of an Antarctic Specially Protected Area (ASPA) or Antarctic Specially Managed Area (ASMA).</li> </ul> <p><i>Heritage.</i></p> <p>Consider if:</p> <ul style="list-style-type: none"> <li>• there are any historic sites listed on the Historic Site and Monument list or protected as part of an ASPA?</li> <li>• there are any historic elements important for on-going or planned science?</li> </ul>
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Figure 2. Checklist of key environmental features that might typically be found in Antarctica.

### **2.1.3 Resources available**

Sufficient resources are instrumental to the success of the monitoring programme. Required resources may include:

- A dedicated budget for the monitoring programme;
- A programme manager to oversee the implementation of the monitoring programme;
- The availability of expert scientists to take responsibility for sample collection and analysis;

- Specialist equipment, including field, laboratory and data management equipment;
- The availability of trained staff to assist with, for example, sample collection and analysis, or data handling and reporting;
- Collaborative opportunities with other national Antarctic operators and/or researchers.

### *Roles and responsibilities*

At this point in the preparation of the monitoring programme it will also be important to clearly establish and record the roles and responsibilities for those people that will be needed to ensure effective implementation.

#### **2.1.4 Baseline Monitoring**

Baseline monitoring is undertaken ahead of a particular activity commencing. The primary purpose of baseline monitoring is to establish a data set of pre-impact conditions of the site or area in question.

#### *Example for Baseline Monitoring:*

*National Programme Bravo wants to establish an ice runway near its existing station. The Environmental Impact Assessment for the runway has identified the need for an environmental monitoring programme for the life of the runway to ensure environmental impacts are monitored and mitigated. Baseline data for the runway site will need to be gathered on surface snow and ice quality prior to operation of the runway in order to compare future data during operation of the runway.*

## **2.2 STEP 2: Defining the programme**

Completing the data and information gathering exercises highlighted in Step 1 should assist in providing a clear understanding of what is known about the site and what resources are available to implement a monitoring programme. The next step is to define the boundaries of the monitoring programme by identifying what needs to be monitored, and the techniques to be used.

### **2.2.1 Deciding what to monitor**

Deciding what to monitor is an essential stage in the process, if the monitoring programme is to meet its stated objectives. Deciding what to monitor will be influenced by a number of factors. These include:

- The key environmental features of the area to be monitored (determined through Step 1);
- The predicted or known impacts of an activity for which monitoring may be required (for example as determined through an EIA);
- Practical and technical issues, such as the ease with which samples can be taken and/or analysed.

### *Prioritisation*

Prioritisation or ranking will need to be undertaken particularly when values and impacts are of too large a number to be adequately monitored within available resources.

The prioritisation of values and impacts that are the most critical should be based on the work carried out in Step 1 using the judgement of relevant experts. Rank the findings, noting that the highest priority in terms of a monitoring programme should be those values that are the most sensitive, those most likely to be significantly impacted, those that are most important to protect, or a combination of these factors.

### *Choosing relevant indicators*

An indicator is defined as: signs or symptoms of changes, potentially due to numerous factors, in an environmental feature or features. Some examples of indicators are shown in Table 1.

### *Choosing what parameters to measure to detect changes in the indicators*

When the most appropriate indicators have been selected it is important to decide on the parameters to measure. There are usually numerous parameters that could be measured for each indicator chosen, and therefore these need to be carefully selected. There are several factors that may influence the choice of parameters, for example, the cost of sampling/analysis, and the level of expertise needed to sample. Consideration should also be given to ensuring comparability with monitoring programmes conducted elsewhere, especially if these are in the near vicinity. Table 1 also gives examples of parameters for the various indicators listed. The COMNAP/SCAR Antarctic Environmental Monitoring Handbook should be consulted as a primary reference.

SCAR/COMNAP 1996 have recommended that the following criteria be used when selecting parameters:

The parameters must:

- Have the potential to exhibit changes in excess of limits of detection;
- Be directly relatable to a testable hypothesis;
- Be known or measurable above natural variability (i.e. background levels);
- Give information from which management decisions can be made;
- Be able to sustain the monitoring activity;
- Be able to be sampled within logistical and time constraints;
- Be measurable on samples that can be transported without deterioration or be measurable on-site in the field;
- Be amenable to quality assurance procedures including demonstrable precision, accuracy and reproducibility.

