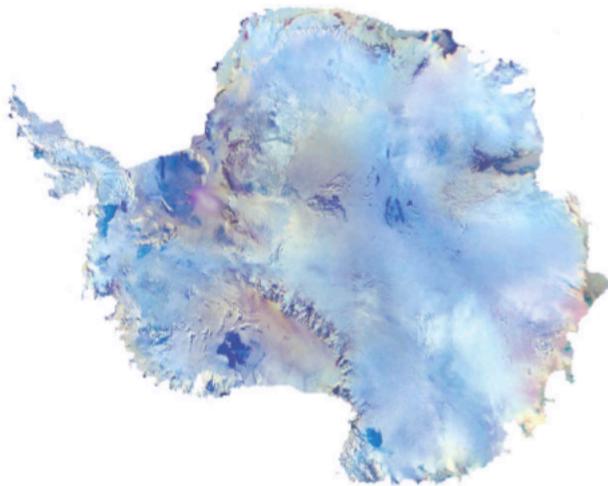


Are the SCAR / COMNAP guidelines effective in
monitoring the impacts of human activities on the
Antarctic environment?

**Antarctic
Environmental Monitoring
Handbook**



Council of Managers of
National Antarctic Programs



Scientific Committee on
Antarctic Research



Council of Managers of National Antarctic Programs (COMNAP)

COMNAP

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

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Abstract

The SCAR / COMNAP Technical Handbook (2000) and Practical Guidelines (2005) for environmental monitoring are designed to help new signatories to the Madrid Protocol create effective environmental monitoring regimes for activities in Antarctica. The documents are only relevant for National Antarctic Programmes so other activities such as tourism and fishing are outside the scope of this investigation. A short history of the Madrid Protocol and summary of the COMNAP guidelines set the scene for three case studies, examining the environmental monitoring programmes at Scott Base (NZ), McMurdo Station (US) and the Thala Valley Tip (AUS). Different monitoring methods are being used by each programme and there is currently no central database for monitoring reports, in part because there is no compulsory requirement to publish the data. Changing the Madrid Protocol to introduce minimum environmental monitoring requirements and to require compulsory reporting on environmental monitoring would help to streamline monitoring systems. Having the reports in one central location would make it easier to access data and identify historical trends while encouraging National Antarctic Programmes to adopt best practices and follow the steps laid out in the COMNAP Guidelines.

Introduction

The Antarctic environment is unique. As such a remote continent with no native population, the impacts of human activity are often more readily recognizable than anywhere else on the planet. Identifying these impacts and gaining an in depth awareness of the situation is empowering. Early detection of issues means they can be met with remediation efforts, helping to reduce the human impact and to conserve an Antarctica that is “valued, protected and understood”.

The SCAR / COMNAP Technical Handbook (2000) and Practical Guidelines (2005) for environmental monitoring are designed to help new signatories to the Madrid Protocol create effective environmental monitoring regimes for activities in Antarctica. The documents were intended to standardise tests and procedures over different National Programmes and provide a step by step guide to effective monitoring. The Madrid Protocol and the Practical Guidelines will be explored in more depth to create context for that monitoring, then the effectiveness of the guidelines in practical situations will be assessed through three case studies: Scott Base (NZ), McMurdo Station (USA) and the Thala Valley Tip (AUS). Data centralization is an ongoing issue that will be addressed before conclusions and recommendations are made.

According to the COMNAP Guidelines, an “activity” is “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” (COMNAP guidelines, p5). The range of human activities that have an impact the Antarctic environment is just as vast as the list of activities being conducted. Tourism, fishing, running a base and conducting science programmes all have an impact. The SCAR / COMNAP Technical Handbook and subsequent Guidelines are designed for use by the 28 members of COMNAP, therefore the question posed directs investigation towards the activities of these National Antarctic programmes. It would be unfair to apply these guidelines to any other activities as this was not their intended purpose. At the same time it is important to bear in mind that National Antarctic programmes account for a fraction of the human activity that occurs in and around Antarctica each year.

In order to answer the question posed, a definition of monitoring is required. The 2005 COMNAP Practical Guidelines for Developing and Designing Environmental Monitoring Programmes in Antarctica state that monitoring “consists of standardised measurements or observations of key parameters over time, their statistical evaluation and reporting on the state of the environment in order to define quality and trends.” In light of this definition, the question posed may be rephrased to read “are the monitoring guidelines effective in defining quality and trends associated with the impacts of human activities on the Antarctic environment?” Examining the use of the information after it was reported was outside the scope of this study.

A key point is that our question relates to the impact of human activities on the Antarctic environment. The guidelines and handbook are focused on the impacts from activities that occur within the Antarctic, in other words the impacts of the Antarctic programmes themselves, as opposed to the impacts from external sources such as climate change. The obvious advantage of such monitoring is that it is focused on activities that National Programmes have control over and thus may be able to use information gained directly.

The importance of monitoring arises from the potential benefits to the environment and the potential cost implications of the monitoring and any associated remedial action. Effective monitoring should enable the early detection of unforeseen consequences in order to reduce the environmental impact and to minimise any clean up costs that may occur. The aim of monitoring is to detect changes and this cannot be achieved through one off or irregular measurements. A prime example of this issue is the detection of the spring reduction in the ozone layer. Due to irregular measurements it took many years to recognise the seasonal ozone depletion that occurs over Antarctica. Monitoring should also be coordinated and consistent to maximize its effectiveness and needs to look at the ongoing impacts of activities themselves, not just the raw inputs into the environment.

