Summary of Environmental Monitoring Activities in Antarctica

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Introduction

> ***"Environmental monitoring is a fundamental element of basic research, environmental management and conservation ... monitoring data are important in the development of models of environmental processes, which in turn facilitate progress towards a predictive capability to detect environmental impact or change".***
> *(SCAR/COMNAP, Discussion Document, 1992)*

This document summarises environmental monitoring activities that have been conducted in Antarctica during recent years. It aims to demonstrate the existing level of Antarctic monitoring, to increase awareness of monitoring activities and help to avoid duplication of information gathering, particularly at multiple operator sites.

The document also provides a source of reference for those planning monitoring programs in Antarctica. It is anticipated that the information will be used to identify gaps in current Antarctic environmental monitoring studies.

While this document is most likely incomplete in its coverage of all environmental monitoring activity currently being carried out in Antarctica, it does provide an indication of the types of studies undertaken and the range of impacts and parameters being monitored.

Improved accessibility to existing data sets will be essential to the success of new environmental monitoring regimes developed to fulfil the requirements of the Protocol on Environmental Protection to the Antarctic Treaty.

The range of monitoring activities listed in this document is diverse although the most common types of monitoring studies undertaken include:

- Atmospheric pollutants associated with station activities
- Quantity and quality of sewage and waste water discharges
- Levels and fate of hydrocarbons in soil and/or water
- Population counts and/or breeding success of Antarctic birds
- Heavy metals in plants, soil and sediment
- Contamination and pollutants in freshwater lakes
- Photography at fixed sites/intervals at stations/field sites

Monitoring information is presented by country under the following categories:

- Existing human impacts monitoring activities;
- Publications on environmental monitoring;
- Research on baseline levels of pollutants in the Antarctic environment.

The information contained in this document has been compiled, and continues to be updated by the Antarctic Environment Officers Network (AEON) of COMNAP.

Argentina

Updated on 27 October 2003; downloaded on 24 July 2006

Existing Human Impacts Monitoring

Analysis of the impact of Esperanza Station on its nearby Adelie penguin rookery	From the beginning of the fifties, Esperanza Station started to run virtually on a territory formerly occupied by one of the most important Adelie rookeries of the Antarctic peninsula. Based on air photos, population estimates and historical maps, rookery behaviour (connected to the Station) was analysed. A monitoring program for the future was set out in order to produce an environmental management plan that might reduce Station impacts on the rookery.
Environmental monitoring at Marambio Station	The aims of the environmental monitoring program at Marambio Station are: to assess operational impacts derived from main current activities and to provide information about mid-term and long-term evolution of corrective and/or mitigation measures put in practice as a result of management recommendations. The variables considered are: hydrocarbon and heavy metal presence in plant samples, total hydrocarbon and trace elements in water and sediment samples, total hydrocarbon samples in areas with spillage risk and systematic effluent monitoring.
Monitoring of atmospheric constituents with climatic impact at the Antarctic stations	Belgrano Station The total ozone measures are made to reveal the annual course of the ozone at the Belgrano Station. The springtime depletion is at the focus of our task. Measurements are made virtually year-round, in a continuing program to document changes in Antarctic ozone. For the twilight month total ozone amounts are deduced from moonlight observations, because of the low sun elevation. Jubany Station Monitoring of atmospheric trace gases increase. Measurements of relative abundance of carbon dioxide, in order to obtain background conditions of this greenhouse gas. Sampling method - non-dispersive infrared analyser (NDIR), continuous. Marambio Station Similar to work at Belgrano Station. During twilight conditions total stratospheric ozone amounts have been deduced from electrochemical concentration cell ozonesonde soundings.
Research on contaminant pathways in coastal shallow food webs	This line of research is oriented towards the knowledge of the transfer of pollutants of anthropic origin through the food web in a shallow coastal environment of Antarctica (Potter Cove, King George Island). Special attention is paid to the dynamics of these substances and their relationships with energy transfer, more than on their presence in different compartments of the ecosystem. A conceptual model of possible pathways was developed.

List of Publications on Environmental Monitoring

Acero J.M. and Aguirre C.A. Human Activities and Adelie Penguin at Hope Bay (Antarctic Peninsula). I. Habitat selection and evolution of the colony area. (Under referees review in Marine Ornithology).

Acero J.M. and Aguirre C.A. (1993) Adelie Penguin Breeding Site Selection and its Relation to Human Presence. Report Workshop on Research - Sea Birds Interactions. Monticello, Minnesota, USA.

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Anav A., Valenti C. and Guerrini A. (1996) Brewer Data from the Belgrano Antarctic Station. Quadriennial Symposium on the Ozone Layer, L¥Aquila, Italia, 1996.

Cazeneuve H., Guinzburg M and Duarte M.L. (in prep) The Ozone Layer over the Antarctic Stations Belgrano and Marambio, during the Period of the Mt. Pinatubo Eruption.

Cazeneuve H., Rodriguez S., Yela M and Cacho J. (1995) NO_2 and O_3 Evolution in the Antarctic Polar Circle: One Year of Measurement at Marambio Station. Symposium on Process with Climatic Impacts. Haikidiki. Greece.

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Yela M. and Rodriguez S. (1996) NO_2 and O_3 Total Column at different latitudes in the Antarctic Continent, by Differential Spectroscopy. Quadriennial Symposium on the Ozone Layer, L¥Aquila, Italia, 1996.

