SCAR BIOLOGY WORKSHOP

27-28 May 2010. Castiglioncello, Italy

ATTENDEES:	Pete Convey	British Antarctic Survey, EBA co-chair
	Shulamit Gordon	Antarctica New Zealand, EBA Secretary
	Antonio Quesada	University of Madrid, Aquatic Ecologist
	Stefano Schiaparelli	University of Genova, Marine Biologist
	Katarina Linse	British Antarctic Survey, Marine Biologist
	Martine Riddle	Australian Antarctic Division, Environment Protection and Change Programme Leader. Applied Benthic Ecologist
	Louise Newman	APECS representative to EBA – PAGES
	Dom Hodgson	British Antarctic Survey, Palaeocology and climate change. Leader of EBA WP1. SALE and ACE programme involvement
	Elie Poulin	University of Chile, Phylogeography.
	Renuka Badhe	SCAR Executive Officer
	Diana Wall	Colorado State University, Soil Ecology
	Andy Clarke	British Antarctic Survey, Marine Ecologist
	Wim Vyverman	University of Ghent, Belgium, Aquatic Ecologist
	Piero Luporini	PNRA Leader of Biology and Medicine
	Clive Howard-Williams	NZ National Institute of Water and Atmosphere. Aquatic Ecologist
	Kathy Conlan	Chief Officer for SCAR LS-SSG. Benthic ecology
	Brent Sinclair	University Western Ontario, Broad terrestrial ecologist, insect molecular ecology
	Lúcia Campos	University of Rio de Janeiro, Brazil, Benthic Biologist
	Angelika Brandt	Hamburg Zoological Museum, Deep sea in polar regions
	Julian Gutt	AWI Germany, Marine Ecologist, Co chair of SCAR group on prediction of biological and physical systems
	Yves Frenot	Director of IPEV and Chair of CEP. Terrestrial ecologist
	Marc Lebouvier	IPEV, France, Impact of climate change and introduced species on terrestrial ecosystems
	Guido di Prisco	National Research Council, Italy, Marine Biochemist
	Cinzia Verde	National Research Council, Italy, Marine Biochemist

Day 1:

Presentation by Yves Frenot

- Outline on the Antarctic Treaty System, Madrid Protocol and the Committee for Environmental protection
- CEP includes experts but has to consult with other experts to get the answers to questions.
- List of points in the 5-year work plan that relate to this workshop - shows main issues and priorities for CEP. These are shown in the table below:
- Non Native species report – highlighted gaps of knowledge and who is best placed to fill those gaps. Future EBA programme is important for this.

Introduction of non-native species	**1**
Actions: 1. Develop practical guidelines / standards / norms for all Antarctic operators. 2. Advance recommendations from climate change ATME	
Tourism and NGO activities	**1**
Actions: 1. Provide advice to ATCM as requested. 2. Advance recommendations from ship-borne tourism ATME	
Global Pressure: Climate change	**1**
Actions: 1. Consider implications of climate change for management of Antarctic environment 2. Advance recommendations from climate change ATME	
Marine spatial protection and management	**1**
Actions: 1. Cooperate with CCAMLR on Southern Ocean bioregionalisation. 2. Identify processes for MPA designation. 3. Advance recommendations from climate change ATME.	
Human footprint / wilderness management	**2**
Actions: 1. Develop an agreed understanding of the terms "footprint" and "wilderness".	
Monitoring and state of the environment reporting	**2**
Actions: 1. Identify key environmental indicators 2. Establish a process for reporting to the ATCM 3. Advance recommendations from climate change ATME	

Biodiversity knowledge	2
Actions: 1. Maintain awareness of threats to existing biodiversity. 2. Advance recommendations from climate change ATME	
Specially protected species	**3**
Actions: 1. Consider listing / de-listing proposals as required.	
Overview of the protected areas system / EDA	**3**
Actions: 1. Apply the Environmental Domains Analysis (EDA) to enhance the protected areas system. 2. Advance recommendations from climate change ATME	

<u>Presentation by Renuka Badhe:</u> Scientific Committee on Antarctic Research (SCAR) - An International Scientific Partnership

What is the Scientific Committee on Antarctic Research?