It is also desirable that the parameters:

- Be measurable by cost effective, simple and standard procedures (if the procedures are non-standard intercalibrations are essential);
- Be strongly related by what is believed to be a causal link to a particular activity or process;
- Be a direct measure of change in a value of concern;

- Permit generalisations about causative agents;
- Be definable in terms of limits beyond which changes are judged to be deleterious; and
- Be measurable without conflicting with scientific activities.

Finally, make sure that the chosen indicators can be readily measured and are achievable within the available resources.

Table 1. An overview of some potential indicators and parameters for use in monitoring programmes in Antarctica.

Indicator	Parameter
“Footprint”	Area subject to human activity, e.g. spatial coverage of buildings and associated impact including roads, pipes etc; number and location of field expeditions
Air quality	SO <sub>2</sub> , particulates
Soil quality	Erosion (e.g. footpaths), metals, TPH, PAH
Sea water quality	TSS, DO, BOD, COD, pH, conductivity
Fresh water quality	TSS, DO, BOD, COD, pH, conductivity
Snow and ice quality	Metals, TPH, particulates
Vegetation quality	Spatial extent, metals
Wildlife health	Population size, breeding success
Fuel handling	Amount consumed, number of spills, size and location of spills
Aircraft/vehicle operations	Distance travelled, number of landings, fuel consumed
Solid and liquid waste	Waste types (including hazard), volume / weight
Waste water	TSS, DO, BOD, COD, pH, conductivity, faecal coliforms, volume
Field activities	Number of person days in field, location of field camps
Introduced organisms	Species, distribution, population size
EIA/permit compliance	Number of breaches recorded

*Examples for Deciding What to Monitor:*

### **1<sup>st</sup> Example**

*National Programme Charlie has decided to undertake an environmental monitoring programme to monitor environmental change in an Antarctic Specially Protected Area (ASPA) near Charlie Station. The information will be used to assist in the preparation of a Management Plan for the ASPA.*

*The key environmental feature in the ASPA is vegetation, namely mosses and lichens. The only potential impact from nearby activities is through pollution.*

## 2nd Example

*National Programme Delta is to undertake an environmental monitoring programme of its new summer station on the plateau. National Programme Delta has limited budget but is keen to meet Environmental Protocol requirements and ensure minimisation of environmental impacts.*

*It has initially developed a list of possible monitoring indicators from local environmental values and possible impacts but is unable to undertake monitoring of all of them due to resource constraints. The Environmental Manager uses the Impact Rating methodology already undertaken in the Environmental Impact Assessment for the new station to rank/prioritise the indicators:*

<b>Indicator</b>	<b>Likelihood</b>	<b>Consequence</b>	<b>Resulting Impact Rating</b>
<i>Station Footprint</i>	<i>Certain</i>	<i>High</i>	<i>High</i>
<i>Ice Pollution by Fuel</i>	<i>Unlikely</i>	<i>High</i>	<i>High</i>
<i>Air Quality – Emissions from station power plant</i>	<i>Certain</i>	<i>Low</i>	<i>Medium</i>
<i>Pollution from windblown debris</i>	<i>Unlikely</i>	<i>Medium</i>	<i>Medium</i>
<i>Introduced organisms on cargo</i>	<i>Unlikely</i>	<i>Low (station is in a remote plateau location)</i>	<i>Low</i>

*The Environmental Manager decides to only implement a monitoring programme on the indicators that score a high impact rating, which can also be undertaken within available resources.*

### 2.2.2 Sampling methods and statistical design

It is important to ensure that the sampling methods and statistical design follow recognised scientific procedures. In this regard SCAR / COMNAP (1996) have recommended a series of basic tenets that need to be followed for the statistical design of monitoring programmes:

- i. *Have a clear question.* The thought process should be:  
question ->hypothesis ->indicators ->parameters ->model ->statistics and tests of hypothesis ->interpretation.
- ii. *Have controls.* These should be both spatial and temporal where appropriate.
- iii. *Have a balanced design,* e.g. the same number of replicate samples at each time and place.
- iv. *Have replicates randomly allocated.*
- v. *Conduct preliminary sampling (pilot study) in order to do the following (vi – ix):*

- vi. *Assess the sampling methods* to ensure they are efficient and do not introduce bias into the study. Adequate quality assurance must be applied from initial sample collection, through transport to the laboratory, and during the analysis.
- vii. *Estimate error variability* and necessary sampling effort to achieve the desired power.
- viii. *Determine natural environmental patterns* to be incorporated into the study design (e.g. stratification).
- ix. *If statistical analysis assumptions are not satisfied* (they probably will not be) then transform variable before analysis, use nonparametric methods or use simulation or randomisation methods.