Australia

Updated on 27 October 2003; downloaded on 24 July 2006

Existing Human Impacts Monitoring

Aerial photography of station environs	Aerial photography is being used to monitor changes in the level and extent of activities associated with Davis, Casey and Mawson Stations on a three year cycle.
Aircraft operations	A one-off study was undertaken in 1994-95 to assess the effects of long-range helicopters on atmospheric particle loadings at Davis. Atmospheric organic carbon loading, elemental concentration of aerosol and total suspended particle mass were measured.
Antarctic Treaty (Environmental Protection) Act 1980 (ATEP) Permit System Database	Australia collects information on the collection of all specimens from the Antarctic and all activities within Sites of Special Scientific Interest (SSSI) and Specially Protected Areas through the ATEP permit system. This information is accessible through a database and will be available for long-term monitoring of activities.
CCAMLR Ecosystem Monitoring Project - Adelie penguin and fulmarine petrel monitoring	Adelie penguin and fulmarine petrel foraging activity and reproductive success is being monitored to determine whether fishing in the CCAMLR region is effecting dependent and associated species in the region.
Cultural eutrophication of oligotrophic lakes	Levels of nutrients and their natural and anthropogenic sources are being studied in lakes both close to and distant from human activity in the Larsemann Hills.
Effects of cement dust on mosses and lichens at Casey	The distribution of cement dust and its effects on moss and lichen communities at Casey during the rebuilding program was monitored. Recovery of the plant communities continues to be monitored.
Effects of helicopter operations on Antarctic wildlife	Experiments are being undertaken to quantify the effects of helicopter operations on Antarctic wildlife.
Environmental Impact Assessment Database	All activities in the Antarctic are subject to Preliminary Assessment of Environmental Impacts before approval. Information gathered by this process is collated in a database and is available for long-term monitoring of activities.
Heavy metals and organic pollutants in the nearshore marine environment	Levels of heavy metals and selected organic pollutants are being measured in biotic and abiotic components of the nearshore marine environment adjacent to stations. Toxic effects and the rates of accumulation and depuration of pollutants by marine organisms are being measured.
Incinerator operations	The weight and type of material to be incinerated and the weight of incinerator residue have been measured on occasions at Casey station. CO_2, CO, NO, and HCl emissions have been measured on nine occasions.
Introduced diseases in	Monitoring of Antarctic vertebrates for introduced diseases has

Antarctic vertebrates	commenced with a baseline study of the microbial, viral and parasitic flora and fauna of Adelie and emperor penguins at sites adjacent to and distant from human activity.
Introduced fungi at Casey	A survey of fungi at Casey and on ships, clothes, resupplies etc has been undertaken in order to identify fungal introductions and the mechanism of their introduction.
Introduced plants in the Larsemann Hills	The site at which four species of higher plant have been found growing outside in the Larsemann Hills is being monitored annually to determine whether viable seeds are still present.
Lead and trace metals in lakes	Levels of trace metals and their natural and anthropogenic sources are being studied in lakes close to and distant from human activity in the Larsemann Hills.
Pelagic plastics in the Southern Ocean	Stranded plastics from beaches on sub-Antarctic Islands and floating plastics from the Southern Ocean are being collected and catalogued to determine the principle sources the quantity and their effect on the flora and fauna.
Population monitoring of Adelie penguins	Photographic records of Adelie penguin populations both adjacent to and distant from stations are maintained to determine the status and trends of the colonies.
Seals in the Vestfold Hills	The number of Weddel seals, their pupping sites and the number of pups successfully reared has been monitored over 20 years. This data set could provide a valuable baseline for detecting the effects of station or other human activity on seals. The number of elephant seals on Davis beach were monitored intermittently during 1957-77 and every year during 1978-present.
Sewage effluent	Suspended solids (mg/L), BOD (mg/L) and dissolved oxygen are monitored in sewage effluent routinely. Faecal coliforms have been measured at nearshore sites on occasions.
Station use of fossil fuels	Fuel consumption by powerhouses is recorded every 3 hours and monthly fuel consumptions for power generation sets, boilers, incinerators and vehicles are recorded. Vehicle use is monitored on a monthly basis.
Wilderness and aesthetic values of the Antarctic	Procedures are currently being developed for assessing wilderness and aesthetic values so that changes over time can be monitored. The techniques will concentrate on the zone of transition between those places that are clearly influenced by human activity and those that are clearly untouched wilderness. Definition of the transition zone is hoped to provide a mechanism to monitor and subsequently control the insidious spread of station activity.
Wind blown debris	The quantity of wind blown debris within and around stations in the Larsemann Hills, and at Davis and Casey has been measured and can be used as a baseline to indicate whether changing practices are leading to improvements.

List of Publications on Environmental Monitoring

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Antarctic Ecosystems: Ecological Change and Conservation. 347-353.

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Clarke, J.R. and Kerry K.R. (1994). The effects of monitoring procedures on Adelie penguins. CCAMLR Science. 1:155-164.

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Hindell, M.A., Brothers, N., and Gales, R. 1995. Cadmium and mercury levels in the tissues of three species of southern albatross. Abstract. First International Conference on the Biology of Albatross, Hobart, 1995.

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Woehler, E.J. (1990). The distribution of seabird biomass in the Australian Antarctic Territory: implications for conservation. Environmental Conservation. 17(3):256-261.

Woehler, E.J. (1990). Two records of seabird entanglement at Casey, Antarctica. Marine Ornithology. 18:72-73.

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Woehler, E.J., Penney, R.L., Creet, S.M. and Burton, H.R. (1994). Impacts of human visitors on breeding success and long-term population trends in Adelie penguins at Casey, Antarctica. Polar Biology. 14:269-274.

Research on Baseline Levels of Pollution in the Antarctic

Atmospheric measurements from deep ice cores
Characteristics of past and present atmospheres including CO_2, methane, NO_x, radioactivity, oxygen isotope, peroxide, lead, other trace chemicals and micro particles are being measured in deep ice cores from Law Dome.

Atmospheric sulphur species
Atmospheric dimethylsulphide, sulphur dioxide, non-sea-salt sulphate and methane sulphate are being

measured from aerosol filter samples in a latitudinal transect between Mawson and Tasmania.

Recent environmental and climatic variability from shallow ice cores (ITASE)
Shallow ice cores representing the last 200 years will be collected between Dome Concordia and Casey Station and analysed for Ca, Mg, Na, NH_4, K, Cl, SO_4, NO_3, F, I, Br, MSA, H_2O_2 and HCHO as part of the International Trans-Antarctic Scientific Expedition (ITASE).

Trace metals in recent Antarctic snow
Recent snow from a large geographical area in the Antarctic is being analysed to determine the levels of dust derived Al, Fe and Mn and to calculate annual atmospheric deposition of these trace metals.