- An interdisciplinary scientific body of the International Council of Science (ICSU)
- Secretariat is housed in the Scott Polar Research Institute at Cambridge, England
- Secretariat includes an Executive Director, an Executive Officer and an Administrative Assistant (1/2 time)

SCAR's Mission

- **Science Leadership -** initiate, develop and coordinate high quality international scientific research in the Antarctic and Southern Ocean region
- **Scientific advice -** provide objective and independent scientific advice to the Antarctic Treaty System (ATS) and other bodies.

How Does SCAR Accomplish its Mission?

- Standing Scientific Groups
- Expert Groups
- Action Groups
- Planning Groups
- Standing Committees
- Scientific Research Programs
- Partnerships
- Open Science Conference
- Thematic Symposia/Workshops

Current SCAR Scientific Research Programs

- ACE
- EBA
- SALE
- AAA
- ICESTAR
- AGCS

SCAR Scientific Research Programs

- Preceded by a Program Planning Group formed by a Standing Scientific Group
- Major cutting-edge research questions
- International in participation and interdisciplinary in scope
- Expected duration: 6 to 8 years
- Strategic and implementation plan required
- 2-year internal and 4-year external review
- Data management policy and outreach plan

Program Planning Group (PPG)

- Need a title and brief (1-2 page) outline of the proposed Scientific Research Programme (SRP), plus a suggested chief officer and initial core membership for the Program Planning Group (PPG)
- This will be further discussed at SSG Life Sciences in Buenos Aires (2010)
- Plan then presented to SCAR Delegates by SSG Life Science chair (Kathy Conlan)
- For those bids approved, a PPG will be established for 2 years and the level of any SCAR funding needed to support the work of the PPG will be set
- After 1 year (2011) PPG will submit a draft Science and Implementation plan (no more than 15 pages) to SCAR Executive Committee for comment
- After 2 years (2012) final plan submitted to SCAR Delegates meeting. Plan will undergo external review
- Delegates will decide if plan should be funded and at what level

Plan will be judged on:

- Science quality/proposal quality
- Science importance/relevance/timeliness
- "Fit" to SCAR Strategic Plan
- Operational and Technical feasibility
- Degree of international involvement/likely commitment
- Data archival and access
- Public/policy profile
- Value added by SCAR involvement.

Scientific Committee on Antarctic Research (SCAR)

The SCAR SRPs are the major focii of SCAR's scientific efforts. They can only be as successful as the people who plan and work on them.

http://www.scar.org/

General Discussion

- Need a one page proposal put to the SSG
- Need to agree on the proposal
- Kathy Conlan to present it/them to the delegates at BA
- If approved, a programme planning group (PPG) will be established for 2 years.
- In 2011 PPG will submit a science implementation plan for review – reviewed by SCAR executive committee, changes submitted. Final plan submitted 8 weeks before OSC. Goes to external review (can have a say on the reviewers).
- **Brent:** What is going to be in the SCAR strategic plan? It will be on-line in 2 weeks.
- **Kathy:** SCAR develops the strategic plan from our science. Bottom up process. So don't need to go to the plan for inspiration. Good to know what other action groups etc are around and what we can tie in with, this is very valuable. Part of the international involvement request.
- PPG can do the work of fitting the final plan in with the SCAR scientific plan. The Plan talks more about integrating across disciplines, outreach, and how do we get a secure place in the wider world. Don't need to worry about this too much now.
- Should keep in mind that we want to go beyond just the biological aspects, but try to find possibilities of interacting with physical sciences and geo sciences. This goes along the lines that SCAR is encouraging at the moment.
- How does SCAR differentiate between action groups and expert groups and SRPS? Action groups are shorter, smaller, less funding, to answer specific questions. Expert groups= individuals who are experts in their field and also have a short period of operation to answer a specific question.
- Evaluation process: When EBA went forward for review – had a problem as it was about everything biological – not very focused. Need to take note of this now. Important to make the connection with physical sciences. But need to try and focus and achieve an end point and not just have a programme about studying life in Antarctica.
- Re AGCS – produced the ACCE document – best document that SCAR has produced. Can the biological community do something like this? Need to recognise the end point we need to get to.
- **Elie:** Should one of the new programmes be about conservation concerns? All the issues listed on the CEP slide show are missing information – so need to fill these gaps if we want to push some recommendations to the parties on these issues.
    - Not the role of CEP to drive the research, but the CEP provides advice to ATCM so they can establish policies. SCAR is the main source of information for the CEP so it's important that there is a close relationship between SCAR and CEP. Is this information available through SCAR scientists – if not – can we ask through the SCAR programmes if it's possible to work on this issue?
- Probably not good to have a whole SRP dedicated to conservation – maybe a sub group would work better.

