

Polar Marine Ecosystems Research: Strategic directions for the EU Research Area

Polar marine ecosystems are a critical aspect of global sustainability research and should be a high priority for Europe and Horizon 2020 because:

- They are integral to the Earth System, influencing global climate and biogeochemical cycles and maintaining unique biodiversity and ecosystem services;
- Their international political and economic significance is rising; there is mounting pressure for expansion of fisheries to provide food security and, in the Arctic, exploitation of oil, gas and minerals;
- They are undergoing unprecedented, dramatic and rapid climate-driven changes affecting regional environments and peoples, with far reaching consequences for the rest of the globe;
- They provide unique historical records and insights, serve as a barometer of the current state of the planet and act as an indicator for future change;
- Assessment of their responses to change is crucial for effective stewardship and predicting effects on the Earth System.

EU polar marine ecosystem scientists recognise that:

- We have extensive (and expanding) networks of EU scientists with the ambition and experience^a to advance polar marine ecosystem research through international, multidisciplinary collaborations;
- Horizon 2020 provides a timely opportunity to unite and harness this collective expertise to address key questions about the Polar Regions and their role in the Earth System;
- The EU should capitalise on its extensive investment and success to date, raising its level of excellence and strengthening its leadership and international partnerships in polar marine ecosystem research.

To advance knowledge of polar marine ecosystems and their influence on global cycles, we recommend that:

Polar marine ecosystem research is focused on the Arctic and the Antarctic

- Rapid changes in the Arctic are clearly a high priority for the Northern Hemisphere. However, from a scientific and Earth System perspective, parallel Southern Ocean research is also crucial;
- The Arctic is warming and sea ice is rapidly receding, with the record minimum Arctic ice extent reached in 2012. The Antarctic has areas of both ice reduction and expansion, and the Antarctic Peninsula is one of the most rapidly warming parts of the planet. Significant ecological responses to such changes are being documented and the consequences need to be understood;
- Physical dynamics of Southern Ocean water masses are rapidly changing due to atmospheric variations (e.g. ozone and greenhouse gases) and are in turn affecting the physical and biological carbon pumps;
- As the oceans continue to absorb anthropogenic CO₂ and become more acidic, the survival of shelled organisms (incl. algae and invertebrates) will be affected. Ocean acidification (decrease of pH, reduced saturation level for calcium carbonate minerals) is especially strong in cold waters, and evidence of dissolution in Antarctic marine snails has already been reported;
- Southern Ocean ecosystem studies provide some of the longest continuous scientific observations on record; much more extensive than from the Arctic. Together these give an historical context predicting change and for appropriate stewardship of these regions;

- The Southern Ocean is one of the few areas where there is sufficient knowledge across a range of spatial, temporal and trophic scales (e.g. from microbes to whales, from local to circumpolar scales) to understand whole ecosystem operation. These analyses also have relevance to Arctic and global ocean ecosystems;
- Both regions have rapidly expanding EU and globally important fisheries. Careful management, underpinned by ecological research, will allow for sustainable development;
- Through comparative studies of both oceans, we will rapidly advance knowledge about the Polar Regions, their influence on global cycles and ecosystems, their responses to change, and their effective stewardship.

Polar marine ecosystem research should be focused on these over-arching priority questions:

- What are the main drivers of ecological responses to change (including oceanographic forcings at different scales, direct effects on individual species, indirect effects through the food web and harvesting)?
- What is the role of these ecosystems in polar (and global) nutrient cycles, how are key processes linked, and how will these be affected by change?
- How should change be accounted for in the sustainable management of resources in the polar oceans?

Key scientific activities, working towards integrated end-to-end ecosystem analyses, should include:

- Multidisciplinary international research cruises in key regions of both polar oceans;
- An international network of long-term multidisciplinary observations (including moorings, gliders and predator-mounted oceanographic instruments) in both polar oceans;
- Comprehensive data mining, syntheses and management;
- A concerted modelling effort to improve the scientific basis and proficiency of models in projecting the response of polar marine ecosystems to environmental change and their feedbacks to the Earth System.

To achieve European and international leadership and collaborations in this field we recommend that:

A clear strategy for integrated European polar marine ecosystem research is developed

- A coordinated, multidisciplinary strategy (linked to the European Polar Board) will maximise the impact of EU research and funding; improve research integration and coordination; ensure dissemination of knowledge, education and outreach to stakeholders; and ensure high level EU contribution to world class research.

The EU polar marine ecosystem communities are now poised to unite for unparalleled scientific integration in understanding and predicting future change, working towards an Earth System perspective. The EU can capitalise on its investment and success, raising its scientific excellence and strengthening its leadership in this globally relevant research. Outputs will address major scientific and socio-economic concerns on climate change, food and employment security. We strongly recommend that marine ecosystem research, focused on both the Arctic and Antarctic, is a high priority for Horizon 2020. We are keen to present further details to support the above.

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³The Framework Programmes (e.g. FP6 EUR-OCEANS NoE and its legacy the [EUR-OCEANS Consortium](#), including [PECS](#)) have enabled multidisciplinary networks of EU polar scientists to lead globally important analyses of polar ecosystems and drive international activities addressing significant science challenges (e.g. Integrating Climate and Ecosystem Dynamics in the Southern Ocean, [ICED](#), programme). These partnerships were strengthened during the International Polar Year (2007-8, planned by the International Council for Science), providing a unique multidisciplinary snapshot of the poles. This legacy of partnerships will allow us to achieve far more than that of any single nation or discipline.