Chile

Updated on 27 October 2003; downloaded on 24 July 2006

Existing Human Impacts Monitoring

Periodical collection of marine debris on Livingston Island	The study includes periodic collection of marine debris in 36 different places of the SSSI No. 32 at Livingston Island since 1990, according to CCAMLR procedure including: analysis of such material in order to inform periodically to CCAMLR; and elaboration of documents to be presented to CCAMLR and to INACH in order to be published in the Serie Cientifica Journal and in the Boletin Antartico Chileno.

List of Publications on Environmental Monitoring

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Torres, D. y A. Aguayo, (1993). Impacto antr_pico en cabo Shirreff, isla Livingston, Antartica. Ser. Cient. INACH 43:93-100.

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Torres, D. (1992). Synthesis of the environmental impact studies at Cape Shirreff, Livingston Island, Antarctica. In: International Seminar "Science in Antarctica". Universidad de Chile, National Science Foundation, Universidad de Magallanes, Punta Arenas, Chile, 12-16 April 1992. 8 pags.

Research on Baseline Levels of Pollution in the Antarctic

Ecotoxicological project
Will obtain information on pesticides and heavy metals present in tissues of Antarctic fur seals and other seals and sea birds.

Monitoring, analysis and impact of marine debris pollution
Baseline established at the SSSI No 32, Cape Shirreff and in San Telmo Islets, Livingston Is. Antarctica, by INACH in order to carry out monitoring activities season after season.

China

Updated on 27 October 2003; downloaded on 24 July 2006

Existing Human Impacts Monitoring

Implementation of monitoring program since 1991/92 in association with scientific research	Focus on baseline levels of pollutants, on sewage water, coastal ecosystems, atmosphere and lakes in the vicinity of stations' and the local environment.

List of Publications on Environmental Monitoring

A preliminary study of organochlorine pesticide pollution in the adjacent waters of the Great Wall Station, Antarctica; petroleum pollution in the adjacent waters of the south of Fildes Peninsula; a preliminary analysis of the distribution of faecal coliform bacteria in the near-shore waters of the south of Fildes Peninsula, Antarctica; and bacterial monitoring before and after treatment of sewage at the Great Wall station, Antarctica.

France

Updated on 27 October 2003; downloaded on 24 July 2006

Existing Human Impacts Monitoring

Coliform bacteria in sea water at Dumont d'Urville Station	The aim of this program, commenced in 1996/97, is to monitor coliform bacteria in the seawater around the station. Effluent is discharged into the sea, although there are plans to install a sewage treatment plant next year.
Population dynamics of Antarctic birds and seal breeding in the Dumont d'Urville area	Population dynamics of Antarctic birds and seals breeding in the Dumont d'Urville area have been monitored since 1956. Data are recorded in an in-house database in a French laboratory.

List of Publications on Environmental Monitoring

Chastel, Weimerskirch and Jouventin. (1993). High annual variability in reproductive success and survival of an antarctic seabird, the snow petrel Pagodroma nivea : a 27-year study. Oecologia 94 : 278-285.

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Jouventin. (1992). Antarctic fauna: the threats and their control. In "The Antarctic environment and International Law", Werhoeven, Sands Bruce eds, Graham Trotman publ., p 33-38.

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Germany

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Existing Human Impacts Monitoring

Air chemistry monitoring station at Neumayer Station	A considerable number of trace gases and particulate components of the air are either measured continuously or sampled for later analysis in the home laboratories. The measurements also provide information on emissions caused by combustion of liquid fuels at the station, such as exhaust gases of the station's diesel generators and snow vehicles. The combustion products routinely monitored at the observatory are carbonaceous particles (black carbon), polycyclic aromatic hydrocarbons (PAH), condensation nuclei (CN), and carbon dioxide (CO_2). Other trace compounds such as nitrogen oxides, peroxides, hydrocarbons, heavy metals, etc. are investigated on a campaign basis.
Gas emissions at Neumayer Station	The exhaust gases of the two diesel generators are controlled and regulated and emission data are monitored fortnightly. The generators are equipped with catalytic converters and waste heat of the two main engines is used to heat the station and to run a snow melter for the production of water.
Human impact monitoring work on the bird mortality in longline fishery	The Federal Research Institute for Fisheries in Hamburg undertakes this work as well as investigations into the effects of commercial fishing activities on fish and krill stocks in the Southern Ocean.
Monitoring of the waste stream	When returning aboard RV "Polarstern", the base commander of the Neumayer Station and the group leaders of field operations are responsible for providing a detailed waste-checklist to the ship's First Officer and to the scientific cruise leader. The checklist includes all types and amounts of garbage and hazardous waste such as chemicals, batteries, used oil and other lubricants as well as the number of full and empty fuel drums. A waste-diary is held on the ship and at the Alfred Wegener Institute.
Monitoring of waste water at Neumayer Station	In January 1997, a biological treatment plant was installed. After microbial decomposition the wastewater is exposed to ultra-violet radiation and then discharged into an ice pit. Regular monitoring of the quality of wastewater will be carried out to test the efficiency of the new system.

List of Publications on Environmental Monitoring

Publications and reports on German monitoring work in the Antarctic, produced by Alfred Wegener Institute (1-5) and the Institute for Fisheries, Hamburg (6-7).

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Research on Baseline Levels of Pollution in the Antarctic

Baseline levels of anthropogenic organochlorine compounds in tissues from seals and in fish of the Weddell Sea and the Bransfield Strait

The investigations, carried out by the Alfred Wegener Institute, aim at characterising bioaccumulation of organohalogens in Antarctic biota and to evaluate global sources, transport, and cold condensation of these

compounds.

Serological study on seals in the Weddell Sea
This study documented antibodies against phocine and feline herpesvirus. Information is provided on the significance and possible origin of infections.

Italy

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Existing Human Impacts Monitoring

Airborne particulate matter monitoring	During the 1986-87 expedition the collection and the analysis of samples was planned and performed in order to obtain preliminary environmental information before the regular operation of the Base. Sampling was done at a site located 1200 metres SW of the base, at an elevation of about 120 metres. The sampling was concentrated on airborne particulates and freshwater to obtain their composition and background levels. During the following years sampling of airborne particulate matter was performed in more sites and analyses were focussed on inorganic and organic compounds that could give a better picture of the impact of human activities all around the Base (the most significantly heavy metals and PAH).
Incinerator monitoring	Difficulties have arisen with the incinerator monitoring program. The greatest problem is due to carry out isokinetic samplings. This is partly due to the fact that the incinerator is a model especially designed for a community of about 60 people and because waste is burnt discontinuously and not homogeneously. Particulate matter sampling was performed with analysis to characterise the daily emissions.
Sewage treatment plant monitoring	The biological sewage treatment plant was monitored taking into account BOD_5, (Biological Oxygen Demand), COD (Chemical Oxygen Demand), temperature, salinity, pH, conductivity, turbidity, fecal coliforms, total coliforms and streptococci. Later, BOD_5 was measured only on a non-routine basis.