- Asked Yves to present – because SCAR's remit is to provide scientific advice to the ATCM. Happens in an ad hoc fashion. But what is clear from the last several years re: invasive issues and human impacts – is that the next few years will see a lot of attention to environmental management and conservation issues. That isn't our focus, but clear that SCAR and Treaty system wants to examine this and it needs strong scientific foundation. So there is a clear applied use for them coming up. Sometimes is a timely opportunity to provide science advice for these kinds of issues.

- **Yves:** It is only recently that CEP became a pro-active body. Used to wait for ATCM requests to focus its work on. But non-native species was pushed by CEP to ATCM – first time CEP did this. ATCM didn't ask about this before. So it's the scientists themselves pushing these issues. Scientists can still highlight missing issues in the CEP workplan.

- **Brent:** Could have a document that summarises human impacts – and be able to identify the gaps that need to be filled.

- **Clive:** We have to be providing this information somehow – we do need to incorporate what the CEP needs in our biological programme. Since SRPs last for 5 years - some of the questions we ask are 'enduring' questions. But some questions are important NOW – fastest changes in biology are going to happen in the non-native species areas – rather than climate change.

- **Julian:** This may be true in the terrestrial environment, but in the marine environment it is completely different. non-native species is of minor importance, but global change is having a faster impact on the marine environment.

- CCAMLR – fishing effect is another impact.

- **Katrin Linse:** In the marine field, data will come out of the census in next 5 years – bio regionalisation – using physical parameters to make bioregions - looking at pelagic system but not including benthic system – and that is where the big results will come out in the next 5 years. Marine community needs to drive the advances – and SCAR to drive bio regionalisation in benthic area – not CCAMLR.

- **Martin:** Very important that our science is relevant by connections to CEP. See 3 timescales of the way science and CEP interact:

    - Practical short term responses to questions. 1-2 years.

    - Strategic – rather longer – agreed prioritised deadlines.

    - Foundation science – longer term science that is necessary to make the right decisions.

- See that the SRPS has an excellent fit to the foundation science timescale.

