Antarctica today, and opportunities for tomorrow

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Why is Antarctica important

A little about British Antarctic Survey

Science opportunities

Collaboration examples
Key science issues in the Antarctic

- Greatest uncertainty in global sea level rise
- Major driver of global ocean system, and hence fundamental to predicting world’s weather and climate
- Largest under-exploited marine living resource
  - Antarctic krill could be ~7% of all current fishery landings
- World’s largest oceanic carbon sinks
- Understanding how the planet works – the polar component
Temperature change in 2012 compared with 1951-1980 mean

Antarctica

Mean annual temperature anomaly 2012
Antarctic Peninsula changes

- Air temperature: 3° C in 50 years
- Ocean: 1° C rise in 50 years
- Circumpolar westerlies: 20% increase over 30 years
- 87% of glaciers in retreat – sea level rise
- Winter sea ice extent decreasing by 10% per decade
- Nine major iceshelves broken up in the last 50 years
Sea ice changing

Ocean Conveyor Belt

Density (no. m$^{-2}$)


Year

South America

South Sandwich Islands

Polar SCIENCE FOR PLANET EARTH
Why does the Southern Ocean matter so much?

Key global connections

Key global transformations
The Southern Ocean overturning transfers carbon dioxide from the surface to the ocean interior

40% of all anthropogenic carbon has been absorbed by the Southern Ocean. At today’s carbon price the Southern Ocean is worth over 1 B€ per annum.

The effectiveness of this CO$_2$ sink is changing.
Survey and science from air, ground and under the sea
The impact of a one metre sea-level rise – displaced people in Asia
British Antarctic Survey – Science Strategy

• Science topics of global relevance

• Fundamental science topics where the polar regions offer particular advantages

• Earth system science approach – inter-disciplinary

• Both poles

• Scientific excellence
Science – approach

- Cutting edge science
- Long term monitoring and survey
- Science that underpins policy decisions
- Expert teams to address big issues
- Collaboration – national and international
- Novel technologies, products and services
Polar Science for Planet Earth

Where have we come from?
Where are we now?
Where are we going?
British Antarctic Survey Mission

- To deliver a world-class programme of scientific research, national capability and long-term observations, concentrating on the regional and global role of polar processes in the earth system.

- Through our science and impact sustain for the UK an active and influential Antarctic regional presence, and a leadership role in Antarctic affairs.
Science Excellence
Advice to Government
- Support at Antarctic Treaty Meetings
- Support at Southern Ocean Fishery management meetings
- Climate change
Presence in Antarctica
Engagement in SCAR
Contribute to the economic growth
Assets

Ships, Planes, Stations
The Route to Antarctica

Ships
RRS James Clark Ross
RRS Ernest Shackleton

BAS Aircraft
1 x Dash-7
4 x Twin Otter

MOD Airbridge
(via Ascension)
Lan Chile
(via Santiago)

Halley VI Build
Charter Ship
DROMLAN Air Link

British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL
BUDGET = £49M

- Ships: 36%
- Science: 28%
- Air Support: 8%
- Field Locations: 14%
- Comms etc: 1%
- Cambridge: 13%

Inflation having a significant impact on budgets
Marine gas oil
Some future opportunities

Science possibilities
New technology
Little known about the lower trophic levels
Polar ocean impacts

Biodiversity high in Tropical and Southern Oceans
Isothermal environment - animals very susceptible to change
Ocean acidification
The deep sea: the complete unknown
the origins of deep sea fauna?
Number of species in the inter-tidal zone

- Limits of life
- Gradients in biodiversity
- Evolution
The Levels of Complexity of the Biosphere

- **Biosphere** - The world we live in
- **Ecosystem** - The set of communities of all domains of life that interacting with one another and the abiotic environment to form a unit (e.g., freshwater ecosystems, taigas)
- **Community** - Interacting populations of organisms (e.g., coral reefs, montane forest)
- **Population** - All individuals of a species or phylotype within a community (e.g., trees of a given species within a single forest, the fishes of a given species in a single coral reef)
- **Organism** - An single individual (e.g., a lizard, a tree, a bacterium)
- **Organ system** - A specialized functional system of an organism (e.g., digestive, nervous)
- **Organ** - A set of tissues that function as a unit (e.g., heart, brain, kidney)
- **Tissue** - A set of interacting cells (e.g., epithelia, muscle)
- **Cell** - The functional unit of all living organisms (e.g., red blood cell, neuron, bacterium)
- **Organelle** - A specialized subunit within cell (e.g., mitochondria, chloroplast)
- **Molecule** - Biochemical constituents of cells (e.g., a protein, a nucleic acid)

SOURCE: Committee on a New Biology for the 21st Century.
New Marine Protected Areas
December 2011

First High Seas Marine Protected Area
November 2009

- What is the appropriate scale of protected areas?
- How good are top predators as an indicator of the state of the environment?
Understanding volcanism, tectonics and sedimentation in the Scotia Sea:

Identifying and exploring for the first time submarine volcanoes in the Scotia Sea.