List of Publications on Environmental Monitoring

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Research on Baseline Levels of Pollution in the Antarctic

Environmental contamination on a global scale
The studies are concerned with: transport and diffusion processes of pollutants on a global scale; pollutant distribution in marine and lake matrices; reference materials and quality control studies; and Antarctic Environmental Sample Bank.

Japan

Updated on 27 October 2003; downloaded on 24 July 2006

Existing Human Impacts Monitoring

Biological program	Population census of Adelie penguin and Weddell seal are carried out and several penguin rookeries are selected for this purpose. Flora and fauna in the Yukidori Valley SSSI (No 22) are monitored annually. Several sites within the SSSI are selected for long term monitoring.
Fuel stock	Fuel piping, storage tanks and related facilities are checked weekly and additional checks are conducted after storms. Fuel tanks are sounded to determine their volume and monthly consumption is checked. Oil spill protection bank sorrounding oil tank is now being set up and new type of double pipe is introduced to oil pipelines.
Limnological program	Several lakes are selected for long term monitoring and these lakes are located from a few kilometres to a hundred kilometres away from the station complex. Water temperature, conductivity, pH, oxygen and nutrient salts are observed irregularly.
Monitoring of potable water	Potable water is obtained from two sources; one is pumped from a small pond near the station complex during summer period and the other is pumped from a snow-melter during winter period. Conductivity, rate of reverse osmosis and pH value are measured every month. An examination of a colon bacillus is made two-four times a year.
Monitoring of waste water at Syowa Station	Biological treatment plant was introduced in 1999. 6 square metres of sewage is processed and dumped into sea daily.
Oceanographic program	Surface water is routinely sampled along the cruise track of icebreaker between Japan and the Antarctic. Samples are analyzed for heavy metals and oil concentration.
Soil algae and oil bacteria	Soil samples are collected annually from routine sampling sites in and around the Syowa Station complex. These samples are analyzed in Japan for detecting occurrence of algae and bacteria.
Waste material removal	Waste segregation, collection and removal from the Antarctic to Japan are managed and monitored routinely. Waste materials are categorised into the following: batteries; fuel, used oil and other lubricants; chemicals; glass; PVC and plastics; rubber and tires; used drums; metals; light bulbs; miscellaneous wastes. These wastes are measured and returned to Japan.

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Toyoda, S. Matsumae, A. Ghoda, A, and Aiso, M. (1986): Total number of bacteria and fungi as an index for human pollution at Syowa Station in Antarctica 1. Special reference to the specimen collected by 18th Japanese Antarctic Research Expedition. Japanese Journal of Bacteriology Vol. 41, No. 2, 527-534

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Research on Baseline Levels of Pollution in the Antarctic

Atmosphere program
Surface water and air are sampled and analyzed for CO2, O3 monitoring on board Shirase and at Syowa Station. Aerosol sampling is conducted at selected inland points and at Syowa Station.

Biological program
Surface water is monitored on board Shirase to have data of water temperature, nutrient salt, and planktons.

Glaciological program
Sea ice is collected and monitored on board Shirase. Snow sampling and analysing are conducted at selected inland points.

Meteorological program
Ground base measurements of carbon dioxide, methane and surface ozone are routinely carried out. Air samplings for CFC and carbon isotope measurements are also made. Total and vertical distributions of ozone in the stratosphere are measured.

Oceanographic program
Oceanographic data are collected through satellite antenna.

Korea, South

Updated on 27 October 2003; downloaded on 24 July 2006

New Zealand

Updated on 8 April 2005; downloaded on 24 July 2006

Existing Human Impacts Monitoring

Cape Roberts Project	A full monitoring program was required by the Comprehensive Environmental Evaluation completed for the project and included a range of methods from photo-monitoring to record keeping, sampling and analysis. Monitoring conducted from 1995 to 2001 included investigations into changes in terrestrial vegetation and skua breeding colonies, the degree of visible surface disturbance and soil contamination, records of fuel spills and monitoring of waste emissions.
Field activity records	A database is kept of all Antarctica New Zealand supported field activities, including site name, dates of occupation, number of people and details of activity including protected area entries, sampling and inteference with flora and fauna. The database has been populated with retrospective records back to 1957.
Fuel use spills	Records are kept of fuel use for Scott Base, field operations and vehicles, and of all fuel spills which occur. Soil sampling is carried out selected spills at Scott Base and in the field. Analysis of total petroleum hydrocarbons in soils from the affected sites and control sites will continue in order to assess the effectiveness of remediation activities carried out after the spills were discovered.
Photo-monitoring - Scott Base	Seven fixed photo-monitoring sites were established at Scott Base in October 1994. A fixed view from each site is photographed each season with the aim to detect and record changes over time in the topography, facilities and other features of the Scott Base environment.
Scott Base sewage outfall	The aim of this program is to assess the environmental impact of the sewage discharge at Scott Base on the marine environment. The program includes sewage discharge quantity and quality including seasonal variations, and a yearly study of faecal coliforms, suspended solids, BOD and nutrients in seawater out from the outfall. Weekly measurements were made from 1995 to 2003. Following the installation of a biological treatment plan for Scott Base sewage, the focus has shifted from receiving water quality to effluent quality.
Vanda Station decommissioning	A monitoring program was undertaken from 1994 to 2002 in accordance with the requirements of the Initial Environmental Evaluation completed to cover the decommissioning. The program included sampling of water and cyanobacterial mats at the old station site and a control site. The samples were analysed for nutrients and heavy metals. The dataset collected provides sufficient understanding of natural variation to allow periodic sampling and analysis to detect contamination should an event such as rising lake levels occur.