- Standing out is the bio regionalisation work the foundation for spatial protection and management. Provides linking process to evolutional science, biology, landscape analysis, biogeography. Provides a broad framework, opportunity to interact closely with disciplines, also a clear deliverable, practical value to the CEP. So very strong opportunity for a focus.
- See in 5-8 years period a major document on foundation for spatial management in the Antarctic. Recognises spatial characteristic of the Antarctic environment. So want to look at what the CEP will ask information about.
- Environmental Domains Analysis – brings easier information on physical environment. Biology is harder to get.
- Monitoring of state of environment on CEP agenda – bio regionalisation very important for this and needs to emphasise the long term data. If we want to follow the challenges of Antarctica – need to follow this. Need a balance between the short term and the long term research.
- See some support round bio regionalisation.
- EBA as is, is a very big open programme, and easy to criticise this.
- Biology community that wants to engage with SCAR wants the SRPs to be inclusive so different parts of the community can buy into the programme (e.g. marine and terrestrial). But it is clear that a repeat of EBA in its bigness is not going to be welcomed. Should be able to propose 2 distinct programmes.
- DISTINCT is very important so we have boundaries between the 2 programmes.
- Discussion puts out 2 possibilities with large organisms and small organisms – though there would be interactions. But need to show how they are distinct in the main ways, and show how you'll draw resources from both communities.
- How else can we split things up? Do we still want to go along that approach?
- **Guido:** Yes distinct, but some things surely must overlap. Too difficult to come out with two completely different things.
- **Guido:** Some problems are typical for marine environments and some that are typical/more important for terrestrial environments. Don't want to create a situation where one programme dominates over another one.
- Don't want a programme driven by ecology, and one driven by genetics.
- **Brent:** disagrees with the approach proposed – suggests 2 good question based grouping.
    1. Direct human impacts.
    2. Indirect impact/long term change – includes evolution, climate change. Feed off each other, though could be quite separate. Some people would fit under either or both of those.

- Delegates think biology is biology – so need a clear way of separating new proposals.
- **Clive:** Concept of long term enduring questions that will still be going on in 15 years time – adaptation to environment and relationship to climate change. But aside from this, we could concentrate on two aspects, but main questions continue to be asked: Rapid change of physical structures e.g. ice shelves, lakes, non-native species.
    - **Andy:** In many areas there are long term questions that continue to interests us, and now there are extra bits that start interesting us. The problems we face are that we as scientists have interesting questions and they are big to answer, but delegates see business as usual. Delegates want new and exciting. But the questions are big and hard to answer. So need to package this big question in new ways to get the buy-in. Don't want to change our work just because we haven't answered them.
    - **Elie:** Trying to separate disciplines, but counterproductive for a multi disciplinary approach. Timescale seems to be the things that defines what we do – keeps interdisciplinary nature. Can join people working on recent climate change with recent processes.
    - 'Omics' disciplines – can work on these on different timescales.
    - **Angelika:** still need to discuss if we do 1 or 2 programmes. Also the main things we want to answer. Don't like the separation of disciplines – as they are just starting to merge.
    - **Renuke:** 2 programmes need to be distinct enough from each other and distinct from EBA too.
    - **Louise:** List of key questions and see if we can get programmes that address key questions then outputs will be more likely to get funding. So what are the key questions?
    - **Guido:** Chuck was definitely encouraging us to have 2 programmes and we don't want to be re-proposing what we already have.
    - **Yves:** Antarctica is under the spotlight of the public after IPY etc and it's important to think about what the public is thinking about the scientists. What do the scientists do? Need to identify clear questions – impact of climate change? Changes in the ocean? Not sure about splitting programmes on disciplines will answer the key questions. Identify 2 key questions with 2 clear separate programmes.
    - **Each workshop participant wrote down what they thought where the key questions that needed to be answered. See Appendix 1 for a list of these key questions.**

Second Session

- Science programme needs to speak to a defined part of biology.
- **Elie:** what will be the output of this programme? Good to think about this. Not just about Antarctic science but about Antarctic concerns. Could suggest the various kinds of outputs. What is the state of play on human impacts on the Antarctic environment?
- **Andy:** For many of programmes in the past, the output have often been an edited volume of science papers. Contrasts with the ACCE volume – edited volume about a specific topic. Useful, big, impressive, but takes a lot of time to do which could be used doing science. So is it still politically acceptable to have as an output of a programme, an edited science volume?
- **Clive:** AGCS volume was seen to be very relevant to the current situation. Didn't matter in what form it was in, just that it addressed very relevant questions.
- **Pete:** ACCE report wasn't just AGCS publication. Other groups were part of this too.