The potential benefits of monitoring can be seen when looking at the examples of climate change, ozone depletion and lead contamination. Earlier detection of these

issues could have led to earlier interventions and reduced harm. In the case of the use of tetraethyl lead in fuels, there is now clear evidence that actions carried out by humans have led directly to contamination of the environment. This contamination has subsequently led to detrimental health effects. Since this contamination occurred over a significant period of time a large number of people have been affected. It is likely that the health effects of lead were an unforeseen impact, highlighting the need to conduct monitoring in a routine manner.

Once detection of an issue has occurred it is not certain that appropriate action will result. Reporting is an important step in between as it allows the dissemination of information to interested parties. The nature of the publication of the data is likely to affect the nature of the response to the findings. An example of this is cumulative damage occurring over time that may be deemed unacceptable by some parties. These parties could exert pressure to cause change that ultimately reduces the cumulative damage. The inclusion of the term “reporting” in the COMNAP definition of “monitoring” is thus an important one and will be explored further. It is conceivable that having a requirement to report on findings may lead to better monitoring through increased awareness of the monitoring that is and is not occurring.

In order to get the most out of collected data sets it is useful to be able to make comparisons between different sets of measurements. This means it is important that methods are standardised. The COMNAP Technical Handbook and Practical Guidelines aim to facilitate this streamlining. The term “key parameters” in the Practical Guidelines recognises that it is not practical to monitor every indicator and that some investment should be made to determine which parameters are best monitored. Ideally these parameters should be similar across different National Antarctic Programmes. Whether or not this is happening is another story and it is debatable how much direct influence the COMNAP guidelines have had. The monitoring programmes investigated in the three case studies of Scott Base (NZ), McMurdo Station (USA) and the Thala Valley Tip (AUS) were initiated prior to their publication but this should not preclude their use as a means to standardise the monitoring.

The Protocol on Environmental Protection to the Antarctic Treaty

The Antarctic Treaty was signed in 1959 by twelve nations that were active in science further south than 60 degrees during the International Geophysical Year 1957 – 1958 (Secretariat of the Antarctic Treaty, 2011). In 1973 members of the Organisation of Arab Petroleum Exporting Companies (OAPEC) initiated an oil embargo until March 1974, oil prices began to increase and nations began to look to other sources of oil that weren't dependant on these countries (Carroll, 1983). Between 1972 and 1982 the Consultative Parties, drafted the Convention for the Regulation of Antarctic Mineral Resource Activities (CRAMRA) that would manage mineral exploitation in Antarctica if it were to ever occur (Waller, 1989). In 1988 thirty-three states signed the Convention, in what was thought to be the solution to the significant gap regarding mining in the Antarctic Treaty System (Waller, 1989). In 1989 however, France withdrew its support of the Convention and Australia followed suit in May 1989 with the Australian Senate opposing the agreement (Waller, 1989).

This showed an obvious gap in the Treaty System, so the Protocol on Environmental Protection to the Antarctic Treaty (The Madrid Protocol) was drafted and signed in 1991. The Protocol builds on the Antarctic Treaty and improves the environmental measures in stating that its main objective is to commit all parties to the comprehensive protection of the Antarctic environment (Jaffe, Leighton & Tumeo, 1994). As well as dealing with the minerals issues and instigating a complete ban on mineral activities under Article 7, with the exception of scientific purposes, environmental principles began to be monitored under different aspects of the Protocol. Certain aspects of The Madrid Protocol have been examined below to demonstrate where environmental monitoring has been added to the Antarctic Treaty via The Madrid Protocol.

Monitoring under The Protocol on Environmental Protection to the Antarctic Treaty

The Preamble of The Madrid Protocol places environmental principles at the forefront of any activities undertaken in Antarctica. It deems the continent a “special conservation area” with the Treaty parties “convinced of the need to enhance the protection of the Antarctic environment and dependent and associated ecosystems.” (The Protocol on the Environmental Protection to the Antarctic Treaty, 1991).

Article 3, entitled “Environmental Principles”, defines the environment and dependant and associated eco-systems as the fundamental consideration in the planning and conduct of all activities in the Antarctic Treaty area. This Article states that regular and effective monitoring shall take place on any activities undertaken in Antarctica to assess and verify environmental impacts, as well as the occurrence of regular and effective monitoring, to detect unforeseen environmental impacts of these activities. (The Protocol on the Environmental Protection to the Antarctic Treaty, 1991).

Article 8, entitled “Environmental Impact Assessment”, supports Article 3 in that any proposed activities shall be subject to prior assessment of the impacts that these activities may have on the Antarctic Environment or associated or dependant ecosystems, and determine if these activities will have either:

- (a) less than a minor or transitory impact; or
- (b) a minor or transitory impact; or
- (c) more than a minor or transitory impact.

If the activity is determined to have less than a minor or transitory impact under Annex I, the activity is able to proceed. Annex I further sets out guidelines under Article 2 and 3 which detail increasing procedures that must occur if the activity is determined to have either a minor or transitory impact or more than a minor or transitory impact. Furthermore, Article 5 of Annex I states that procedures shall be put in place to assess and verify the impact of any activity by monitoring key environmental indicators and informing on the need for cancellation or suspension or

of an activity if the environmental impacts are not consistent with The Madrid Protocol and the Environmental Impact Assessment of the activity.

Under Annex III of the Protocol (Waste Disposal and Waste Management), all Treaty parties are committed to clearing up past waste disposal sites on land as well as abandoned work sites of past Antarctic Activities (Annex III, Article 1(5)). This cleanup work, however, is only to be undertaken if the removal of these structures or waste would not result in greater adverse environmental impact than leaving the structure or waste in its current location untouched (The Protocol on Environmental Protection to the Antarctic Treaty, 1991). The Madrid Protocol is an integral part of the Antarctic Treaty System and particularly relevant when considering environmental monitoring.