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Research on Baseline Levels of Pollution in the Antarctic

Atmosphere mercury levels in the Ross Dependency
Mercury concentrations in the atmosphere in and around Scott Base were measured during a 3-week period in January and February 1987. Mercury levels within Scott Base were low, varying in the range of 8 to 124 ng/m^3. A total of 34 samples collected up to February 23 gives a total gaseous concentration of 0.44 + 0.12 ng/m^3. These data are comparable to those measured at Lake Vanda in December 1985 and are lower than those recorded in New Zealand, typically about 1 ng/m^3.

Chemical and nutrient analysis of meltwater in the Victoria and McKelvey Valleys
Melt waters and marginal melt in the lakes of the Victoria and McKelvey Valleys were sampled during January 1990. Analysis includes major elements, trace metals and nitrogen and phosphorous-based nutrients. Chemical analysis includes pollutant trace metals: Cu, Zn, Pb, As and Cu. Six samples of tissue and skin were taken from mummified seals around the eastern end of Lake Vanda for analysis of traces of dioxin and

PCB.

Environmental pollutants from the Scott and Shackleton expeditions during the Heroic Age of Antarctic exploration
This investigation found high concentrations of polyaromatic hydrocarbons in soils under and around the historic fuel depots, including anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, fluorine, and pyrene, as well as benzo[a]anthracene, benzo[a]pyrene, and fluoranthene, which are recognized carcinogens. Asbestos materials within the huts have been identified and extensive amounts of fragmented asbestos were found littering the ground around the Cape Evans hut. Published in Polar Record Vol 40 (31) (Blanchette, R.A., Held, B.W., Jurgens, J.A., Aislabie, J., Duncan, S., Farrell, R.L., 2004). Copyright: Cambridge University Press.

Heavy metal pollution in Antarctica: a molecular ecotoxicological approach to exposure assessment
Trematomus bernacchii sampled from two sites at Ross Island, Antarctica, were assessed for condition (gonadal and hepatic somatic indices and condition factor), pathological state (liver and gill histology), hepatic metal (Zn, Cu, Cd and Ni) concentrations, and metallothionein induction by quantitative competitive (qc) RT-PCR. Fish from a polluted site (Winter Quarters Bay) had pathological anomalies including necrosis and periductal inflammation in their livers, and X-cell disease, epithelial hyperplasia, lamellar fusion and aneurysms in their gills. Such anomalies were less common in fish from a relatively pristine site (Backdoor Bay, Cape Royds). Fish from both sites had similar liver concentrations of Zn, Cu and Cd and qcRT-PCR revealed similar levels of hepatic metallothionein mRNA. Ni in the livers of fish from Winter Quarters Bay were higher than those in fish from Backdoor Bay, but the differences were not great enough to affect hepatic metallothionein mRNA significantly. Despite the polluted state of Winter Bay Quarters Bay waters, it seems that the heavy metals present may have only limited impact on the health status of fish collected from this locality. This may reflect a low bioavailability of the heavy metals in Ross Island marine sediments and suggests that other factors, such as relatively high levels of organic pollutants (PAHs, PCBs) or pathogens from the nearby sewage outlet, may play a more significant role in the aetiology of pathological conditions in fish from Winter Quarters Bay. Published in Journal of Fish Biology, Vol 57A (Evans, C.W., Hills, J.M., Dickson, J.M.J., 2000).

Hydrocarbon spills on Antarctic soils: effects and management.
A review was conducted of the current understanding of the physical, chemical and biological effects of hydrocarbon spills on Antarctic soils. Published in Environmental Science and Technology Vol 38 (5) (Aislabie, J.M., Balks, M.R., Foght, J.M., Waterhouse, E.J., 2004).

Measurement of trace gases and aerosol size distribution on the Ross Sea Region
Gas samples were taken in the Ross Sea region in 1986/87 to measure the size distribution and concentration of aerosol, backed up by atmospheric boundary layer measurements at three sites. Aerosol and boundary layer measurements were taken over seven to eight day periods at each of the sites, sixteen kilometres east of Williams Field, MacDonalds Beach at Cape Bird, and Bratina Island in the dirty-ice area.

Mercury in Antarctic snow
Snow samples were taken and analysed for mercury on the Antarctic Plateau, near Horseshoe Mountain. Results from samples on the Ross Ice Shelf in the 1987-88 season indicated that mercury levels, at probable <1ng/kg were very much lower than obtained in the Arctic or the Antarctic by other investigators.

Sources of organic nitrogen, phosphorus and carbon in Antarctic streams
Dissolved and particulate organic materials were analysed in 14 stream waters of the McMurdo Sound region. These streams are fed by glacial meltwaters and pass through catchments largely devoid of terrestrial vegetation. Nonetheless they contained measurable amounts of organic material in both dissolved and particulate form. Most of the dissolved organic carbon (DOC) values lay in the range 1-3g C m^{-3}. Higher values were recorded close to penguin rookeries on the coast. Dissolved organic nitrogen (DON) concentration was generally two orders of magnitude less than DOC.

TBT contamination identified in Antarctic marine sediments
Butyltin contamination in marine sediments was found at six sites in McMurdo Sound, with concerntrations up to 2290 mug Sn kg-1 found. The research is published in Marine Pollution Bulletin, Vol 48 (Negri, A.P.,

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The analysis of reduced sulfur gases in air and melt waters by gas chromatography at Bratina Island
Water column and sub-cyanobacterial mat aqueous samples were examined from various sites within the Bratina Island Pond study area. Pond waters above the mats generally contained only dimethylsulfide (DMS) and carbon disulfide (CS_2). The sulfur gas composition of sub-mat waters was more variable, but often dominated by hydrogen sulfide (H_2S). The only reduced sulfur gases detected in the atmosphere were DMS and CS_2, a manifestation of the importance of biological activity within the aqueous systems of the dirty ice.

Trace elements concentrations in Lake Vanda, the Onyx River and Don Juan Pond, Wright Valley, Antarctica
Previously reported enrichment of Cu, Zn and Ni in the basal brine at Lake Vanda could not be confirmed. Concentrations of Mn and Fe in the upper levels of Lake Vanda are lower than those of the Onyx River, though both elements are enriched in the basal brine by re dissolution of descending oxide precipitates. Don Juan Pond is a calcium-chloride evaporite brine to the west of Lake Vanda. Of the trace elements assayed in the basal brines of Lake Vanda, only Pb, Zn and Sr levels are significantly higher in the Don Juan Pond; Cu, Ni, Co, B, and Ba levels are similar or slightly higher, and those of Mn and Fe lower.

