Latitudinal Gradient Project
Science Overview

May 2003

Version 1

FOREWORD

The Latitudinal Gradient Project (LGP) is aimed at increasing the understanding of the coastal marine, freshwater and terrestrial ecosystems that exist along the Victoria Land coastline in the Ross Sea region, and describing potential environmental variability that may occur in the future.

Antarctica New Zealand is providing the logistical capabilities for research camps to be located at specific sites along the Victoria Land coast. Thus, the opportunity to work at particular locations in collaboration with other scientists from various disciplines and National Antarctic Programmes is provided.

LGP has been formally incorporated into the SCAR programme RiSCC (Regional Sensitivity to Climate Change). Certain data collected within the LGP will be housed and made available within the RiSCC database framework. Details on how the data will be shared and the timing of when the data will be made available have yet to be decided. It is intended that publications arising from the LGP will be published in a special issue of a refereed journal such as *Antarctic Science*.

A New Zealand steering committee has been appointed by Dean Peterson and Clive Howard-Williams to work along side the LGP Project Manager, Shulamit Gordon (Science Advisor, Antarctica New Zealand). The steering committee consists of:

Dr Jackie Aislabie	Landcare Research	
Dr Megan Balks	University of Waikato	
Prof Allan Green	University of Waikato	
Dr Ian Hawes	NIWA	
Dr Clive Howard-Williams	NIWA	Chair
Dr Dean Peterson	Antarctica New Zealand	Ex-officio

This committee met in October 2002 and March 2003 to discuss the contents of the LGP Science Overview and Logistics Plan (released in August 2002) and other LGP-related issues.

This document includes the scientific reasoning and expected outcomes of the LGP and incorporates revisions made by the steering committee on the August Plan and outcomes of an LGP workshop held in April 2003. An accompanying document 'Site Description and Literature Review of Cape Hallett and Surrounding Areas' provides a physical description of Cape Hallett, the first site proposed for the LGP, and a thorough review of relevant research conducted there.

Contents

LATITUDINAL GRADIENT PROJECT DRAFT SCIENCE OVERVIEW

1. PROJECT BACKGROUND

The Latitudinal Gradient Project (LGP) is a framework within which interdisciplinary and international collaborations can be supported logistically towards the common goal of understanding the complex ecosystems that exist along the Victoria Land coast and determining the effects of environmental change on these ecosystems.

The development of such a framework has been prompted by Antarctic scientists who identified the need for co-ordinated research along the latitudinal gradient. This document is put forward as a response to fulfilling this need.

1.1 Introduction to the Latitudinal Gradient Project

The Victoria Land coastline spans 14^{o} of latitude along a narrow longitudinal band from 72^{o}S at Cape Adare to 86^{o}S at the southern end of the Ross Ice Shelf (see Figure 1). Important environmental factors such as solar radiation, temperature and sea ice cover predictably vary with latitude along the Victoria Land coast. Other environmental gradients such as depth below sea level, height above sea level and distance from the coast complicate the latitudinal gradient influence on the coastal ecosystems.

The Latitudinal Gradient Project will study five identified sites along the Victoria Land coast in detail. The information gained from the different sites along the coast will increase our understanding of polar ecosystems and help create a predictive knowledge of the future effects of environmental change on these ecosystems.

Although various studies have been, and are still being undertaken which attempt to describe ecosystems and environmental variations (e.g. the Long Term Ecological Research project (LTER) in the McMurdo Dry Valleys, the International Trans Antarctic Scientific Expedition (ITASE) across the Polar Plateau, and Antarctic Aquatic Ecosystems at locations around McMurdo Sound), none have attempted a latitudinal coastline, marine and terrestrial survey of physical and biological parameters. The results from the LGP are therefore expected to break new ground and open up new areas of scientific understanding. LGP's success is dependent on the interdisciplinary aspects of the project and the interaction of researchers at each site, forming a complete picture of the ecosystems studied.

Three principal research zones determined by naturally occurring physical boundaries related to the presence and persistence of ice have been identified along the Victoria Land coast (Figure 1, Table 1). Five terrestrial sites situated along the latitudinal gradient spanning all three zones are to be the centre of intensive research for two consecutive years each, with a year-off between each site. The life span of the project is therefore expected to be 15 years starting in the 2003/04 season. The five proposed sites are: Cape Hallett, Terra Nova Bay, Granite Harbour, Darwin Glacier and the Beardmore Glacier (Figure 1). Other than Cape Hallett, these sites are still open to discussion.