Once specific parameters have been selected, technical requirements that need to be followed in order to measure the chosen parameters, need to be identified. The COMNAP/SCAR Antarctic Environmental Monitoring Handbook should be consulted when carrying out this step in the process.

### **2.2.3 Consultation**

As a final step in the planning phase of the monitoring programme, it is important to consult with relevant stakeholders (scientists, logistics staff, managers, permitting authority etc) to ensure that the proposed monitoring programme meets the objectives identified in Step 1, and can effectively be resourced and implemented.

#### *Example for Consultation*

*The Environmental Manager from National Programme Echo has prepared a draft monitoring programme for its shipping activities. The Environmental Manager undertakes widespread consultation with managers, maritime associations and the shipping companies to ensure the programme is realistic prior to implementation. As a result of consultation the Environmental Manager discovers that the maritime association already undertakes monitoring of one the indicators, and is pleased to provide data free of charge, saving thousands of dollars on the programme.*

## **2.3 STEP 3: Implementing the programme**

### **2.3.1 Pilot project**

If circumstances allow, consideration might be given to undertaking a pilot study to test the effectiveness of the indicators and parameters chosen. This could include taking a small set of samples for analysis to test both sampling and laboratory methodologies.

#### *Example of a pilot study*

*National Programme Hotel undertakes the first year of its monitoring programme as a pilot study to ensure its effectiveness prior to full commitment and expenditure. As a result of the pilot study it discovers that it cannot retrieve sufficient water quality samples at one of the monitoring locations to achieve required statistical rigour due to unsafe sea ice conditions. National Programme Hotel amends its monitoring locations as a result of the pilot study to ensure reliable and continuous water quality data can be gathered.*

### 2.3.2 Baseline monitoring

It will be important to collect baseline data in circumstances where, for example, very little is known about the site to be monitored, or in those cases when some degree of impact is expected. Collection of baseline data may take some time (e.g. it may be necessary to collect baseline data over a full Antarctic season, or even over a full annual cycle. As such adequate time may need to be factored into the monitoring programme to ensure that sufficient baseline data can be collected.

### 2.3.3 Data handling (collection, storage and analysis)

The data collected through the monitoring programme must be analysed in order to assess whether the monitoring goals are being achieved. Relevant experts and scientists should be consulted in interpreting the data. It may be useful to establish a small group of relevant experts/scientists with responsibility for assessing and reporting on the monitoring information.

For more detailed assistance with data handling reference is made to Chapter 3 of the COMNAP/SCAR Antarctic Environmental Monitoring Handbook and to Section 11 of the SCAR report 1996.

It is also noted that in the future a State of the Environment Reporting system may be developed by the Committee for Environmental Protection (CEP) for centralised data management of key environmental indicators. As such standardised reporting and data handling methods will be important to ensure comparability of data collected from various sources.

In addition it is recommended that the expertise of the Joint Committee on Antarctic Data Management (JCADM – [www.jcadm.scar.org](http://www.jcadm.scar.org)) be considered for data management needs.

#### *Example for Data Handling*

*Tourist Operator Foxtrot has decided to implement an environmental monitoring programme for all of its tours. It establishes a data handling system on its internet site, using password access to allow its Voyage Leaders to input data on a weekly basis.*

### 2.3.4 Reporting and publishing

It is recommended that the results of environmental monitoring programmes in Antarctica should be made available to other operators and interested scientists for data comparison and knowledge sharing. Options include:

- Publishing in operational and environmental journals or peer-reviewed scientific journals;
- Informing the CEP by means of Information Papers;
- Making information available via COMNAP reporting procedures and website (refer to COMNAP database of environmental programmes);
- Publishing on national programme websites;

- Provision of data and information to the CEP's State of the environment reporting system.

#### *Example for Reporting and Publishing*

*Tourist Operator Foxtrot stores its environmental management data on an internet site. It has developed a computer programme that automatically compiles and sends a monthly report to its national regulator. The Tourist Operator also uses the data to compile a yearly report that it forwards to IAATO for their information. In turn IAATO makes the information available to the CEP and the ATCM by means of annual reporting to the meetings.*

### **2.3.5 Programme review**

Individual national programmes should periodically review any proposed monitoring programme, and, as noted above, the results of such reviews shared amongst national operators. It is recommended that review and critical evaluation focus on each of three phases of the monitoring activity: data collection, data analysis and use of the results in management decisions.