Trace substances in Antarctic air and snow
This work aimed to determine the sources of a range of chemical species, the method of their transport to the East Antarctic Plateau (78°1.5’S 139°38.2’E) and the relationship between snow concentrations and the impurity content of the atmosphere. Shallow firn cores were also collected to look at a short historical record of these contaminants. Data has been obtained on the following "contaminants" which have predominantly natural sources in this region: the ions: chloride, nitrate, sulphate, MSA, sodium, potassium, magnesium, calcium as well as aluminium and Beta Radiation.

Ultratrace pollutants in Antarctic air and snow
Snow and air were sampled at a remote site on the Ross Ice Shelf to examine the air/snow relationship for a range of impurities. Air was filtered for analysis of natural particulate impurities (aerosols) such as rock dust, sea-salt and sulphate and possibly for pollutant heavy metal determination. Freshly fallen snow as collected after the one major snowfall event and two snow cores down to approximately 4 metres depth were taken. In addition a series of samples down to a depth of 1.33m were processed for analysis of toxic organic pollutants such as pesticide residues and dioxins.

Russia

Updated on 27 October 2003; downloaded on 24 July 2006

Existing Human Impacts Monitoring

Analysis of available scientific and technical data - first Antarctic expeditions to present	This work aims to obtain basic information on the initial environment state of the area, detail the geographical scale of the performed work, to identify areas for environmental monitoring based on the observation series and to determine areas for comparative analysis and modelling of the ecosystem recovery process following disturbance. Results have included a chronology of Russian research in Antarctica, a description of natural conditions of the RAE station areas and their infrastructure, and a scientific monograph on Bunger and Schirmacher Oases as potential areas for the long-term monitoring is ready-to-publish.
Biological program	Monitoring of population dynamics of birds of the Fildes Peninsula has been continued during the summer season of 1997-98 at the Bellingshausen Base, including mapping of seabird breeding colonies and skua nesting territories. Breeding biology studies of birds with emphases on giant petrels and skuas including population counts throughout breeding season, phenology, breeding success, feeding ecology and predation. Studies of human impact upon most vulnerable bird species including southern giant petrel and skuas (behavioural responses in birds, usage of base vicinities as feeding biotopes, breeding success etc.).
Clean-up program	Waste removal, clean-up of current pollution at the base areas, reconstruction of fuel tanks is continuing at the Mirny, Molodezhnaya and Bellingshausen Bases.
Ecological state of the Progress Base	Soil and water samples will be taken from the area adjacent to Progress Base (Larsemann Hills) to be analysed for heavy metals, hydrocarbons and other pollutants.
Reduction of the Molodezhnaya Base and reopening of the Progress Base	The first stage of the reduction of Molodezhnaya Base will be carried out during 1997/98 including evaluation of building condition, determination of recommendations for dismantling the main houses and a study of possible further transfer to the Progress Station.

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Research on Baseline Levels of Pollution in the Antarctic

Lake monitoring
Measurements of hydrochemical parameters is conducted in water bodies of Shirmacher Oasis including Lake Glubokoe which has been impacted earlier. Comparison of data obtained by autonomous probe and by sampler with further analysis in the lab is carried out to establish long term monitoring using autonomous probe.

Land ice monitoring work
Deep ice drilling at the Vostok Base has been continued. Analysis of ice deep cores will update data base on atmosphere contents including methane, carbon dioxide and dust.

Monitoring of trace gases and ozone
Ground base measurements of ozone were conducted at Molodezhnaya in 1997/98. Measurements of carbon mono-oxide, methane, total ozone, distribution patterns of aerosol and integral decreasing of solar radiation by aerosol are carried out at Mirny Base.

Observations on the abiotic objects state including
This work aims to identify local sources and input mechanisms of contamination, to study the spatial-temporal variability of the concentration of contaminants in soil and water, to determine possible cumulative impacts on the environment, to simulate processes occurring in ecosystems affected by the human activity in order to predict their behaviour.

Sea ice monitoring work
Sea ice distribution and dynamics are recorded routinely by means of remote sensing, land and ship base visual observations.

South Africa

Updated on 27 October 2003; downloaded on 24 July 2006

Existing Human Impacts Monitoring

Environmental health and safety audit program of the new SANAE IV facility at Vesleskarvet, Queen Maud Land.	The auditing program consists of the following elements: * on site audit of the EHSMS of the new SANAE IV facility * on site audit of the waste management program * on site audit of compliance of the code of conduct

List of Publications on Environmental Monitoring

Audit report: 1993/94 Summer take-over of the construction phase of the new SANAE IV facility at Vesleskarvet, Queen Maud Land, Antarctica.

Audit report: 1994/95 Summer take-over of the construction phase of the new SANAE IV facility at Vesleskarvet, Queen Maud Land, Antarctica.

Spain

Updated on 27 October 2003; downloaded on 24 July 2006

Existing Human Impacts Monitoring

Global Change monitoring at Juan Carlos I Base, Livingston Island, South Shetland Islands	Monitoring activities include work on trace gases (CO_2, O_3, NO_x) through specific sensors, climatic and meteorological parameters through automatic meteorological stations and ozone soundings and radio soundings (up to 40 km).
Monitoring of gases	Monitoring activities include measurements on gases emissions of the generators, vehicles and septic tank (CO, NO, NO2, HCO).
Monitoring of littoral ecosystem South Bay, Livingston Island	Monitoring activities include work on physical, chemical and biological characteristics of coastal waters and benthic communities. The work is related to the CS-EASIZ program.
Monitoring of noise	Monitoring activities include studies on the noise intensity of the generators and vehicles.
Monitoring of septic tank emanations	Monitoring activities include studies on physical, chemical and microbiological characteristics of the septic tank waters (methane, ammoniac, SO2,CO2), sewage, sea water and fresh water (ammoniac, pH, nitrites, nitrates, oxygen, phosphates, DBO and temperature).
Monitoring of soil contamination	Monitoring activities include measurements on volatile contents in different zones around the station, storage fuel zone (fuel hydrocarbon, SO2), sewage, drainage zone (ammoniac), septic tank zone (ammoniac, natural gas).
Monitoring related to base impact at Gabriel de Castilla Station, Deception Island, South Shetland Islands	Monitoring activities, including control of the emissions of the septic tank, soil contamination, gases pollution and noise.
Monitoring related to base impacts at Juan Carlos I Base, Livingston Island, South Shetland Islands	Monitoring activities include work on effluent from the sewage treatment plan and lichen communities. Work is planned on emissions of gases of the incinerator, generators and vehicles.