Post Lunch Session – Day 1

- Participants split off into groups taking the key questions that were listed in Appendix one and tried to put them into natural groupings.

Pete's group:

1. **Ecosystems, environment and change:** All aspects of climate – large global scale and local drivers
    - Climate (global [e.g. OA]/local drivers [human impacts])
    - Human impacts
    - Rates of change (palaeo to immediate)
    - Ecosystem function
    - Environmental description
    - Tipping points, Resilience/resistance, sensitivity/thresholds
    - Cross-discipline – physics – climate
    - Modelling and prediction (link from large scale climate mod to small scale bio prediction and mod)
    - Functional adaptation
    - Feed to CEP

2. **Biogeography:**

    - Bio-regionalisation (and history)
    - Biodiversity and monitoring
    - Phylogeography (inc palaeo; link to glaciology, and climate)
    - Refugia
    - Modelling and prediction (bio geographical prediction, macro ecology)
    - Colonisation processes
    - Conservation and management (protected areas: CEP/ATS) [consider EG role, or for aliens specifically]
    - Uniqueness
    - Global patterns/gradients/bipolar

Brent, Elie, Julian, Andy & Kathy

1. **Long-term processes** (Biodiversity? Antarctic biodiversity in a global context?)

    - Biodiversity – survey ideas
    - Biogeography / Bio regionalisation
    - Origins, diversification and adaptation of the Antarctic biota – evolutionary biology
    - Antarctic connections to the rest of the world
    - Non-native species
    - Macro ecology

2. **Ecosystem resilience and functioning** – current climate change and human impacts and the responses to these:

    - Current climate change
    - Organism & Ecosystem responses to the environment and its changes
    - Human impacts
    - Non-native species
    - Extreme events (e.g. ice shelf collapse and responses of ecosystems to these)
    - Ecosystem services – recognise that biological ecosystems do things that interact with other parts of the world – e.g. marine ecosystem. So impact is high but not necessarily recognised.

Yves' Group :

Project 1 GLOBAL impact	Common key words, tools	Project 2 LOCAL HUMAN IMPACT
Effect of "natural" Global Environmental Changes on Antarctic organisms – past, present, future	**(time and space scales)**	**Effect of human impacts**
• evolutionary history and biogeography, phylogeography • deep sea biodiversity vs shallow water changes • rare species and global changes • palaeoscience (refugia...) including all sciences (geol. climate...)	• Prediction, modelling • adaptation (genomics, biochemistry, physiology, morphological adaptation...) • bio regionalisation • rapid vs slow changes • resilience of ecosystems • develop innovative techniques for environmental monitoring (marine and terrestrial) --- • think about what products are expected	• vulnerability and threats (species, habitats, ecosystems), risk assessment • introduced non-native species • tourism • fisheries (cf CCAMLR + Expert group Birds and Seals)

Diana, Clive, Dom, Louise:

Went for stakeholder focus.

1. **Vulnerability and threats to the Antarctic Environment**

- Working Group – Effects of Climate Change
  - Rapid climate change
  - Long-term changes

- Working Group - Human Impacts
  - Species invasions
  - Tourism and science impacts
  - Pollution
  - Resource utilization – links with CCAMLR

2. **Understanding Antarctic ecosystems – underpin the stakeholder focus. Not sure if this is a programme in itself.**

    - Biogeochemistry
    - Nutrient cycles
    - Food webs
    - Ecosystem interactions
    - Life history strategies
    - Adaptations

3. **State of the Environment – covers ICEMATE stuff**

    - Biodiversity (marine, terrestrial, sub-glacial) – SALE coming to an end so lots of work that could be taken in from them
    - Bioregions (marine, terrestrial, sub-glacial)
    - Ecosystem services e.g. absorption of CO2 to exploitation of fisheries

Things we need to flag:

General introductions and outcomes:

- Fit to SCAR requirements
- Why Antarctica?
- Connectedness to the world
- Products