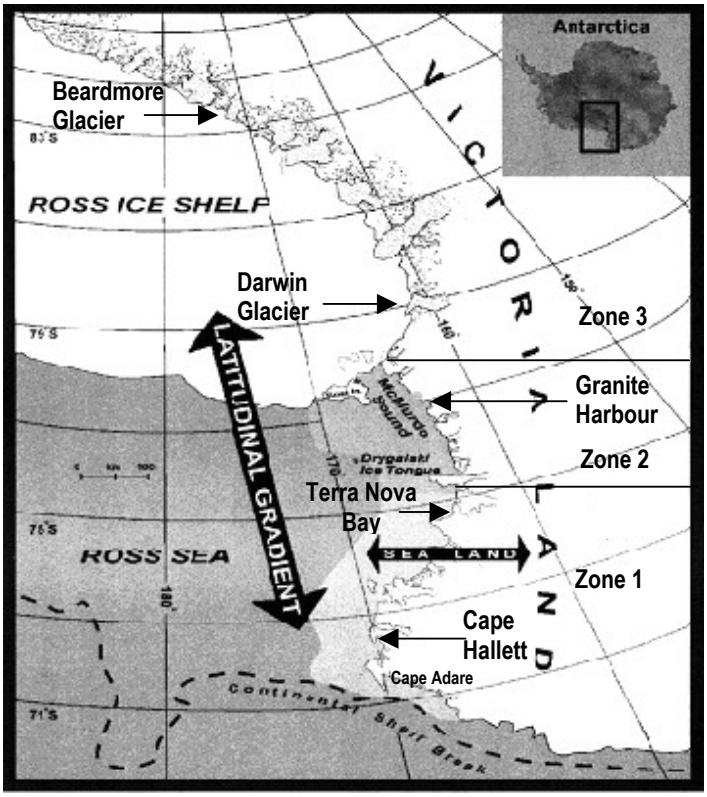

Figure 1. The Victoria land coastline

Zone	Designation	Extent
One	Open Water Zone	South of Cape Adare to the Drygalski Ice Tongue
Two	Fast Ice Zone	South of the Drygalski Ice Tongue to McMurdo Sound and the edge of the Ross Ice Shelf
Three	Ice Shelf Zone	South of the Ross Ice Shelf edge along the Transantarctic Mountains to the southernmost terrestrial ecosystems on Earth

Table 1. Zones identified along the Victoria Land coast.

Marine studies from research vessels will be conducted along the Victoria Land coastline at predetermined times through the project's lifetime. These are addressed in the BioRoss research plan. A marine research voyage is scheduled for January/March 2004 supported by the Ministry of Fisheries (under the BioRoss programme) and Land Information New Zealand.

There are two central elements to the success of the LGP initiative:

- Interdisciplinary collaboration; and
- International collaboration.

It has long been recognised that the interactions within and between marine, freshwater and terrestrial ecosystems are complex. In order to understand such interactions, interdisciplinary studies are crucial, and to cover the full range of disciplines, international collaboration is desirable.

A number of scientists and National Antarctic programme managers from New Zealand, Italy and the U.S. (the three countries with scientific bases in the Ross Sea region) representing a broad range of disciplines have been instrumental in bringing the LGP initiative to fruition from the first discussions in January 1999 to the presentation of the current document (see Appendix A). The most recent document produced is the report on the Latitudinal Gradients in Victoria Land SCAR Workshop held in Amsterdam in August 2001.

The expertise of the scientists who have shown interest in the LGP are:

- Limnology and oceanography;
- Marine and terrestrial ecology;
- Physiology and genetics;
- Soil science and microbiology;
- Meteorology and climate modelling;
- Glaciology and geomorphology; and
- Sediment- and ice-core paleoclimatology.

Collaborations between other countries besides those mentioned, are currently minimal, but welcomed.

1.2 General Hypothesis and Key Questions

The culmination of the discussions and workshops listed in Appendix A on the LGP concept is an overarching, general hypothesis for the project. This hypothesis is that:

Ice-driven dynamics control the structure and function of ecosystems (marine, terrestrial and freshwater) near the limits of life at high latitudes.

From the general hypothesis, eight key questions have emerged. They are:

1. To what extent does ecosystem structure and function (diversity/complexity) change with latitude?

2. How do ice dynamics (e.g. movement, melt, accumulation and ablation) influence the relationship between solar radiation and primary producers?

3. What is the role of persistent, large-scale ice structures in defining community composition along Victoria Land (e.g. Drygalski ice tongue)?

4. How does climate affect the availability of free water and how does this change in space and time?

5. How does climate affect the predictability, persistence and extent of sea ice cover along the latitudinal gradient?

6. To what extent does soil development (e.g. degree of weathering, carbon content and nutrient accumulation) change with latitude and therefore influence terrestrial ecosystems?

7. To what extent are past conditions along the Victoria Land coast preserved in paleoindicators (e.g. glacial, lacustrine and marine cores, and biological records)?

8. How are key marine biological processes (such as respiration, photosynthesis and reproduction) influenced by sea ice extent?

The general hypothesis and key questions have been revised by the LGP Science Steering Committee (see section 2.3) from the original hypothesis and questions found in the August 2002 LGP Plan to better reflect the realistic capabilities of New Zealand researchers.

The Committee wanted to stress that while recognising the importance of altitude in studying varying ecosystems along the latitudinal gradient, the New Zealand component of LGP is best suited to concentrate its efforts between sea level and approximately 800m above sea level in the foreseeable future.

It is envisaged that these key questions are to be the driving force for the studies undertaken within the framework of the LGP, however additional questions are encouraged and will be sought as our understanding of the ecosystems under study increases.

1.3 Links to RiSCC

Regional Sensitivity to Climate Change in Antarctic Terrestrial and Limnetic Ecosystems (RiSCC) is an international research program on Antarctic terrestrial and limnetic (lake and pond) organisms and ecosystems. It is sponsored by the Scientific Committee on Antarctic Research (SCAR). The RiSCC programme was formally adopted as a research programme under the auspices of the SCAR Working Group on Biology during SCAR XXVI, Tokyo, Japan in July 2000.

The goals and rationale of RiSCC are very much aligned with those of LGP. RiSCC aims to understand the interactions between biodiversity, functioning and climate of Antarctic terrestrial and limnetic ecosystems, and to predict regional sensitivity to the impacts of climate change by:

- Identifying and quantifying differences in environments and biodiversity within and between ecosystems;
- Understanding the potential for ecosystem processes to respond to changes in climate;
- Partitioning the effects of climate change among the key components of the ecosystems;
- Using new and existing data to provide a synthesis of the likely effects of climate change on Antarctic terrestrial and limnetic ecosystems to contribute to their management and conservation;
- Orienting the research to achieve links with other international programmes seeking to understand the implications of global changes (Huiskes, 2002).

RiSCC has defined three key scientific questions:

1. What factors influence species richness and functional group diversity along the Antarctic Environmental Gradient (AEG), and how will changes in species richness and functional group diversity affect ecosystem structure and functioning?