COMNAP Handbook and Guidelines

The COMNAP Practical Guidelines for Developing Environmental Monitoring Programmes in Antarctica were published in 2005. Designed as a practical tool for developing and designing an environmental monitoring programme, the guidelines were the hands-on follow up to COMNAP and SCAR's Technical Handbook of 2000. The issue of environmental monitoring was discussed at length at the 1989 ATCM meeting and the guidelines are the final step in making environmental monitoring as easy and accessible as possible for all nations. The foreword to the guidelines concludes that "a unified approach to environmental monitoring will assist the continued protection of resources and values, and in minimizing human impacts on the Antarctic continent" (COMNAP 2005, iv).

These guidelines define terms such as "monitoring", "impacts" and "activities" as follows (COMNAP 2005, p6):

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.

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

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.

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.

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

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.

They go on to outline a model, designed for use by new signatories to the Environmental Protocol or those wishing to review their procedures. According to the document, the guidelines can be used to “[meet] the monitoring requirements of the Environmental Protocol” and to “[monitor] ... activities in response to environmental impact assessment requirements” (p6). The introduction concludes that “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”, a point that is vital to keep in mind when reviewing their effectiveness.

The COMNAP model is made up of three parts: scoping, defining and implementing. Scoping the monitoring project consists of setting objectives, undertaking background research, allocating resources and baseline monitoring. Defining consists of making decisions on what to monitor, choosing the best sampling methods and statistical design and any relevant consultation. The third step of implementation involves undertaking a pilot project, collecting baseline data, reporting and publishing results and conducting a programme review (COMNAP, p8). All three stages are described in more detail in the next section of the guidelines and hypothetical examples are provided, linking the guidelines to real world situations.

Scoping

Any monitoring programme needs clear objectives that are ‘meaningful, achievable and concise’ (COMNAP, p8). Once objectives are clear, background research into the relevant areas is necessary in order to determine what is already known. The guidelines provide a list of questions to assist researchers in gaining a total picture of the scientific and environmental situation. It is necessary to identify key environmental features within the area and the following checklist is provided:

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

Having appropriate resources is important if a monitoring programme is to work effectively. The guidelines include bullet pointed suggestions of what “required resources may include” (p10). The word ‘may’ is used frequently throughout the document, underlining the fact that none of the recommendations are binding and that parties are free to interpret and use the guidelines as they desire. The guidelines suggest delegating responsibility for tasks at this point. Little is said about baseline monitoring except that its purpose is “to establish a data set of pre-impact conditions” (COMNAP, p11) for the relevant location.

Defining

When defining the programme, one must decide what to monitor. Key environmental factors, predicted impacts and technical concerns should all be taken into account. Prioritisation is used to choose the most relevant indicators, or signs of change and parameters are then chosen to measure those indicators. This means that if it is envisioned that a project will only have an impact on soil quality, it is not necessary to plan to sample the air or water quality as well. The following table from page 13 of the COMNAP guidelines illustrates possible indicators to consider and parameters that may be used as measures:

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 ₂ , 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

After selecting parameters, the COMNAP Technical Handbook should be used as a guide in order to ensure recognized scientific procedures are followed when conducting sampling and subsequent statistical analysis. Consultation with relevant stakeholders at this point can help prevent overlapping of data gathering.

Implementing

When implementing the monitoring programme a pilot project is recommended prior to baseline monitoring in order to “test the effectiveness of the indicators and parameters chosen” (COMNAP, p15). The collected data must be analysed to assess whether monitoring goals are being achieved. Section 2.3.3 includes an interesting note about future plans:

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.

At present there is no State of the Environment Reporting system for centralized data management, although the concept has been discussed numerous times over the past two decades and “exchange of information” is included in the CEP’s current five year plan. One main reason for this lack of centrality is outlined in section 2.3.4, where reporting and publishing are addressed:

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.

Important words in this section include “recommended” and “should”. Both highlight the fact that the reporting of data is not compulsory. The bullet pointed options for publication also illustrate the lack of centrality. Reporting is not mandatory and if countries do choose to report there are many places they could choose to share their data, making it difficult for those wishing to access historical monitoring records to access the relevant documents easily.

Section 2.3.5, “Programme Review”, uses similar language:

“Individual national programmes *should* periodically review any proposed monitoring programme... It is *recommended* that review and critical evaluation focus on each of three phases of the monitoring activity” (p16)

For smaller projects the review process may be conducted by the programme’s environmental manager. For larger scale or long term projects independent peer review by qualified professionals or other national operators is recommended.

The COMNAP guidelines were designed as a tool to be used by national Antarctic programmes for designing monitoring regimes. They lay out a step by step method to creating a well thought out and effective monitoring system. The guidelines are not mandatory, illustrated by language such as “should” “may” and “recommended” throughout the document and this is a shortfall. While reporting of data is recommended, this is an area of concern. Without access to the data collected by different national programmes it is not possible to assess the effectiveness of the monitoring that is taking place. The State of the Environment Reporting system would help with this, but has not eventuated.

Case Study 1: Scott Base (NZ)

Scott base provides accommodation and logistical support for the New Zealand Antarctic programme. The base accommodates up to 85 people over the summer season.

Antarctica New Zealand is environmentally aware and it undertakes a number of different projects at and around Scott Base relating to sustainability, environmental change and environmental impact. Some of the projects undertaken are monitoring activities while others are scientific studies and do not meet the COMNAP definition of monitoring as they are not standardised and repetitive. Examining each of these three types of projects and assessing whether or not they constitute monitoring helps to provide better understanding of the situation at Scott Base.

Sustainability monitoring

Antarctica New Zealand gained CEMARS certification in 2010 and is currently working towards carbNZero certification. This requires monitoring of base operational activities such as fuel use, water use and energy data for the running of Scott Base, paper use air travel and waste production (Antarctica NZ, 2010). This type of activity is monitoring, but it does not monitor the impact of human activities directly. Instead, it is monitoring the level of activity, which may in turn lead to an impact.