<u>Discussion</u>

- Do see similarities in these. But need to pick one and see what can be put under them.
- **Angelika:** all 4 presentations show we need to focus on global environmental change as well as ecosystem functioning and services
- Global and environmental change together and bio regionalisation.
- Do need to ensure we don't make another EBA – need to stay stakeholder focused.
- Can see that everyone is thinking of global and climate change – both fast and slow changes. So climate change is high up there and can be underpinned by ecosystem structure and function.
- Set of things that will underpin how we look at these questions – these were a lot of the points made earlier.
- **Lucia:** Not just climate change – need to be careful about that – global environmental changes. Its responses to perturbations. Vulnerability and threats.
- Titles we settle on now will really guide our thinking – stakeholder focus or just general studies. Climate change studies are so bland now – that we need to try and change our focus.

- **Elie:** one group about recent global climate change and the other is more on evolutionary timescales – origination and adaptation. Seems to be a natural separation. Timescale again seems to be the easier way to split things. Recent ecological change and longer term evolutionary changes.

Appendix 1: Important points that workshop participants identified to be worked on

- Work from final product backwards – with both observations and predictions included
- State of play in the current Antarctic Environment
- Several over-arching problems/questions – make them fit to SCAR requirements
- Output of scientific papers vs edited volume like ACCE – which is more acceptable?
- Depends on relevance and time/effort required
- Biological Invasion
- Bio geographical history + glacial reconstruction
- Response **of** CC – past – present – future
- Colonisation process
- Evolutionary isolation and adaptation
- Energetic tradeoffs
- Life history strategies
- Cryptic speciation
- Vulnerability and Threats
    - Describing and identifying vulnerable regions
    - Bio-geography of terrestrial, lacustrine, marine
    - Ecosystem evolution - Future trajectories
    - Ecosystem ability to adapt to change without irreversible impact
- Protected area selection/definition/management
- Nutrient cycles – carbon, nitrogen
- Land-sea-ice interaction
- Human impacts on ecosystems
- Extreme events
- Bio-regionalisation:
    - Uniqueness of each region
    - Vulnerability to human impacts and climate change
- Predicting climate change effects on terrestrial and coastal ecosystems
- Valuation of Antarctic biodiversity – bio prospecting
- Rapid processes affecting Antarctic biota and impact on diversity and ecosystem functioning
- Using past Climate shifts and refugia as a tool for interpretation of present climate change
- Census of non-marine Antarctic life (CONMAL)
- Macro-ecology, biocomplexity, biology+geology+physics
- Measure and predict changes in Antarctic ecosystems
- Uniqueness of Antarctic biodiversity
- Adaptations of Ant. Organisms
- Historical biogeography in the Ant.
- Biodiversity: past-present-change (impact of CC, impact of non-native species)
- Flexibility of life history traits – macro-physiology (e.g. Chown et al)
- Impact of human activities
- Phylogeography – including Long distance dispersal
- Biological processes and biogeochemistry with impacts on global climate

- Impacts of rapid physical change – e.g. collapsing ice-shelves, rapid glacier melt, loss of marine and freshwater ice) on Ant ecosystems
- Susceptibility of the Ant. Communities to invasive species, process of invasion
- Long term response/adaptations to env CC of Ant. Organisms (includes 2 above points to answer this question)
- Response of ecosystem to Environmental Change
    - Ecosystem scales
    - Past responses to change
    - Ecosystem resilience/sensitivity
    - Relation of ecosystem structure to climate

- Human impact on environment
- Antarctic biodiversity census (incl biogeography + molecular)
- Resilience of the Antarctic Environment to: (using 2 above points)
    - Alien species
    - Climate Change
    - Human impact
- Climate Change in the Antartctica
- Rapid Climate Change
    - Responses in water and on land (which species and where located)
    - Product: Online atlas of soil biodiversity
    - Product: Bioregional map
    - Product: Nature paper summarising if changes are positive, negative or unknown across Ant.
    - Product: Biodiversity to global database
    - Product: Climate envelope for species in a region