2. How do organisms and communities respond to abiotic variables along the AEG and how will climate change influence these responses?

3. How do phenotypic plasticity and genetic variation and their interaction differ in key groups within and between sites along the AEG?

These key questions relate closely to those of LGP (Table 2). However, note that not all LGP's key questions fit within RiSCC's due to LGP's additional marine component.

RiSCC Key Questions	LGP Key Questions
1	1,3
2	1, 2, 3, 4, 6
3	3

Table 2. How LGP's key questions relate to those of RiSCC.

The two main differences between RiSCC and LGP are:

(a) The extent of geographic coverage: LGP works within the 14 degrees of latitude of the Victoria Land coast, whereas RiSCC covers approximately 30 degrees of latitude continent-wide from the Sub-Antarctic to the McMurdo Dry Valleys, along what is defined as an 'Antarctic Environmental Gradient' (AEG).

(b) LGP's marine component: LGP focuses on both the marine and terrestrial environments, whereas RiSCC is concerned solely with terrestrial and limnetic environments.

Besides these differences, it is clear from the overlap of the key questions and the location of the LGP sites within the AEG, that collaboration between the two programmes would be mutually beneficial. This has been recognised by both programmes and LGP is now formally linked with RiSCC.

RiSCC has recently completed a document which includes a science plan, implementation plan, guidelines for research, and methodologies for this research (found at www.riscc.aq). Contributions to the methodologies have been made by the relevant researcher for each discipline. It is envisaged that the LGP will use relevant parts as a source for baseline measurements to be undertaken at the LGP sites. In this way, measurements made along the AEG by both RiSCC and LGP researchers will be comparable.

These baseline measurements are discussed in more detail in Section 4.

Reference:

Huiskes, A. (ed). 2002. Regional Sensitivity to Climate Change in Antarctic Terrestrial and Limnetic Ecosystems.

2. PROJECT ORGANISATION

2.1 Project Facilitation

Antarctica New Zealand has assumed the role of project facilitator for the New Zealand portion of the LGP and will fulfil two main functions:

(c) The provision of logistical support to New Zealand events working within the framework of LGP. Antarctica New Zealand has secured financial support for the provision of a field camp and will co-ordinate the set-up and removal of the camps as well as support staff requirements at the camp site and transportation to and from the sites for New Zealand events.

(d) The development of international linkages. Antarctica New Zealand already has strong linkages with the Italian and US Antarctic programmes. These will continue to be fostered to encourage current and additional collaboration between New Zealand, Italian and US scientists as well as other international researchers.

Antarctica New Zealand has planned the logistic support needed for the terrestrial portion of the project on the basis that there will be equitable logistical support from other countries when they become involved in the project. At present, planning is for the support of New Zealand scientists and one US science event. It is hoped and anticipated that further US involvement and new Italian collaborations will occur in the near future.

2.2 Project Management

Antarctica New Zealand has appointed Shulamit Gordon (Science Advisor, Antarctica New Zealand) as the Project Manager of LGP to achieve the functions set out above. This position will co-ordinate with the LGP science steering committee (see 2.3) and the Operations Group at Antarctica New Zealand, and is expected to be the central contact point for matters relating to New Zealand LGP logistics.

2.3 LGP Science Steering Committee

The role of the LGP Science Steering Committee (LSSC) is to co-ordinate the group of New Zealand LGP researchers towards the aim of attaining the scientific goals of the project. This committee will make the difference between separate events undertaking their individual research at the proposed sites and the pre-planned, co-ordinated effort of a group of scientists working towards common goals. Collaboration and interdisciplinary research will be fostered and encouraged by the LSSC. This committee will be the central contact point for matters relating to LGP research and is expected to work closely with the LGP Project Manager.

The steering committee consists of four researchers actively involved in LGP. The positions are for two years with an option to continue for another two years. In addition to these three, Clive Howard-Williams of NIWA will act as Chairperson and Dean Peterson will represent Antarctica New Zealand. The steering committee consists of:

Dr Jackie Aislabie	Landcare Research	
Dr Megan Balks	University of Waikato	
Prof Allan Green	University of Waikato	
Dr Ian Hawes	NIWA	
Dr Clive Howard-Williams	NIWA	Chair
Dr Dean Peterson	Antarctica New Zealand	Ex-officio

The LSSC and LGP Project Manager met in October 2002 and March 2003 to discuss the LGP Science Overview and Logistics Plan that was released in August 2002 and other LGP-related issues. The main points arising from these meetings are reflected in this revised Science Overview and the associated document 'Site Description and Literature Review of Cape Hallett and Surrounding Areas'.

2.4 Bidding Round

Antarctica New Zealand's bidding round for the 2003/04 season proceeded as usual with a deadline of 4 October 2002 for submission of applications. Out of the 39 proposals submitted, 12 were relevant to LGP and 8 of these were approved for support by Antarctica New Zealand.

3. PROJECT TIMETABLE

Research under the LGP will be both ship-based and land-based. At present, ship-based research, funded under the Ministry of Fisheries' BioRoss programme and the Italian Antarctic Programme, has been scheduled for January/March 2004 with a research voyage planned using two vessels aimed at supporting near-shore and deep-water marine research. The vessels dedicated to this research are NIWA's *RV Tangaroa*, and the Italian Antarctic Programme's *RV Italica*. Further information about the ship-based research can be found in the BioRoss research plan and in the BioRoss call for statements of interest.

Five land-based sites have been proposed to be studied for two years each starting in the 2003/04 season. The definition of a site will be based on a 'hub and spoke' model, with the central site acting as a hub to 'satellite' sites around it where logistics allow. This acknowledges the fact that the site chosen to locate the main camp may not have all the desired attributes that the scientists involved want to study.