#### *Data collection*

The sampling process should be reviewed to ensure that:

- The original design of sampling location, frequency, replication and measured variables is being followed consistently. If costs, operational difficulties, changing technologies, etc. are limiting the intended design, appropriate changes must be put in place;
- The quality of the data is as originally specified.

Once analysis has begun, data collection should also be reviewed to ensure that the design is adequate and that the collected information is meeting the objectives of the monitoring programme.

It is also worth remembering that changes in the objectives/testable hypotheses may be required as new insights, or new activities, and/or technologies occur.

#### *Data analysis and use*

Data collection and analyses are intended to provide decision-makers with sound scientific information from which environmental management decisions are made. Therefore programme review should consider:

- If the data and the results of the monitoring are providing managers with the information that was envisaged in the original designs. If not adjustments must be made;
- Whether management's use of the data has resulted in a measurable decrease in human impact.

### *Review mechanism*

For small scale monitoring programmes, review is likely to be conducted by the environmental manager or the monitoring programme supervisor. For larger scale or longer-term monitoring programmes programme evaluation/review is best undertaken by external peer review, which may include representatives from other national operators. Such peer review should be undertaken by individuals with relevant scientific, logistical or policy expertise.

Additional issues, which may also need to be factored into the programme review, include resource use and allocation, reporting procedures, and publication opportunities.

### *Example for Review of the Monitoring Programme*

*National Programme Golf undertakes its biannual review of its monitoring programme for its station. As part of its review it discovers that incineration is no longer undertaken on station, significantly improving air quality emissions. It revises its ranking/prioritisation of indicators and determines that air quality emissions is no longer a high ranking issue. It decides to cease all air quality monitoring, as the data no longer provides any management benefit.*

## **REFERENCES**

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SCAR/COMNAP. 1996. "Monitoring of Environmental Impacts from Science and Operations in Antarctica". Workshop reports. Available on [www.comnap.aq](http://www.comnap.aq).

The Protocol on Environmental Protection to the Antarctic Treaty (1991). Available on [www.cep.aq](http://www.cep.aq) and [www.ats.org.ar](http://www.ats.org.ar).

The Antarctic Master Directory (AMD) has been established at <http://gcmd.nasa.gov/Data/portals/amd/> by the Joint Committee on Antarctic Data Management (JCADM) [www.jcadm.scar.org](http://www.jcadm.scar.org) for Antarctic Treaty nations to lodge metadata records.

## APPENDICES

**Appendix I:** Monitoring requirements of the Environmental Protocol to the Antarctic Treaty; text of Recommendations XV-5 and XVII-1.

### **Appendix I:**

#### **Requirements of the Protocol on Environmental Protection to the Antarctica Treaty (the Protocol)**

As indicated above, the Protocol, which came into force in 1998, is the principle basis for determining monitoring requirements in Antarctica.

Article 3(1) of the Protocol sets out key environmental principles for all operations in Antarctica and states that the fundamental considerations in the planning and conduct of all activities in the Antarctica Treaty area shall be, “The protection of the Antarctic environment and dependent and associated ecosystems and the intrinsic value of Antarctica, including its wilderness and aesthetic values and its value as an area for the conduct of scientific research, in particular research essential to understanding the global environment...”

Against this background Article 3 of the Protocol specifically identifies monitoring as key to the evaluation of impacts of all activities in that:

Article 3(2)(c) states:

*“Activities in the Antarctic Treaty area shall be planned and conducted on the basis of information sufficient to allow prior assessments of, and informed judgments about, their possible impacts on the Antarctic environment and dependent and associated ecosystems and on the value of Antarctica for the conduct of scientific research; such judgments shall take full account of:*

*(v) whether there exists the capacity to monitor key environmental parameters and ecosystem components so as to identify and provide early warning of any adverse effects of the activity and to provide for such modification of operating procedures as may be necessary in the light of the results of monitoring or increased knowledge of the Antarctic environment and dependent and associated ecosystems;”*

Article 3(2)(d) states:

*“regular and effective monitoring shall take place to allow assessment of the impacts of ongoing activities, including the verification of predicted impacts;”*

Article 3(2)(e) states:

*“regular and effective monitoring shall take place to facilitate early detection of the possible unforeseen effects of activities carried on both within and outside the Antarctic Treaty area on the Antarctic environment and dependent and associated ecosystems.”*

Furthermore, monitoring is specifically identified in Annex I to the Protocol as a key element in respect of assessing the environmental impacts of activities in Antarctica:

- In respect of preparation of Comprehensive Environmental Evaluations (CEEs) Article 3(2)(g) of Annex I provides for “*identification of measures, including monitoring programmes, that could be taken to minimise or mitigate impacts of the proposed activity and to detect unforeseen impacts and that could provide early warning of any adverse effects of the activity as well as to deal promptly and effectively with accidents.*”
- Article 5 of Annex I states:
  1. “*Procedures shall be put in place, including appropriate monitoring of key environmental indicators, to assess and verify the impact of any activity that proceeds following the completion of a Comprehensive Environmental Evaluation.*”
  2. *The procedures referred to in paragraph 1 above and in Article 2(2) [activities proceeding on the basis of an Initial Environmental Evaluation] shall be designed to provide a regular and verifiable record of the impacts of the activity in order, inter alia to:*
    - a. *Enable assessments to be made of the extent to which such impacts are consistent with the Protocol, and*
    - b. *Provide information useful for minimising or mitigating impacts, and where appropriate, information on the need for suspension, cancellation or modification of the activity.*”

Whilst not explicitly stated, monitoring is also likely to be a primary means of meeting additional requirements of the Protocol:

- Annex II sets out provisions for the conservation of Antarctic fauna and flora, and Article 6(1)(b) of Annex II requires Parties to make arrangements for “*obtaining and exchanging information as to the status of native mammals, birds, plants and invertebrates in the Antarctica Treaty area, and the extent to which any species or population needs protection.*”
- Annex III sets out provisions for waste disposal and waste management, and, in respect of waste management planning Article 8 of Annex III requires Parties to “*prepare and annually review and update its waste management plans, ...specifying...current and planned arrangements for analysing the environmental effects of wastes and waste management*” (Article 8(2)(c)).
- Annex V sets out provisions in relation to Antarctic Specially Protected Areas and Antarctic Specially Managed Areas. Article 10(1)(b) of Annex V requires Parties to make arrangements for “*obtaining and exchanging information on any significant change or damage to any Antarctic Specially Managed Areas, Antarctic Specially Protected Areas or Historic Site or Monument.*”

It is also noted that two of the primary functions of the Committee for Environmental Protection, as set out in Article 12 of the Protocol, are “*to provide advice (to the ATCM) on:*

- *the state of the Antarctic environment (Article 12(1)(j)); and*
- *the need for scientific research, including environmental monitoring, related to the implementation of this Protocol (Article 12(1)(k)).*

## **RECOMMENDATION XV-5**

### **HUMAN IMPACT ON THE ANTARCTIC ENVIRONMENT: ENVIRONMENTAL MONITORING IN ANTARCTICA**

The Representatives,

*Recognising* that, because of its relatively pristine state, Antarctica provides an important natural laboratory to obtain baseline information on Antarctic environments and for detecting and monitoring some of the effects of human activities on the global environments and ecosystems upon which the welfare and survival of the human species depends;

*Recognising* also that scientific research, related logistic support activities, tourism, natural resources exploration and development, and other human activities in Antarctica could have local, regional or global environmental effects, or compromise the scientific value of Antarctica;

*Recalling* the Scientific Committee on Antarctic Research (SCAR) response to Recommendation XII-3 and Recommendation XIV-2, which call upon the Antarctic Treaty Consultative Parties to establish programmes for detecting and monitoring the effects of human activities on key components of Antarctic Ecosystems;

*Conscious* that determining cause-effect relationships between certain human activities and observed changes in Antarctic environments will require knowledge of natural variation in Antarctic environments and accurate record of such things as the types and quantities of fuels used to supply heat and light to Antarctic station and to operate aircraft and land vehicles in Antarctica;

*Aware* of the ecosystem monitoring programme being developed to help meet the objectives of the Convention on the Conservation of Antarctic Marine Living Resources;

*Desiring* to identify and initiate cooperative, long-term monitoring programmes necessary to verify the predicted effects and to detect and quantify the possible unforeseen effects of human activities on the Antarctic environment; and

*Recognising* that the design and implementation of integrated, comprehensive and cost-effective environmental monitoring programmes in Antarctica service both scientific and environmental protection purposes;

**Recommend** to their Governments that:

1. They encourage their national Antarctic programmes, individually and collectively, to continue and, as appropriate expand programmes in Antarctica aimed at detecting and monitoring global environmental change, including its effects on the ozone layer over Antarctica, effects on Antarctic terrestrial, marine and atmospheric environments and dependent and associated ecosystems as well as effects on Antarctic living resources.
2. They undertake, individually and collectively to establish environmental monitoring programmes to verify the predicted effects and to detect the possible unforeseen effects on Antarctic environments and living resources of activities in the Antarctic Treaty area, including:
  - (a) Waste disposal;
  - (b) Contamination by oil or other hazardous or toxic substances;