Environmental change monitoring

This is a key feature of research in the Ross sea region. A number of major initiatives are underway and listed on the Antarctica New Zealand website:

- Latitudinal gradient project.
- Terrestrial Antarctic Biocomplexity Survey
- Landcare Adelie Penguin research
- Landcare soils database

Erebus bay weddell seal population.
Evolution and Biodiversity in the Antarctic
McMurdo Dry valleys Long term Ecological research
Weather and climate monitoring

These studies would appear to fulfil the requirements of monitoring in that they are likely to consist of standardised tests and many of them are occurring over a long time frame. In general they are not related to human activities in Antarctic but are investigating the nature of changes that are occurring due to effects such as climate change. The notable exceptions are the marine studies projects, such as the Adelie Penguin research, which form part of the monitoring of the impacts of fishing in the Ross sea region.

Environmental impact monitoring

Some of the environmental change monitoring taking place at Scott Base has relevance in terms of impact monitoring. The monitoring of the various krill, seal and penguin populations in the Ross sea area serves as a form of impact monitoring for the impacts of fishing in the area. This is carried out under the CCAMLR Ecosystem Monitoring Programme (CEMP). Due to the sensitive nature of some of the data it is not made publicly available, reducing its effectiveness.

As part of its obligations under the Madrid protocol, Antarctica New Zealand prepares and files an Initial Environmental Evaluation (IEE) for the running of Scott base. As required under the protocol the IEE specifies the monitoring that will be carried out in conjunction with each activity. Some of the activities mentioned in the IEE appear to fit the definition of monitoring. Regular tests are carried out on the waste water that is discharged into McMurdo sound, biological oxygen demand, dissolved oxygen levels, the level of faecal coliforms and total suspended solids are measured monthly. The data from these measurements has not been sighted but is available on request from Antarctica New Zealand.

Other monitoring activities noted in the IEE are carried out by students from Post Graduate Certificate in Antarctic Studies (PCAS) course at the University of Canterbury. These activities include photo monitoring, ground disturbance monitoring, litter surveys and waste audits. These activities are carried out annually and nominally follow a standard procedure. The personal experiences of this year's PCAS groups have indicated that there is room for improvement in this testing.

Students experienced some level of difficulty with each of the activities. These difficulties generally arose from a combination of inadequate preparation and faults with the activity design. The preparation included a talk from Antarctica New Zealand and the provision of printed instructions including background material highlighting the importance of the monitoring. Due to the relatively intense nature of the course it was felt that most students did not adequately prepare for the work. It is recommended that some form of formal check be made prior to departure to Antarctica to ensure that adequate preparation has been done and that there is sufficient understanding of the procedures, including prior access to data collection forms or spreadsheets and historical data.

The students carrying out the Waste Audit noted that whilst the waste was provided in a suitable facility with appropriate measurement equipment, there was very limited time available to carry out the audit due to the course timetable. The spreadsheet that was provided as a template was confusing and not directly related to the measurements required which led to a non-standardised measurement procedure. It was also noted that due to the timing of the audit, undertaken over the Christmas period, the data may have not been representative of a typical waste stream. The audit itself does not monitor an environmental impact relevant to Antarctica as all waste is removed to New Zealand.

The litter survey required a quadrat to be thrown at four sites and the litter within it detailed. The collected data suggested a clean environment. A more thorough clean up the following day revealed a significant amount of litter was present. This indicates that the survey is not adequately sampling the litter on the ground. A new procedure is justified in this case, which implies that it will be difficult to trend the

data until a number of surveys have been carried out in the future. It is possible that a pilot study may have highlighted this issue before the testing was initiated.

The ground disturbance study aimed to visually identify the level of ground disturbance. A notable feature of this study is that the data is collected from different points each year. It is questionable whether the number of samples taken represents adequate coverage for this non-repetitive approach.

A number of studies have been conducted investigating various aspects of the environment around Scott Base, including bio-diversity, the impact of hydrocarbon contaminations and the presence of metals in the soils and marine sediments around Scott Base. In general these are one off studies that investigate an aspect of the environment but are either not repeated, or are repeated over large time scales. A case in point is a study at Cape Hallett investigating the vegetation change over 42 years. Only two data sets were used in the study, one from 1962 and one from 2004 (Brabyn, Beard, Seppelt, Rudolph, Turk & Green, 2006).

Several short term studies undertaken at Scott Base have noted the existence of some environmental impact. Ground penetrating radar and electromagnetic induction was used to investigate ground contamination in 2003 (Pettersson and Nobes, 2003). The area around Scott Base was analysed and mapped. Four main anomalies were identified as resulting from hydrocarbon contamination. The area labelled “2” in figure 1 is thought to be a plume of contamination from a spill of 1500 L of jet fuel from a pipeline leak in 1999. The data suggests that the plume might be progressing down the slope towards the sea. A subsequent 2005 paper noted that hydrocarbon contamination had an effect on the biodiversity of micro-organisms (Saul, Aislabie, Brown, Harris & Foght, 2005).

In a short term study, Negri et al (2005) reported on analyses of Antarctic marine sediments, bivalves and sponges. It was noted that the marine sediments adjacent to Scott Base are mildly contaminated with THC's, PAHs and PCBs. Given that studies are detecting some levels of contamination it would appear to be prudent to implement some form of standardised, repetitive monitoring of indicators such as soil

and marine sediment contamination. While there is some testing of water quality, this is limited to biological indicators in the wastewater. The testing could include testing water runoff and wastewater for the presence of contaminants such as PCBs, metals and THC's. Impact testing from the marine environment such as taking sediment samples might be justified.