A year out between each site will allow for reconnaissance of the next site and facilitate re-location of camp resources, as well as providing time for data analysis and write-up. The proposed sites are listed below (Table 3) in chronological order and shown in Figure 1. With the exception of Cape Hallett, the timetable and site locations are open to discussion.

Activity	Years
Cape Hallett	2003-2004 and 2004-2005
Year out and reconnaissance	2005-2006
Darwin Glacier	2006-2007 and 2007-2008
Year out and reconnaissance	2008-2009
Terra Nova Bay area	2009-2010 and 2010-2011
Year out and reconnaissance	2011-2012
Granite Harbour	2012-2013 and 2013-2014
Year out and reconnaissance	2014-2015
Beardmore Glacier	2015-2016 and 2016-2017

Table 3. LGP proposed land-based research sites and periods for their support.

Marine Studies are constrained to areas where water is easily accessible by either boat operations or by drilling through the sea ice. At present, it is logistically prohibitive to undertake marine research by drilling through the ice shelf.

4. BASELINE MEASUREMENTS

The need to measure particular variables at each site along the latitudinal gradient for comparative purposes has been recognised. Baseline variables suggested by the LSSC and other scientists approached for their input were discussed at an LGP workshop held in conjunction with the Annual Antarctic Conference in Dunedin in April 2003. The outcomes of this workshop are presented below.

A two-tiered system of measurements was envisaged where the first tier could be collected by anyone (i.e. baseline data listed below), whilst the second tier, would be collected by the scientists in the applicable discipline.

Baseline data identified combine both one-off and time series observations and are designed to characterise basic aspects of the different environments as far as is possible without resorting to specialised techniques and equipment.

Workshop participants agreed that at any single sample site, a researcher would attempt to measure as many of the baseline variables as possible (where applicable), even if they would not normally measure them for their specific research purposes.

The baseline variables measured by the LGP participants will be aligned with those measured as part of the RiSCC programme so that the data are comparable along the Antarctic Environmental Gradient (see section 1.3).

These baseline data are presented below, and are open to further discussion and input.

4.1 General Site Description

Site Name		
Geographical coordinates	Latitude and Longitude	Note if from GPS or Not GPS
Elevation	Metres above sea level	Note if from GPS, altimeter or map
Slope	Degrees	Note if estimated or measured
Aspect		
Samples taken?		
Photos taken?		
Aerial Photos available?		

4.2 Soil Parameters

Geomorphological characteristics	□ Pro-Glacial □ Nival - Chionophilous □ Periglacial □ Fluvial □ Coastal □ Fell-Field	□ Slope □ Plateau □ Valley □ Landslide □ Scree slope □ Rock wall □ Other
Rock Lithology	□ Siliceous rock □ Calcareous rock	Rock type
Soil Typology	□ Soil Absence □ Soil Presence	□ Mineral soil □ Organic soil □ Other
Surface Lithology	□ Outcropping Rock □ Loose Material □ Glacial □ Fluvial □ Eolic □ Coastal □ Scree Slope, Debris	
Surface Texture	% Blocks (∅>25cm) % Pebbles (5cm< ∅ <25cm) % Gravel (0.2cm< ∅ <5cm) % Sand and finer material (∅ <0.2cm)	

4.3 Vegetation

Plants and Lichens	Species type/name Presence/absence Rare, Occasional, Common, Abundant % cover If unsure, take a photo and GPS the point

4.4 Fauna

Mammals	Species names/Presence/Absence or abundance/Area
Birds	Species names/Presence/Absence or abundance/Area
Invertebrates	Species names/Presence/Absence or abundance/Area

4.5 Glacial

Ablation/accumulation	Using bamboo poles drilled into the glacier surface
Ice temperature	At consistent depth; NB can give mean annual temperature.
Snow pit measurements	

4.6 Aquatic Non-Marine Systems

The intention here is to document the distribution of melt pools, ephemeral streams, ponds and lakes, their melting characteristics and basic limnological features. Required observations combine both one-off and time series and are designed to characterise the pond and its biota as far as is possible without resorting to specialised techniques and equipment (beyond a temperature/conductivity meter).

Type of water body	i.e. flush, stream, pond or lake
Sketch/map of water body and immediate catchment.	Include orientation
Size and depth	Estimate or actual
Inflows and outflows (for non running systems) – size, discharge estimate (l/s), duration of flow	
Duration and spatial distribution of free water	
Evidence of water level variation? If so, what is the evidence and by how much?	
Isolated habitat or part of a connected network?	
Proximity to other aquatic systems	
Any sign of salt or vegetation accumulation around margins?	
Range of levels over season (peg or otherwise reference the margin)	
Water sources	- % Snow, - % Glacier - % Non-glacial Ice - % Other
Catchment:	- Size - Vegetation: coverage (%), type (lichen, mosses, vascular, etc....) - Geology (see Soils section) - Geomorphology (see Soils section) - Animal influence (nesting birds, marine mammals, etc) - Snow and Ice
Ice cover: (to be recorded at intervals over the season)	- permanent ice (if there are records) - % of coverage (anchored or loose) - thickness - transparency (clear, dirty ice, snow cover, etc.)
Water properties. (to be recorded at intervals over the season)	- Clarity (measured or estimated) - Colour (measured or estimated) - Foams (e.g. none, slight, abundant) - Conductivity (measured) - Temperature (measured)

Bed characteristics	- Substrate (%)
	  o Cobbles
	  o Gravel
	  o Sand
	  o Silt
	- Vegetated (% cover)
	  o cyanobacterial mats
	  ▪ Colour
	  ▪ Thickness
	  ▪ Gross morphology (flat, pinnacle, lift-off)
	  o Encrusting (note colour)
	  o mosses
	  o green algae

Others	Animal observations (rotifers, crustacea, mites etc)
Sample collection and preservation	Numerous samples for water and biota will ideally be collected to characterise the ponds. It is out of the scope of this to describe how to collect these. Guidance from specialists should be sought before embarking on this.