- (c) Construction and operation of stations, field camps, and related ship, aircraft and other logistic support facilities;
  - (d) Conduct of science programmes;
  - (e) Recreational activities;
  - (f) Those affecting the purposes of designated protected areas.
3. They take such steps as necessary to maintain accurate records of the activities of their national programmes in Antarctica, including, among other things, maintaining accurate records of the types and quantities of fuels and other materials transported to and used to support their national programmes in Antarctica, the types and quantities of materials subsequently removed from Antarctica, and the types and quantities of materials disposed of in Antarctica by various means, bearing in mind Recommendation XV-3.
4. They convene, in accordance with Recommendation IV-24, a meeting of experts to consider and provide advice on:
- (a) The types of cooperative, long-term monitoring programmes that would be useful for detecting, quantifying, monitoring, and determining the likely causes of observed changes in air quality, snow and water quality, and other key feature of Antarctic environments and living resources;
  - (b) On the methods that should be used to collect, report, store, exchange, and analyse needed data; and
  - (c) On where and how frequently various environmental parameters should be measured.

To this end, they invite SCAR through their national committees, to consider and provide advice on the above matters.

5. They exchange information and establish cooperative working relations with those Specialised Agencies of the United Nations and other international organisations having a scientific or technical interest in Antarctica that are engaged in the planning and implementation of related scientific research and environmental monitoring programmes.

## **RECOMMENDATION XVII-1**

### **ENVIRONMENTAL MONITORING AND DATA MANAGEMENT**

The Representatives,

*Recalling* Recommendations XV-5, XV-16, XV-12 and paragraphs 106-109 of the Report of the XVIth ATCM;

*Noting* the report and the valuable work of the First Meeting of Experts on Environmental Monitoring in Antarctica (XVII ATCM/INFO 9) and the recommendation sent forth in the afore mentioned report;

*Noting* that better data management can improve the quality of Antarctic Environmental Monitoring, operations and science;

*Noting* additionally the report by SCAR-COMNAP (XVII ATCM/WP5) describing actions that could be taken to develop a coordinated data management system with the intent to improve the comparability and accessibility of both scientific and environmental data being collected by national programmes, as called for by ATCM Recommendations XIII-5 and XV-16;

*Recognising* that, in the Final Act of the Protocol on Environmental Protection to the Antarctic Treaty, it was agreed that it was desirable to ensure effective implementation at an early date; and that paragraph 69 of the Report of the XVIth ATCM exhorts the Consultative Parties to ratify the protocol as soon as possible, and that meanwhile efforts also should be made to implement the provisions of the Annexes as rapidly and completely as possible;

*Acknowledging* that in order to meet the requirements of the Protocol on Environmental Protection to the Antarctic Treaty that calls, under Articles 3.2(d) and 3.2(e) for regular and effective monitoring, to allow assessment of the adverse impacts of human activities, it is necessary to focus environment impact monitoring particularly on anthropogenic effects at a local level;

*Aware* that once established, the Committee for Environmental Protection may offer its advice on these measures, consistent with its terms of reference as provided for in the Protocol;

*Aware* that applied monitoring can be expensive and may require long term commitment and that any environmental monitoring should be scientifically defensible, practicable and cost-effective;

**Recommend** to their Governments that they:

1. Through their SCAR National Committees request SCAR to consider and provide advice on:
  - i. The types of long-term programmes, if any, necessary to verify that human activities (such as tourism, scientific research or other activities) do not have significant adverse effects on birds, seals and plants; and
  - ii. Emission standards that should be established to ensure that the combustion of fossil fuels and incineration of waste do not contaminate the Antarctic atmosphere, terrestrial, ice, aquatic or marine environments in a way that would compromise their scientific values;
2. As their COMNAP Representatives in consultation with SCAR to establish research programmes at a representative subset of facilities in Antarctica to determine how

different types and sizes of facilities in different localities (e.g. coastal and inland station on rocks and on ice shelves) affect the Antarctic environment;

3. Provide a list of the Antarctic data sets being compiled and archived by their nationals and make this list available to other Parties, SCAR and COMNAP, as soon as possible, to form the basis for the development of an Antarctic Data Directory;
4. Establish, as appropriate, national arrangements for obtaining expert advice on the types of data products and data access mechanisms which would best meet both the basic scientific requirements and long-term environmental monitoring requirements.