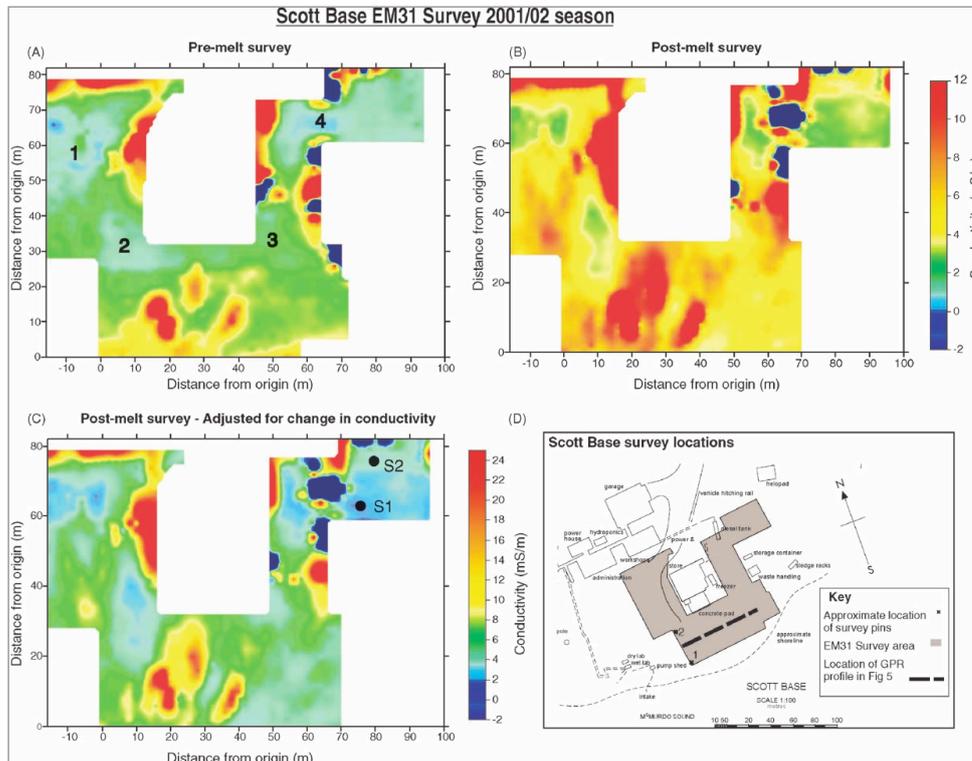


Figure 1: Scott Base soil conductivity study (Pettersson and Nobes, 2003)

In summary there are environmental impacts occurring at Scott Base, and Antarctica New Zealand conducts activities to minimise these impacts. Only some of the activities carried out could be classified as monitoring and few of these are focused on the impacts of human activity. This creates the potential for unforeseen impacts to be occurring without remediation.

There is some recognition that there are improvements to be made to the impact monitoring activities. In particular the recommendation to improve the analysis and reporting of the impact monitoring information should be implemented. There should be additional activities to monitor impacts identified through the scientific studies that are carried out from time to time. There exists a need to review the existing PCAS

monitoring activities to ensure the methodology, analysis and reporting is appropriate. These changes could significantly improve the quality of the environmental impact monitoring occurring at Scott Base.

The COMNAP guidelines could be a useful template to enable this programme to move forward. Budgetary constraints often lead to non-optimal solutions. Given the budget pressures that the base is operated under, it is important that adequate monitoring is carried out and that reporting of the results occurs. In this case there may be creative solutions to achieving the monitoring without excessive cost and human resourcing could be achieved through the use of volunteers or similar.

Case Study 2: McMurdo Station (USA)

McMurdo Station has been the logistics hub of the United States Antarctic Program (USAP) since its establishment in 1956. The current spatial impact the station has is confined to the areas initially developed for the base. When the Madrid Protocol came into effect in 1998, McMurdo Station began a 3 year pilot project (1999-2002) for monitoring anthropogenic impact on the surrounding area (Kennicutt II, Wolff, Alsup & Klein, 1999). The primary purpose of the pilot project was to establish the sample sites for an ongoing monitoring programme and to get a full understanding of the logistical capabilities of such a study. Prior to this the monitoring was minimal.

In 1991 an overview, the *Final Supplemental Environmental Impact Statement* (SEIS), of the USAP facilities and activities was summarised by the National Science Foundation (NSF) and four alternatives for environmental monitoring and protection strategies were proposed (NSF, 1991). The favoured alternative to the then-current situation was to decrease logistics staff thereby reducing the source of waste, in addition to implementing or continuing environmentally sound practices. Areas of interest were recycling, spill reduction, discontinuation of open burning, monitoring of wastewater and runoff and the treatment of wastewater. Wastewater was included but only on the recommendation of a future biological monitoring programme. The document also suggested that other programmes be brought in to identify and investigate remedial action sites, monitor local ecosystems to identify stress resulting from human presence, and the allocation of qualified environmental staff to facilitate the changeover. When the pilot project came into action nine years later, the focus was on construction sites, spill cleanup locations and environmental impact assessments (Kennicutt II, Klein, Sweet, Wade, Palmer, Sericano, & Denoux, 2010). Local studies dating from the 1980s were assessed to provide information on what areas to include in a monitoring programme (Figure 2) and objectives for the long-term monitoring programme were set. The intended targets were to establish the station footprint, determine whether heavy use areas were stable in spatial size, document the effect of specific activities and to provide an overall assessment of the station progress.