Sweden

Updated on 27 October 2003; downloaded on 24 July 2006

Existing Human Impacts Monitoring

Monitoring human impacts	In order to monitor human impact of activities in the areas of Vestfjella and Heimefrontfjella permanent plots were established in 1991/92 to study changes in lichens and mosses. A sampling program was also initiated in 1991/92 to explore the possibility of using trace analyses of snow samples to identify anthropogenic emissions from the two small research stations Wasa and Aboa. Snow samples were collected during three summer seasons, 1991/92, 1993/94 and 1996/97.

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Research on Baseline Levels of Pollution in the Antarctic

Baseline data at Swedish stations in Dronning Maud Land
In the season 1991/92 the main task was to investigate lichens, mosses and endolithic algae in the area of the Finnish and Swedish stations in Vestfjella and Heimefrontfjella. In addition studies of birds and mites and a sampling program for terrestrial microfauna and aquatic organisms in small ponds were carried out. The environment project continued in 1993/94. In some cases, the program from 1991/92, i.e. investigation of lichens and mosses, terrestrial microfauna and limnological studies, was extended but new aspects were also included. Snow sampling was repeated for pollution studies and air photography was continued to detect any changes in the extensions of snow fields surrounding the Wasa and Aboa stations.

United Kingdom

Updated on 27 October 2003; downloaded on 24 July 2006

Existing Human Impacts Monitoring

The concentrations of heavy metals in lichens around the British Antarctic Survey (BAS) research stations	To monitor heavy metal concentrations (lead, zinc, cadmium, aluminium, manganese, copper, magnesium and iron) in Antarctic lichens (Usnea spp.) around Rothera and Signy research stations, to establish the area of contamination and to verify whether any observed contamination is as a result of station activities.
The distribution, numbers and breeding success of nesting birds at Rothera Point, Adelaide island	To monitor the distribution, numbers of breeding pairs and breeding success (eggs laid, chicks hatched and chicks fledged) of skuas (Catharacta spp.) and Dominican gulls (Larus dominicanus) nesting near to Rothera Research Station, Rothera Point, Adelaide Island, and to establish whether any observed changes related to station activities.
The entanglement in marine debris of Antarctic fur seals, and the ingestion of marine debris, particularly fishing hooks, by sea birds at Bird Island, South Georgia	To monitor the entanglement in marine debris of Antarctic fur seals (Arctocephalus gazella), and the ingestion of marine debris, particularly fishing hooks, by seabirds at Bird Island, South Georgia, and to establish whether the trends observed relate to offshore fishing effort.
The environmental fate and effects of fuel leaks and spills at BAS research stations	To monitor petroleum hydrocarbon concentrations in soil, seawater, sediments and marine fauna around Rothera and Signy research stations, particularly after major fuel spills, and to establish the environmental pathways and fate of petroleum hydrocarbons in local ecosystems.
The incidence of marine debris found at Bird island, South Georgia and Signy Island, South Orkney Islands	To monitor marine debris washed ashore on Bird Island, South Georgia, and Signy Island, South Orkney Islands and to establish whether the number and type of items recovered relate to offshore activities, particularly fishing effort.
The near-shore marine biology of Rothera point, Adelaide island	To identify and survey near-shore marine flora and fauna, habitats and communities around Rothera Point, using sub-aqua diving techniques, and also to investigate the local impact of sewage effluent from the research station on nearby sub-tidal marine communities.
The topographic survey of the extent of the ice ramp at Rothera research Station	To survey the surface profile of the ice ramp leading from Rothera Research Station to the Wormald Ice Piedmont, and to establish whether any observed changes in the profile relate to station activities, particularly possible ablation due to the deposition of dust generated during construction activities.

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* Note: Requests for copies of publications or reprints should be sent to the Senior Librarian, BAS.

Research on Baseline Levels of Pollution in the Antarctic

Black carbon (soot) in air at Halley V Research Station
Black carbon is being measured continuously at Halley V Research Station. Background levels of about 0.02-2 ng/m ^{3} are seen when the wind is not from the station generators whose exhaust gases contaminate readings.

Heavy metals in Antarctic snow
A 70-year profile of Cd, Cu, Pb, and Zn has been obtained at an inland site, Dolleman Island, and samples have also been taken around Halley V Research Station. Background levels found in recent snow at Dolleman Island are 0.08 ng kg $^{-1}$ for Cd, 4 ng kg $^{-1}$ for Pb and 0.4 ng kg $^{-1}$ for Zn. Increased levels are seen up to 10 km from Halley V, but levels, even a few hundred metres from the building, are still about 1000 times lower than typical concentrations in precipitation in inhabited countries.

Hydrocarbons and heavy metals in tissues from seals and seabirds at South Georgia
Tissues taken from Antarctic fur seals (Arctocephalus gazella), penguins and albatrosses breeding at South Georgia, and are being currently archived for future analysis.