- Magma generation in a uniquely simple subduction zone
- Identification of vents with unique fauna
- Unique sedimentary environment because of high erosion on glaciated islands

Saunders Island, South Sandwich arc

Multi-beam bathymetry, NE Antarctic Peninsula
Tropospheric Atmospheric Chemistry

Largely free from pollution

Peninsula ~60°S
Marine all year
Sunlight all year

Halley – 76°S
3 months daylight/3 month darkness
Sea level
Ocean remote in winter; close in summer

Trans-national pollution

Svalbard 79°N
Very similar to Halley except pollution

Dome C 76°S
High altitude (3200 m)
Same latitude as Halley
Remote from ocean and sea ice
The Southern Ocean Observing System (SOOS) addresses six scientific challenges:

1. The role of the Southern Ocean in the planet’s heat and freshwater balance
2. The stability of the Southern Ocean overturning circulation
3. The role of the ocean in the stability of the Antarctic ice sheet and its contribution to sea-level rise
4. The future and consequences of Southern Ocean carbon uptake
5. The future of Antarctic sea ice
6. The impacts of global change on Southern Ocean ecosystems
New technology opportunities for new science and potential commercial activity

- Allow to scale up local measurements to region/continent
- Allow to scale up from few to many measurements
- Can help address space-time ambiguities
- Reduce the requirement of human effort

- Increased use of remote observation from land e.g. cameras
- Use ships of opportunity e.g. fishing and tourist vessels
- Increased level of automation
- Increased use of satellite remote sensing from space penguin counts, whale counts, geology, habitat mapping
- Increased use of autonomous vehicles
Unmanned vehicle for atmospheric chemistry

Aerial vehicles

Oceanographic gliders

Automatic recognition

Remote counts

Emperors from space

Unmanned vehicle for atmospheric chemistry
Future Science

- Oldest ice – 1.5 million years
- Regional and global impact of atmosphere/sea ice/ocean interactions
- Predictions of the Southern Ocean ecosystem on a circum-polar scale
- Evolutionary link between the polar regions and the deep sea
- Ocean mixing and its implications for ocean circulation and climate
- Rapid icesheet changes and their regional implications
Collaboration

• Scientist to scientist
  o Visits to each others institutions
  o Sabbatical study visits
  o PhD students
  o Joint proposals – FP7, Horizon 2020

• Institution to institution

• Government to Government

BAS has a history of national and international collaboration

• Number of papers doubled in a decade (158-310)
  o 61% of BAS papers have an international co-author
  o 50% of BAS papers have a UK author from another institution
  o Supervisors of over 50 PhDs – some from overseas
Collaboration with the Dutch

• Started ~20 years ago at a very low very informal level
• Driven by one or two key individuals
• Focus on terrestrial biology
• Collaborative studies with British Antarctic Survey scientists
• Became formal arrangements with annual fee, and written agreement

• Increasing Dutch interest in the polar regions
  o Access to a land based research station – Rothera – BAS
  o Marine Research Vessel – AWI
  o Terrestrial Arctic research – Norway
• Made a major contribution to the science infrastructure at Rothera
• Very detailed discussions to ensure new developments and science highly complementary to UK research
• All Dutch proposal have a UK PI/co-I
• 2012-13 first full science season – excellent arrangements
Collaboration with the Dutch

Dirck Gerritsz Laboratory consists of four separate shipping containers that have been modified into working laboratories.
Collaboration with Malaysia

Following a very similar development to the Dutch

A few informal visits initially

2013 – a formal agreement to take some Malaysians south every year for an agreed fee

Their focus is terrestrial using modern biological techniques – Signy

All training and clothing provided by BAS; point of contact in BAS

Two BAS staff appointed honorary professor at Malaysian Universities
• Antarctica – remote but understanding is essential for predicting the future of our planet

• Continuing need to explain relevance of Antarctica to Government

• All of the key issues require international collaboration

• Many successful national and international collaborations in science and logistics