- Genetic ability of Antarctic Organisms to withstand temp fluctuations
    - Comparing sequences/enzymes/whatever at different temps – eco-physiology
- Non-native species (maybe as EG?)
- Rapid physical changes and effect on species
- Direct impact of human activities
- Long term change – prediction?
- Resilience of Ant biological systems to environmental change
- Integrate mechanisms, processes and observations – leading to predictions, management recommendations
- Local impacts:

    - Critical thresholds: Sensitivity as a basis for prioritisation. Trigger values/targets
    - Cascading impacts – dependencies and interactions (tropic pathways etc)
    - Remediation technologies: in situ bioremediation using native Antarctic species
    - Sewage effluent as a source of non-native micro-organisms. Development of composting using Antarctic native species.

- Impact of climate change on Antarctic biodiversity including: Adaptation, responses changes in communities
- Non- native species including: monitoring, prediction (habitat/species), response of native communities.

- Impact of human activities in Antarctica including: non native species, local/regional pollution, 'footprint' (physical and biological), type of impacts (science, logistics, tourism, fisheries)
- Bio regionalisation in Antarctica, terrestrial and marine
- Habitat modelling, prediction of habitats useable for species – present and under different climate predictions.
- Phylogeny/evolutional history of marine and terrestrial tax and the timing of events.
- Assessment of recent biodiversity
- Effects of climate change on ecosystems, species invasions, range shifts
- Climate change/ocean acidification/stratification/changing currents and heat transfer, repercussion for biodiversity/repercussions for humans
- Changing human impacts on the Antarctic; introduction of alien species/shipping and transfer of aliens/pollution both local and long range introduction of contaminants/fishing and exploitation/tourism and science impacts on the environment and indigenous fauna/large experimental manipulations e.g. with fertilization
- biodiversity/evolution/systematic/conservation/change in population/adaptational change – molecular to biochemical.
- Connectedness – Antarctica not an as isolated environment: migration, export, CO2 uptake/global climate influence: what we can learn from Antarctica.
- Arctic/Antarctic parallels/ bioprospecting and fishing/resource use/conservation/evolutionary radiations/vulnerabilities.
- Human impacts on biogeography of organisms at every level, also microorganisms (will answer human impacts as well as refugia ideas on biological dispersion concepts).
- Untouched areas vs human-visited regions.
- Effects of global environmental changes on Antarctic organisms
- Biogeographical /bio regionalisation
- Why Antarctica? – Key role for extrapolation of response and defence.
- Adaptation and evolution remain key questions. Knowledge of adaptation mechanisms.
- Questions that can be tackled by 'omics'
- Ares of interactions with physical science, geoscience, paleo science, etc.
- Vulnerability of Antarctic ecosystems to environmental change
- Adaptation to extreme environments
- Are Antarctic ecosystems different from those elsewhere?
- Why are there so few Antarctic (Polar?) species?
- Has the physical history of Antarctica influenced the present biota?
- What are the impacts of non-native species?
- Ecosystem response to climate change:

    - Sustained observing
    - Sensitivity to change
    - the past as indication of the future of the future
    - modelling/prediction
    - vulnerability/risk assessment
    - functional genetics-gene potential vs gene expression
    -

- Scientific foundation for spatial management

- **VUNERABILITY ANALYSIS BASED ON:**

    - Rarity/uniqueness

    - Robustness/fragility
    - connectivity/habitat fragmentation
    - Genetic relatedness/distinctness

- Antarctic organisms threat by climate change. Past-present-future
- Environmental protection in the Antarctic terrestrial and marine environments
    - The impact of tourism and fisheries including CCAMLR

- Ecosystem response to environmental change
- Ecosystem response to climate change, changes in sea ice dynamics, ice shelf collapse
- Conservation to human impacts – to what extent human activities are affecting Antarctic organisms.