4.7 Aquatic Marine Systems

CTD data (current, temperature, depth)
Sea ice cover: when, where, how thick, light transmission
Tide/current information
Chlorophyll-a (water samples)
Sediment cores
Images using drop camera

4.8 Environmental (AWS)

The ideal situation would be to have one AWS on ice-free land, and one on permanently snow/ice covered land.

Incoming solar radiation
Net or reflected radiation
Air temperature
Air relative humidity
Quantum flux (Photosynthetic quantum flux density)
Wind speed and direction
Soil temperature, moisture and electrical conductivity to >1.2 m
Extent and duration of snow cover (from Remote Sensing, air photos and snow boards)
Associated logger info with reading frequency and sensor types/position

5. LONG-TERM MONITORING

The long-term monitoring of certain variables is key for putting into context the research that is undertaken over short time scales at sites along the latitudinal gradient. Long-term monitoring of variables will help link the five LGP sites and give important information on physical gradients along the coast.

Two types of long-term monitoring can be identified: contemporary, and historical (so called for the purposes of this document). Contemporary long-term data include measurements of temperature, wind speed, humidity, air pressure and occasionally soil moisture by Automatic Weather Stations (AWSs), and tidal activity by tide gauges. These data are currently being collected at discrete points along the Victoria Land coast.

Historical monitoring is being undertaken by projects such as ITASE (the International Trans Antarctic Scientific Expedition) which attempts to determine the environmental variability of Antarctica over the past 200 to 1000 years. In addition to this, the Long Term Ecological Research project (LTER) in the McMurdo Dry Valleys is conducting an interdisciplinary study of the aquatic and terrestrial ecosystems by obtaining baseline ecologically-relevant data from the atmosphere, glaciers, streams, soils, and lakes.

5.1 Contemporary long-term monitoring

5.1.1 Automatic Weather Stations

The basic Automatic Weather Station (AWS) measures air temperature, wind speed and wind direction at a nominal height of three metres above the surface, and air pressure at the electronics enclosure at about 1.75 meters above the surface. The heights are nominal because of snow accumulation that may occur at the site. Some units may also record soil moisture and temperature using underground sensors.

The operations of the AWS unit are controlled by a small microcomputer, which updates the data at a nominal 10 minute interval. If the stations have satellite telemetry capabilities, transmissions will be received and stored by an ARGOS Data Collection System located on board the National Oceanic and Atmospheric Administration (NOAA) series of polar-orbiting satellites. Those stations that are not telemetry capable rely on data loggers to store the information. These require manual downloading.

The AWS are usually powered by six to twelve 40 ampere-hour 12 volt gel-cell batteries charged by one or two 10 watt solar panels.

AWSs operated by US, New Zealand and Italian agencies are currently located at various points along the Victoria Land coast (Figure 2) measuring a range of variables (Table 4).

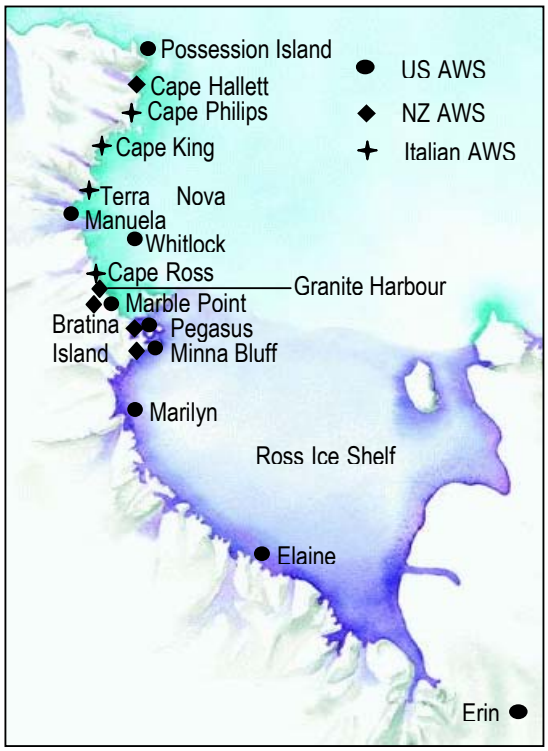

Figure 2. AWS units currently operating along the Victoria Land coast. (Base map sourced from Waterhouse, 2001)

The National Science Foundation Office of Polar Programs automatic weather station project has approximately 9 AWS along the Victoria Land coast (not including those at Ross Island). Data from these AWS are housed by the University of Wisconsin and can be accessed by the public on the web via their ftp site.

The Italian Antarctic programme have six AWS along the coast, and the data from these are also publicly available from the web.

Data from the US and Italian AWSs are currently being downloaded by the LGP Project Manager for easier access to LGP participants.

The New Zealand supported event K081 run by NIWA currently have two AWS in the area; one on Bratina Island (which measures pond temperatures as well as the regular suite of variables) and one at Cape Hallett. Data from these are downloaded manually on an annual basis and are housed by NIWA.

Landcare Research, in collaboration with the US Department of Agriculture, is responsible for 4 AWS relevant to LGP. These are located at Scott Base, Marble Point, Minna Bluff and Granite Harbour. These measure soil moisture and temperature as well as the regular suite of measurements.

It is intended that AWS units will be installed at the remaining proposed LGP sites as soon as the opportunity arises.