United States

Updated on 27 October 2003; downloaded on 24 July 2006

Existing Human Impacts Monitoring

Air emissions	Incinerator and power plant In December 1992, air emissions tests were performed on the power plant and interim incinerator at McMurdo station. Results showed that the interim incinerator performed better than EPA requirements for larger incinerators in five parameters. Aerosols This work involves investigation of anthropogenic activities in Antarctica which have the potential of producing both contemporaneous and long-term environmental impacts on pristine surroundings. One of these impacts arises from the emission of black or elemental carbonaceous aerosols from the exhaust of diesel-powered generators and vehicles used to support Antarctic operations. The results of this work will contribute to the determination of the station s environmental impact resulting from combustion-derived emissions.
Ambient air quality	An ambient air quality monitoring network was established in the vicinity of McMurdo Station in 1993. The network was designed to determine the highest concentrations of selected air pollutants, to determine representative concentrations of selected air pollutants, to determine background levels of air pollutants and to determine the impact on ambient air quality of significant air pollution sources. Air pollutants routinely monitored include particulate matter, total particulate and gaseous pollutants, CO, SO_2, NO, NO_2, and NO_x. Another study currently under way at McMurdo Station is attempting to determine the contributions of natural and anthropogenic sources to particulate matter less than ten microns (PM-10) aerosol during the austral summer. The natural sources are expected to include geological dust, seasalt aerosol, and marine-biogenic sulfate.
Ambient water quality	USAP have measured ambient water quality in McMurdo Sound and around Palmer Station in 1982 and in the early 1990s. In 1982, field data was collected on tidal currents, water quality and sediments. Water samples were analysed for faecal coliforms, suspended solids, total volatile solids, ammonia, hydrogen sulfide, PCBs, cyanide, 8 trace metals as well as alpha and beta radioactivity. A dye test was also conducted. In 1990-91, seawater samples were collected for coliform numeration from 40 to 50 sites in front of McMurdo Station. In 1992, water samples were taken and analysed for water quality parameters, volatile and semi volatile organics and trace metals. Lipid dosimeters were also deployed and vertical profiles of pH, dissolved oxygen, salinity, temperature and turbidity were also measured.
Fuel and hazardous substance spills	USAP has initiated monitoring and reporting of fuel and hazardous substance spills for several years. For any spill, records are kept related to time and date of spill, spill location, amount and type of material

	spilled, cause of spill, operation under way when the spill occurred, method of containment and removal, and the parties which responded to and performed the spill removal.
Marine benthos	McMurdo Station As part of a long term USAP benthic monitoring program, a comprehensive study of the benthic community around McMurdo Station was conducted between 1988 and 1993. Three general types of benthic information were collected - structure of the community, physical sedimentary environment and anthropogenic contamination in sediment, clams and fish tissue. Field observations indicated that benthic communities are highly impacted by chemical contamination. More recently, a study has been established to determine if sewage-derived organic material is assimilated by the benthic food web and if there is a biological response to anthropogenic organic enrichment and how this compares to natural enrichment by seals. Palmer Station As part of the environmental monitoring program following the fuel spill incident of the Bahia Parasio near Palmer Station in January 1989, an investigation was carried out on the contamination in limpets near the station. Limpet tissue was analysed for aliphatic and aromatic hydrocarbons, PCBs and trace metals.
Marine sediment	Contaminant levels in the sediments are good indicators of long term and accumulative effects of contamination. Limited sediment samples were collected from McMurdo Station in 1982 and analysed for trace metals, PCBs, oil and grease, and gross alpha and beta radioactivity. More extensive monitoring began in the late 1980s and early 1990s at McMurdo and Palmer Stations and involved investigations of hydrocarbons, organic carbon, nitrogen, metals, chlorinated pesticides, PCBs and PCTs.
Soil contamination	Monitoring of soil contamination at McMurdo Station started with preliminary site investigations in 1991 followed by soil sampling at Fortress Rocks and Winter Quarters Bay and overall surveillance of hydrocarbon contamination in 1995. At Palmer Station, soil contamination monitoring has also been carried out at Palmer Station. Contamination of soils at McMurdo Station is mostly related to fuel spills and the past practice of waste disposal and correlates well with operational activities carried out on the sites investigated.
Surface snowmelt runoff	In January 1991, 12 snowmelt runoff water samples were collected from drainage ditches around McMurdo Station and analysed for 34 volatile and 65 semi-volatile organic compounds, total petroleum hydrocarbons, PCBs, alpha and beta radioactivity and 18 metals. In January 1994, four snowmelt runoff samples were analysed for VOCs, SVOCs, PCBs, TPH and metals.
Wastewater discharge	Regular monitoring of wastewater discharge has been instituted at McMurdo Station since 1989. A composite wastewater sampler was installed at the sewer outfall in 1992/93, allowing the collection of flow-proportional 24 hour composite samples. Routine analysis of wastewater samples includes BOD_5, COD, suspended solids, volatile suspended solids, total dissolved solids, ammonia, total Kiejdahl nitrogen, total phosphorus, selected trace metals and organic compounds.

Selected samples are analysed for volatile and semi volatile compounds, pesticides and PCBs. Results indicate that the wastewater if typical of domestic wastewater. Limited samples were also collected in 1994 and 1995 at Amunsden-Scott South Pole Station. Sampling was initiated at Palmer Station in 1994.

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Process for Development of the Summary

May 1994	At ATCM XVIII in May 1994, the Scientific Committee on Antarctic Research and the Council of Managers of National Antarctic Programs offers to convene a meeting of technical experts on environmental monitoring.
October 1995/March 1996	Two workshops are subsequently organised through SCAR and COMNAP and held in October 1995 and March 1996. The workshops are aimed at providing consensus on an approach to Antarctic monitoring that is practical, scientifically sound, realistic and cost effective while meeting the requirements of the Environmental Protocol and Antarctic Treaty. Prior to the second workshop in March 1996, COMNAP compiles a summary of existing information on Antarctic environmental monitoring through a survey of its members. The results of the survey are made available to all participants at the March 1996 monitoring workshop. Monitoring information is supplied by 13 countries.
July 1996	The results of the workshops are published jointly by SCAR and COMNAP in July 1996 in the report "Monitoring of Environmental Impacts from Science and Operations in Antarctica".
September 1997	Following the completion of the workshop report, the COMNAP Environmental Coordinating Group requests the Antarctic Environmental Officers Network (AEON) to expand and update the survey.
May 1997	A draft of this document is subsequently tabled at ATCM XXI in May 1997 in Christchurch as a COMNAP information paper (Information Paper No 67). It is also posted on the AEON WWW site.
April 1998	A further request to AEON members for updates of the information contained in the draft is extended to 1 April 1998 and the document is subsequently published.
April 2000	The document is posted on the COMNAP web site to facilitate public access and continuous updating by AEON members.