Impact	Location
• Low level air pollution from combustion related activities	• McMurdo Station
• Elevated noise	• Air Operations Areas and Flight Paths
• Erosion	• McMurdo Station
• Changes in drainage patterns	• McMurdo Station
• Retreat and redistribution of snowfield	• McMurdo Station
• Contaminated runoff	• McMurdo Station, WQB
• Contaminated soils/ice/snow/sediments	• WQB, Fortress Rocks, Air Operation Areas
• Fuel/hazardous materials spills	• McMurdo Station environs
• Landscape change-(mechanical actions, constructions, excavations, fill, explosions, compaction)	• McMurdo Station
• Physical disruption of biological communities	• McMurdo Station
• Debris	• WQB
• Deposition of sewage discharges	• Discharge, Adjacent Shore
• Contaminants in biota	• WQB
• Marine benthic community change	• WQB

Figure 2: Summary of known impacts in the McMurdo Station system (Kennicutt II et al, 2010)

The pilot project also considered the logistical capabilities of the resources available. The National Science Foundation is responsible for all US activities in Antarctica but subcontracts to Raytheon. The private company carries out all the research operations within an allocated budget and utilises the scientific resources available. The COMNAP Guidelines suggest conducting baseline monitoring, defined as the “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”. Due to the fact that no impact monitoring was occurring in Antarctica during the 1950s, there is no baseline data for comparison. There were however studies conducted during this time and impact conclusions can be drawn inadvertently from the studies, such as early aerial photography as an indicator of snow cover, to substitute the unavailable baseline data. In the ongoing monitoring programme there are control sites some distance from the station to allow for comparison of effects.

A regular water quality programme has been in place at McMurdo station since 1989. Occasional hydrocarbon soil monitoring and snowmelt analysis have also taken place. The health of the local marine environment has been analysed by surveying for chemical contamination and disturbances to the benthic community. This method has received particular attention due to past waste disposal practices of ‘sea-icing’, or the act of dumping refuse on the ice during winter, where it floats away and sinks during the summer potentially causing detrimental effects to the sea floor.

Initial land disturbance to the site between the 1950s and 1970s was significant due to the overall lack of environmental impact awareness. The land was scraped and the surroundings were contoured in the process of building construction taking place. Since then the dimension of disturbed areas has not extended significantly. The lack of run-off combined with slow natural processes means that these disturbed areas will take a long period of time to recover.

McMurdo's environmental monitoring programme design was based on habitat and considers terrestrial, marine and ice-covered areas. This allows optimal sampling design as each habitat has its own unique monitoring requirements. Terrestrial monitoring includes aerial photography to monitor the snow extent, vegetation coverage and change in topsoil. These images are used to define the station's footprint and zone usage classification. Point-data sampling is used to verify the aerial photography and looks at standard soil and physical properties of the terrain as well as hydrocarbons and trace metals. Snow covered areas are also tested for suspended solids and all major runoff channels are sampled with the aim of identifying unrecognised contaminant sources.

Marine monitoring looks at the nearby benthic communities by taking contaminant measurements from sediments and biological tissue, looking at benthic community structure and abundance and conducting sediment toxicology tests. The spatial extent of human impact still needs to be determined with the use of 'through the ice' sampling in order to overcome the limitations presented to divers (Kennicutt II et al, 2010). Standard water quality measurements adjacent to sewage outfall are also performed with control sites being at a distance from the area. Of the 5 proposed transect lines, only 3 have been sampled in the ongoing programme.

The COMNAP Guidelines recommend an implementation phase of any monitoring programme and NSF has successfully facilitated this for a number of years with the help of Raytheon. Where the programme falls down is in the publishing phase of implementation. NSF publication occurs when the researchers find particularly interesting information, rather than publishing annual reports. An Information

Paper was recently submitted to the 34th ATCM meeting giving a summary of assessment on the programme design and how other Antarctic monitoring programmes may benefit from their insight. The data they collect is used to track their own progress on cleanup efforts and changes in practice to reduce impacts in the area (A. Dahood, personal communication, January 19th, 2012).

Case Study Three: Casey Station's Thala Valley Tip clean up (AUS)

Australia operates three bases in Antarctica (Casey, Davis and Mawson) as well as one base on the sub Antarctic Macquarie Island. Australia took over operation of the United States - Wilkes Station in January 1959, two years after it was opened. Wilkes station was often buried under large amounts of snow, and due to this a replacement station was built 2km away from this location and fully operation in 1969 (AAD, 2012). Again, environmental factors took their toll and the 'Old Casey station' suffered major corrosion and heat loss. This station was decommissioned, demolished and returned to Australia in 1989, with 16 buildings of the current Casey station being opened in 1988 (AAD, 2012).

Prior to The Madrid Protocol it was common practice to leave rubbish and waste behind in Antarctica, create landfill tips, allow open pit burning, and push all rubbish out on to the sea ice, where it would eventually melt and drop into the ocean (O'Brien, Todd & Kriwoken, 2004). The Thala Valley Tip was used by Casey station between 1965 – and 1986 in a time where waste disposal activities were no different, with ice melting and wastes being discharged into Brown Bay. Thala Valley was chosen as a test case for cleaning up other abandoned Australian sites that are of much larger scale, as the tip is relatively small at 2500m³ (Stark, Snape & Riddle, 2006).

In December 1993 samples were collected from the Thala Valley Tip in order to assess the contamination levels around Casey and the tip site. Results showed that the main contaminants in the soil and melt water were copper, lead and zinc as well as oil slicks leaching from the tip into Brown Bay in Summer (Deprez, Arens & Locher, 1999). Attempts to clean up in 1995-1996 were detrimental, when approximately 150 tonnes of rubbish were removed from the disposal site via an access road that was carved through the ice. This become a major disturbance to the site and its surrounds as contaminants were mobilized and dispersed to other areas (Snape et al. 1998a, 2001; Deprez et al. 1999 cited in Stark, Snape & Riddle, 2006). By examining the results of their environmental monitoring, Deprez et al (1999) found that metal and hydrocarbon contaminants in surrounding soils were higher than when the site was left untouched.