AWS Name (Location)	ID #	Latitude	Longitude	Altitude (masl)	Maintained By	Data From	Data To	Measurements
Elaine	89837 (WMO)	83.13°S	174.17°E		Uni of Wisconsin	Feb 93	May 99	Air temperature, air pressure, wind speed
Erin		84.90°S	128.81°W		Uni of Wisconsin	Feb 96	May 99	Air temperature, air pressure, wind speed
Manuela (Inexpressible Island)	89864 (WMO)	74.95°S	163.69°E		Uni of Wisconsin	Feb 85	May 99	Air temperature, air pressure, wind speed
Marble Point	89866 (WMO)	77.44°S	163.75°E		Uni of Wisconsin	March 80	Dec 99	Air temperature, air pressure, wind speed
Marilyn		79.95°S	165.13°E		Uni of Wisconsin	Feb 87	May 99	Air temperature, air pressure, wind speed
Minna Bluff	89768 (WMO)	78.55°S	166.66°E		Uni of Wisconsin	Feb 91	May 99	Air temperature, air pressure, wind speed
Possession Island	89879 (WMO)	71.89°S	171.21°E		Uni of Wisconsin	Jan 93	May 99	Air temperature, air pressure,
Whitlock (Franklin Island)	89865 (WMO)	76.14°S	168.39°E		Uni of Wisconsin	Feb 82	March 98	Air temperature, air pressure, wind speed
Alessandra (Cape King)	7351 (ARGOS)	73° 35'S	166° 37'E	120	Italy	1987		*Atmospheric pressure, air temperature, relative humidity, wind speed and direction, global solar radiation
Eneide (Terra Nova Bay)	7353 (ARGOS)	74°42'S	164° 06'E	90	Italy	1987		*Atmospheric pressure, air temperature, relative humidity, wind speed and direction, global solar radiation+
Arelis (Cape Ross)	7357 (ARGOS)	76° 43'S	162° 58'E	150	Italy	1990		*Atmospheric pressure, air temperature, relative humidity, wind speed and direction
Silvia (Cape Philips)	7379 (ARGOS)	73° 03'S	169° 36'E	310	Italy	1990		*Atmospheric pressure, air temperature, relative humidity, wind speed and direction
Bratina Island		~78° 01'S	~165° 32'E		NZ/NIWA	Jan 97		**
Marble Point		77° 25'S	163° 41'E	50	NZ/USDA	Jan 99		***
Minna Bluff		78° 30.691'S	166° 45.971'E	130	NZ/USDA	Jan 03		***
Granite Harbour		77° 0.39'S	162° 31.54'E	10	NZ/USDA	Jan 03		***
Cape Hallett		~72° 19'S	~170° 13'E		NZ/NIWA	Feb 01		****
Cape Hallett		~72° 19'S	~170° 13'E		NZ/USA	April 57	Feb 64	+Air temperature, atmospheric pressure, wind speed and direction.

* Atmospheric pressure (hPa); Temperature (°C), ~2m a.g.l; Relative humidity (%) ~2m a.g.l.; wind speed and direction ~ 10m a.g.l.; Global solar radioation at ground (W/m^2).

** Currently measuring wind speed and direction, air temperature and humidity (though humidity sensor may be down), incoming radiation, net radiation, water temperature (four probes)at hourly intervals.

*** A data-logger (CR10X, Campbell Scientific Inc.) was installed at each site with sensors to record air temperature, relative humidity, solar radiation, and wind speed and direction. Thermistor temperature probes (Campbell107) and Vitel moisture probes (hydra type A, Stevens Vitel Inc.) were installed at depths of 2 cm to 1.2 m. Measurements of atmospheric variables are made at 10-second intervals. Soil variables are measured every 15 minutes. All measurements are averaged and recorded hourly with data down-loaded annually. Initial data analysis indicated quite wide between-season variability in active layer depth. Work is underway to test and calibrate the Vitel soil moisture probes that are being used.

****Currently measuring wind speed and direction air temperature and humidity incoming radiation, soil temperature (four probes) at hourly intervals. Also conductivity and temperature (two water sites) at daily intervals.

+Included as this historical data will be invaluable for the Cape Hallett studies.

Table 4: Automatic Weather Stations along the Victoria Land coast

5.1.2 Tide Gauges

Two tide gauges are located within the Victoria Land coast area. The first is at Cape Roberts at approximately 77°S. This is run by the Victoria University of Wellington and was initially set up in 1990 to support marine geological investigations and the Cape Roberts Project drilling operations. This is a permanent installation and has been in continued operation since 1990 providing the longest tidal record for the Ross Sea region. The collected data is housed by LINZ.

The second tidal recorder is at Scott Base. This was installed by NIWA in January 2001 and samples sea levels and atmospheric pressure at five minute intervals. Data is telemetered back to the NIWA office in Christchurch. A local tide model using this data is being developed to enable accurate tide forecasts to be made for any location of the Ross Sea.

5.2 Historical long-term monitoring

Two major projects fall under this category which collect data relevant to the goals of LGP. These are the International Trans Antarctic Scientific Expedition (ITASE) and the Long Term Ecological Research project in the McMurdo Dry Valleys (LTER).

5.2.1 ITASE

This programme was initiated in 1990 to collect and interpret a continental-wide array of environmental parameters assembled through the co-ordinated efforts of scientists from several nations. Due to the remoteness of the continent, Antarctica was seen as an ideal location to monitor biogeochemical cycles and local-to-global scale climate change. However, this remoteness has also prevented the collection of instrumental records, similar to those collected in the northern hemisphere, that are required to assess Antarctica's role in, and response to, environmental and climate change.

As a consequence ITASE addresses two key scientific objectives:

1. To determine the spatial variability of Antarctic climate (eg. accumulation, air temperature, atmospheric circulation) over the last 200 years, and where the data are available the last 1000 years. These variations include: major atmospheric phenomena; snow accumulation variations; and extreme events such as volcanic eruptions and storms; and

2. To determine the environmental variability in Antarctica over the last 200 years, and where the data are available the last 1000 years. Environmental proxies could include: sea ice variation, ocean productivity, anthropogenic impacts; and other, extra-Antarctic continental influences.

In fulfilling these objectives ITASE will: produce continental scale "environmental maps"; elucidate transfer functions between components of the atmosphere and snow/ice; verify atmospheric models; and interpolate spatial time-series determined from satellite remote sensing.

By combining the contemporary meteorological data available from the Antarctic and Southern Ocean with annually-dated, highly-resolved, multi-parameter ice core proxies for a variety of climate parameters (e.g., moisture balance, atmospheric circulation and temperature) ITASE is extending the Antarctic climate record.

This coverage offers the temporal perspective needed to assess the annual to multi-decadal state of natural climate variability in Antarctic climate.

The US ITASE is due to commence a traverse along the Victoria Land coast commencing in the 02/03 season, with traverses perpendicular to the coast also planned. Work conducted during this traverse will include ice core collection, snow pit sampling, atmospheric chemistry observations, weather observations, and GPS experiments to measure mass balance.

It is envisaged that data collected by ITASE can be used to put LGP-collected data into context and visa versa.

5.2.2 LTER

The McMurdo Dry Valleys LTER project is an interdisciplinary study of the aquatic and terrestrial ecosystems in a cold desert region of Antarctica which commenced in 1993. The McMurdo LTER project is one of 21 sites comprising the LTER Network (sites throughout US and two in Antarctica) and is conducting long-term ecological research in a broad array of ecosystems. Each site within the LTER Network shares a common commitment to create a legacy of well-designed and well-documented long-term field experiments and observations for use by future generations to improve understanding of basic properties of ecosystems as well as factors causing widespread changes in the world's ecosystem.

The overall objectives of the McMurdo LTER are to understand the influence of physical and biological constraints on the structure and function of dry valley ecosystems and to understand the modifying effects of material transport on these ecosystems. The McMurdo Dry Valley ecosystems are driven by the same basic processes, such as microbial utilisation and re-mineralisation of nutrients found in all ecosystems, but they lack many confounding variables, such as higher plants and animals, found in other ecosystems. McMurdo LTER research contributes to general ecological understanding through studies of processes that are readily resolved in these ecosystems.

Baseline ecologically-relevant data is being obtained from the atmosphere, glaciers, streams, soils, and lakes of the McMurdo Dry Valleys. These data indicate that the dry valleys are very sensitive to small variations in solar radiation and temperature and that this site may well be an important natural regional-scale laboratory for studying responses to human alterations of climate. While the Antarctic ice sheets respond to climate change on the order of thousands of years, the glaciers, streams and ice-covered lakes in the McMurdo Dry Valleys respond to change almost immediately. Thus, it is in the McMurdo Dry Valleys that the first effects of climate change in Antarctica should be observed.

As with the ITASE data, results from the long-term monitoring being undertaken as part of this project can also be used to put LGP-collected data into context and visa versa.

A group led by Prof. Berry Lyons from the LTER programme have been granted 3 years of support from the National Science Foundation to undertake work at Cape Hallett from 03/04. This project proposes to make comparisons between Taylor Valley and Cape Hallett as representatives of end points of a gradient where soil organic matter availability, soil moisture and salinity represent the broad range of soil factors found across Victoria Land.

6. CONSTRAINTS IN THE FIELD

Constraints on conducting field research in Antarctica may be obvious, but nonetheless need to be considered. The limitations on Antarctic field research are, on the whole, imposed by weather, logistics, safety and environmental impact evaluation.

6.1 Weather

Weather is maybe the most obvious of constraints in the field. Due to the nature of the LGP, the five research sites proposed have diverse climates associated with them. All are obviously subject to cold temperatures and winds can also be frequent and severe. In short, weather is unpredictable, and researchers can often find themselves confined to camp, or worse, stranded on trips away from camp in adverse weather conditions. When going to and from the camp site, please plan for delays due to weather conditions.

6.2 Logistics

Logistical considerations begin with the departure from the researcher's point of origin to Christchurch, where intra-continental airborne operations are conducted from. Delays due to mechanical breakdown or weather conditions should be planned for when scheduling flights to and from Antarctica. Travel to the field camp may be by helicopter, twin otter, or ship. Once again, delays can often be experienced here due to mechanical breakdown or weather conditions.

Once in the field, camp facilities are likely to be basic and possibly limiting to some forms of scientific research.

6.3 Safety

Safety is of primary concern to Antarctica New Zealand, especially in the field. Due to the nature of Antarctic field research the potential for accidents to occur is ever present. Participants in the LGP are expected to adhere to the safety and risk management procedures endorsed and used by Antarctica New Zealand (e.g. diving manual, OSH compliance, risk management manual). A risk assessment must be carried out for each field party and contingency plans formulated. Basic safety and emergency procedures can be found in Antarctica New Zealand's 'Field Manual'.

6.4 Environmental Impact Evaluation

The environmental impacts imposed by cumulative field parties on a single site are of concern and need to be addressed. Limitations may be imposed on proposed activities if they are deemed to cause an unacceptable impact on the environment.

In accordance with the requirements of the Antarctica (Environmental Protection) Act 1994 all activities supported by Antarctica New Zealand must undergo an Environmental Impact Assessment (EIA). Such activities may not proceed until these assessments have been approved (Section 6 below).