The Australian Antarctic Division completed a Preliminary Assessment of Environmental Impacts (PA) in 2002 and this determined that the cleanup of the Thala valley tip was likely to have a minor and transitory impact on the environment. Under Annex I, this meant that an Initial Environmental Evaluation (IEE) needed to be completed to assess the impact on the environment if the clean up was to occur (AAD, 2003). This IEE identified that the cleanup of this site would take ten summers, commencing in 2003/2004. It outlined the impacts on the environment that the activity would have and the measures taken to mitigate these effects. The AAD further added in its IEE that it will monitor the condition of the environment (Short term, medium term and long term) in order to detect environmental changes that may be caused by the clean up by using chemical and biological monitoring (AAD, 2003).

Environmental Monitoring of the Thala Valley Clean Up

The aim of the short term monitoring was to assess whether the techniques used for the clean-up were successful in containing the contaminants, which would be mobilised during the operation (AAD, 2003). After preliminary testing of the chemical assessments and water treatment techniques at Casey in January-February 2003, the Thala Valley clean-up operation commenced in October 2003 (Stark, 2004). The objective of the operation was to reduce the amount of contaminants leaching into Brown Bay's marine environment by removing the sources of contamination (Stark, Snape & Riddle, 2006).

Short Term monitoring

The AAD (2004, (1)) stated that "The Human Impacts Research Program is in the process of developing the most appropriate monitoring techniques for Antarctica and trialling a range of monitoring strategies in the current cleanup so we can compare their effectiveness and the information gained." This monitoring consisted of the three components detailed below, two of which are briefly outlined with regards to the COMNAP guidelines and the methods or techniques that were employed for the chemical and biological assessments.

(1) Chemical assessment of removed material:

A plan for the sampling, preparation and analysis of soil samples from the tip was prepared by the AAD environmental chemist Scott Stark (Stark, 2004). Soil sampling was carried out as specified by Australian Standards and National Environmental Protection Measures (NEPMs') under the Australian National Environmental Council Act (Stark, 2004). XRF spectrometry was used to determine the total metals in the soil because "it is a relatively straightforward, robust technique, capable of providing a direct, rapid, multi-element analysis of soil over a large concentration range." (AAD, 2004 (10)). This was compared to the Casey station background soils analysed in 1994, 1999, and 2001 (Stark, 2004). Currently there are no 'acceptable levels' of contamination written into Antarctic regulations or guidelines, so the AAD used the Tasmanian guidelines for the disposal of waste (or contaminated soil) to reduce the levels of metal contaminants to similar levels in Tasmania, where the waste was treated and disposed (AAD, 2006).

(2) Biological monitoring of the cleanup operation

The AAD developed a biological monitoring strategy which is published in the Marine Pollution Bulletin. (Stark, Johnstone, Palmer, Snape, Lerner & Riddle, 2006). Biological monitoring over the excavation period was used to provide fast and effective analysis of the short term effects of the clean-up. This involved testing the metal concentrations of water in Brown Bay and two other control locations away from the tip site using diffusive gradients in thin films methods (Stark, 2004). This was compared to the mortality of a common, near shore Antarctic amphipod crustacean suspended in mesocosms in the same sites under 2 – 3 metres of sea ice, over different periods of the 2003/2004 summer season (AAD, 2006).

Medium and Long Term Monitoring

Jonny Stark, in charge of the environmental monitoring at Thala Valley and employed by the Australian Antarctic Division, has indicated that the monitoring is still ongoing. A paper is due to be submitted for publication soon on the medium term monitoring component and there is a planned field season to continue the long term monitoring in 2013/2014 summer season.

In terms of the COMNAP guidelines, the AAD environmental monitoring follows the model of “scope, define and implement”. With regards to scoping they have identified their objective, completed background research by testing the metal contamination levels in the soils pre and post clean up in 1995/1996. With regards to defining, the AAD have identified the areas that are most relevant to monitor as the chemical aspects of soil, water around the tip and the chemical/biological aspects marine species at Brown Bay. The third step of implementation is also evident in that preliminary testing of chemical assessments and water treatment techniques was completed in 2003 and then implemented in the 2003/2004 summer. The monitoring at the Thala valley tip appears to be regular, with short term monitoring occurring at the beginning of the clean-up in 2003/2004, a paper to be submitted for review currently for the medium term monitoring and a field trip planned for the 2013/2014 long term monitoring. This short term monitoring has been published in various journals and is reported on, however all the data has not been placed in one central location. This would facilitate greater benefit from increased use of the data.

Australian guidelines have been used with Specific scientific methods created to chemically and biologically assess the impact of the activity on the environment that is required under The Madrid Protocol. Ideally these methods would be adopted into a revised version of the COMNAP Technical Handbook.

Data Centralisation

There is currently no compulsory or favoured publishing option for data relating to impacts monitoring in Antarctica. Each national programme has a responsibility to conduct quality scientific research and to “promote international cooperation in scientific investigation by exchanging, and making freely available, scientific observations and results from Antarctica” (Antarctic Treaty Article III (3) (c)). This is done through the National Antarctic Data Centre (NADC) of each national programme. In 1998 the Antarctic Treaty Consultative Meeting (ATCM) XXII ruled that each NADC would support and encourage their scientists to make their scientific findings available for distribution through the Antarctic Data Directory System. The NADC is responsible for collecting the appropriate data and entering it into the Antarctic Master Directory (AMD) who then make the datasets available internationally with relative ease. This unprecedented coordination of data collection and distribution on such a large scale promotes efficient use of resources by minimising duplication and increasing cooperation between researchers. Not all Antarctic programmes endorse the database however, so it is not a complete master directory. The data centres themselves do not extend their services to the data collected specifically for environmental impact monitoring, and as a result the Antarctic Master Directory does not in fact hold a complete record of all Antarctic “scientific observations and results” (Antarctic Master Directory, 2011).

A key part of the COMNAP guidelines for environmental monitoring programmes in Antarctica is the recommendation that the results are made available to those who seek them. The importance of sharing the results of environmental impact monitoring of Antarctic stations and bases should not be overlooked. Having data easily available can help mitigate duplication of resource use and is useful for data comparison. The sharing of knowledge and experiences is illustrated by the IP 1 submitted by the United States at ATCM’s 34th meeting. IP 1 was an assessment of the USAP programme design at McMurdo Station. The temporal and spatial patterns of anthropogenic disturbance from this study could potentially be used to give insight to other Antarctic stations and bases designing impact monitoring programmes.

The ATCM meetings can and are being used to submit Information Papers that are beneficial to other operators within Antarctica. One example is the IP 99, introduced by the Russian Federation at the ATCM 34th meeting. Here the Russian Federation had found potentially dangerous pathogenic fungi in places not recently impacted by human activity whilst conducting a study of anthropogenic impact on the Antarctic environment, and invited cooperation on the work. These types of short-term studies make up the majority of submitted Information Papers and do not contain the time scale necessary for them to be considered long-term base and station impact monitoring.

The COMNAP Guidelines suggest many avenues for the publication of environmental monitoring reports, though it must be noted that publication is not compulsory. Operational, environmental and peer-reviewed scientific journals are suggested as publication options but none of the suggested options are stated as the preferred or recommended method of reporting, meaning those seeking data must search through many avenues with no guarantee of finding it freely. The websites of individual national programmes would also be a logical place to report on environmental monitoring, although the issue of the reports not being together in the same location would remain. One solution would be to have a regular journal that was dedicated to Antarctic environmental impacting monitoring programmes. Submitting monitoring data as Information Papers to the ATCM meetings is another sensible suggestion because there could easily be a section on the ATCM website dedicated to national programmes' annual reports on their environmental impact monitoring. The same could be said for recommending publication on the COMNAP website as COMNAP is already a central body of programme managers. The Committee of Environmental Protection's (CEP) State of the Environment reporting system is in much the same situation and could also easily serve as an information hub for monitoring information, particularly if the State of the Environment Reporting System mentioned in its current five year plan eventuates.

Conclusions

After looking closely at the three case studies of Scott Base, McMurdo station and the Thala Valley Tip, no evidence has been found that the COMNAP Technical Handbook or the associated 2005 Guidelines are being used when designing monitoring programmes. Explicit reference was not made to either document at any time. This does not mean that the current environmental monitoring programmes being conducted are not effective. COMNAP's definition of "monitoring" can be applied to many of the alternative programmes running, provided they illustrate the use of standardized measurements over time and ensure statistical evaluation and reporting lead to synthesized data where it is easy to recognize both quality and trends.

In the Thala Valley tip example, Australian guidelines were utilised. McMurdo station used a system designed by an Environmental Monitoring team at the University of Texas. While similar to the COMNAP guidelines, the US monitoring system predates the COMNAP version by 6 years and the sampling techniques used are inline with US standards. Anecdotal evidence from field parties required to report on their activities whilst in Antarctica indicates that Antarctica New Zealand is aware of the COMNAP guidelines and has made attempts to incorporate them into best practice, although no explicit references to either the Practical Guidelines nor the Technical Handbook have been found.

Reporting on the methods and results of environmental monitoring programmes is not as good as it could be. It has been difficult to access historical reports relating to the various case studies due to the lack of a requirement to publish data, the range of options open for publication and the lack of a central repository. Data collected for this study was sourced from the websites of various National Antarctic Programmes, science journals, meeting minutes and through making contact with individuals from the relevant programmes. The diverse range of reporting methods presented a barrier to obtaining historical monitoring information.

The type of monitoring undertaken and methods used are different at each base. The COMANP Technical Handbook and Practical Guidelines were designed to streamline monitoring data and collection but this is not currently happening. Various tests referred to in the monitoring programmes of the three sites considered include XRF spectrometry and diffusive gradients in thin films methods, neither of which are listed in the COMNAP documents as preferred testing methods.

Recommendations

In order for the COMNAP Technical Handbook and Practical Guidelines to become more effective, changes need to be made at a higher level. The documents provide a guide that may be used by National Antarctic Programmes at their own discretion but nothing is mandatory. The Madrid Protocol needs to be modified to make a specific set of standard monitoring requirements compulsory in order to ensure that the intended streamlining and standardizing of monitoring data takes place.

These monitoring requirements should set out a minimum level of monitoring and reporting to be conducted by each National Antarctic Programme. One current issue is the way decisions on what should be monitored are made based on expected impacts. Introducing mandatory testing for variables such as air quality, water quality and substrate quality would provide a consistent set of data that would also reveal any unexpected impacts of the human activity. This could be achieved by altering the Protocol to make certain tests in the Handbook compulsory, while providing for regular updating of the Handbook to keep these tests in line with best practice. The Guidelines would still reflect the practical implementation of the steps in the Handbook, but making particular tests compulsory would provide more incentive for National Programmes to pay closer attention to them.



Mandatory reporting would ensure environmental monitoring data was openly available and easily accessible. To this end it would be beneficial to include a requirement for annual reports on environmental impact monitoring, including but not limited to the compulsory tests, to be forwarded to a neutral, centralised location and kept in a repository. This would make the data easily available to all national programmes and make it easier to identify historical trends. As the identification of quality and trends is one of the key elements of ‘monitoring’ according to COMNAP’s definition, these steps would lead to more effective environmental monitoring in Antarctica and help ensure the continent remains a place that is “valued, protected and understood”.

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