7. ENVIRONMENTAL IMPACT/MANAGEMENT

All activities supported by Antarctica New Zealand must have a Preliminary Environmental Evaluation (PEE) approved before they can take place, in accordance with the requirements of the Antarctica (Environmental Protection) Act 1994. The Ministry of Foreign Affairs and Trade (MFAT) administers this Act, and has established a specialist body – the Environmental Assessment and Review Panel (EARP) – to advise it on the potential environmental impacts of proposed activities under the Act.

Antarctica New Zealand, in consultation with EARP and MFAT, has developed a standard format for PEEs for the activities it supports (see Antarctica New Zealand's website). This PEE document must be completed by the leader of every event proposing to undertake research in Antarctica under the framework of LGP.

As the cumulative impact of the individual activities proposed under the framework of LGP are likely to be minor or transitory, the PEEs submitted will be compiled into an Initial Environmental Evaluation (IEE) by the LGP Project Manager for each of the proposed sites. IEEs for each site will be submitted to EARP by June of the year the field work is intending to commence.

8. DATA MANAGEMENT

It is proposed that the majority of the data collected under the LGP will be housed and managed by AAD under the auspices of RiSCC. RiSCC already has a fully developed biodiversity database that can easily accommodate the LGP data. Data entry forms will be made available by AAD as soon as they are completed.

The RiSCC database is web accessible and allows for easy access to the data by LGP participants. It is anticipated that an LGP PI must make the data available to the database manager in an acceptable format within a specified period of time after of returning from the field. This data will be stored in the database and be password protected, limiting data access to LGP participants for two years before it becomes publicly available. These timelines are yet to be confirmed.

9. REPORTING & PUBLICATION

Enquiries are being made into the possibility of devoting predetermined sections of *Antarctic Science* to LGP-related publications throughout the life time of the LGP on an annual or biennial basis.

10. APPENDIX A: DISCUSSIONS REGARDING THE LATITUDINAL GRADIENT PROJECT

JANUARY 1999 Discussions begin between Paul Berkman (US), Riccardo Cattaneo-Vietti (IT), Mariachiara-Chiantore (IT) and Clive Howard-Williams (NZ).

MARCH 1999 Clive Howard-Williams (NZ) - Annual New Zealand Antarctic Science Workshop.

APRIL 1999 Ian Goodwin (AU) and Ross Powell (US) - SCAR-IGBP GLOCHANT Meeting.

MAY 1999 Robertta Marinelli (US) - SCAR-RISCC Workshop in Madrid, Spain.

MAY 1999 Paul Berkman (US) - SCAR-ANTIME Antarctic Radiocarbon Workshop, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts U.S.A.

MAY 1999 Clive Howard-Williams and Dean Peterson (NZ) - "Integrating New Zealand's Research Efforts in Antarctica Using the Concept of a Latitudinal Gradient." A proposal submitted to Antarctica New Zealand's Science Strategy Theme (Life in Extreme Environments).

JUNE 1999 Roberto Cattaneo-Vietti (IT), Paul Berkman, Mariachiara Chiantore (IT), Francesco Regoli (IT), David Garton (US) and Marco Nigro (IT) - "The Victoria Land Coastal Transect Project." SCAR-EASIZ Meeting. Bremerhaven, Germany.

SEPTEMBER 1999 Paul Berkman - West Antarctic Ice Sheet Meeting, Sterling, Virginia USA.

FEBRUARY 2000 Paul Berkman, Berry Lyons (US), John Priscu (US), Walker Smith (US) and Ed Waddington (US) - "The Victoria Land, Antarctica, Coastal Biome: Marine-Terrestrial Biocomplexity Across a High-Latitudinal Environmental Gradient." A proposal to the National Science Foundation, Biocomplexity Program.

JUNE 2000 Berry Lyons - SCAR-RISCC Meeting, Johannesburg, South Africa.

JUNE 2000 Roberto Cattaneo-Vietti (convenor)- "Victoria Land Coastal Program" Meeting, Siena, Italy.

JULY 2000 SCAR Biology Working Group, Geology Working Group and Committee of Managers of National Antarctic Programs - Tokyo, Japan.

AUGUST 2000 Clive Howard-Williams and Dean Peterson (convenors) - "The Latitudinal Gradient Project" Workshop, Christchurch, New Zealand, Supported by Antarctica New Zealand.

SEPTEMBER 2000 Paul Berkman (convenor) - Workshop planning session at the West Antarctic Ice Sheet (WAIS) meeting in Sterling, Virginia.

26-29 APRIL 2001 Paul Berkman, Berry Lyons, Ross Powell, John Priscu, Walker Smith and Ed Waddington (convenors) - "Victoria Land, Antarctica, Coastal Biome: Marine-Terrestrial Biocomplexity Across a High Latitudinal Environmental Gradient" Workshop at the Byrd Polar Research Center, The Ohio State University, Columbus, Ohio U.S.A. - supported by the NSF Office of Polar Programs.

25-26 AUGUST 2001 Workshop on "Latitudinal Ecosystem and Environmental Variability Across Victoria Land" which will be convened at the SCAR Symposium on Antarctic Biology in Amsterdam, The Netherlands.

28 February 2002 Meeting on BioRoss cruise plans with representatives of Antarctica New Zealand, NIWA and Italian Antarctic programme, Christchurch.

24 April 2002 Shulamit Gordon (NZ) - LGP presentation at Annual Antarctic Conference, Auckland.

31 May 2002 Meeting on BioRoss cruise with representatives from Antarctica New Zealand, Ministry of Fisheries, NIWA, LINZ and the Italian Antarctic programme, Wellington.

8 October 2002 First LGP Science Steering Committee meeting, NIWA, Hamilton.

25 March 2003 Second LGP Science Steering Committee meeting, University of Waikato, Hamilton.

24 April 2003 LGP workshop in conjunction with Antarctica New Zealand's 2003 Annual Antarctic Conference, University of Otago, Dunedin.