

## **1. INTRODUCTION**

Ice shelves form the floating edges of ice sheets that cover Greenland and Antarctica, constructed from the accumulation of snow on the continents. The shelves cover sea water cavities open to the ocean at their edges. These cavities can be several hundred kilometres long with water several hundred metres deep beneath ice up to a kilometre thick. The processes beneath ice shelves are involved in the waxing and waning of ice sheets that in turn affect sea level and climate, in addition in some cases to influencing the formation of bottom waters that drive ocean circulation. Ice shelves are also the source of icebergs that transport freshwater to the ocean.

The Autosub Under Ice (AUI) thematic programme aims to investigate the marine environment of floating ice shelves with a view to advancing the understanding of their role in the climate system. Central to this aim is the establishment of a community of researchers to use the Autosub vehicle as a platform to obtain data from the sub-ice shelf environment. However, the scientific theme of AUI is both interdisciplinary and multidisciplinary, and questions may be tackled by a range of methodologies in addition to Autosub missions. For example, support may be available for sea ice and ice shelf modelling, ice surface observations, spaceborne observations, and shipborne oceanographic, atmospheric and biological measurements and bathymetric surveys, where these are relevant to the interpretation or extension of data collected by Autosub. The AUI programme will therefore build an active and collaborating community, bringing together people with Autosub experience and those with polar and oceanographic experience who may not have used Autosub before.

## **2. AUTOSUB TECHNOLOGY**

Autosub is an Autonomous Underwater Vehicle (AUV): an unmanned and untethered submersible programmed to carry out missions without surface communication. These features allow the vehicle to survey remote environments that are inaccessible to other platforms. Autosub can collect physical, chemical, biological and geophysical data from the ocean surface to the seabed using a suite of sensors and sampling devices tailored to individual mission requirements.

The design concept of Autosub began in 1988 as a NERC community project to develop future technology for marine science. Extensive system development took place over 5 years and the first complete vehicle was built between October 1995 and May 1996. Autosub undertook its first autonomous mission in July 1996.. Since 1998 the vehicle has been employed by the Autosub Science Missions thematic programme for projects ranging from mapping manganese distributions to assessing krill populations beneath Antarctic sea ice.

Autosub measurements can include conductivity, temperature, transmissivity, fluorescence, photosynthetically active radiation, current velocities, turbulence, ice draft, and water depth. Sub-bottom acoustic profiling can reveal structures of glacial origin in the seafloor sediments,

while a water sampler can collect samples for geochemical and biological analyses. Sidescan sonar can give measurements of ice shelf, sea ice and ocean bottom relief at high resolution. There may also be an opportunity for the accommodation of other instruments proposed by the community.

### **3. PROGRAMME SCIENCE**

The principal questions motivating the programme are as follows:

#### **Physical Oceanography**

- How do ice shelves and icebergs affect the ocean, by contributing to water mass transformation, both near surface and at depth?
- How do the seasonal inputs of brine and of fresh ice meltwater influence the circulation and stratification on and near the continental shelves?
- How can we parameterise sea ice and dense water production rates in climate models which do not represent the ice shelves and the adjacent polynyas?

#### **Glaciology**

- Which climatic factors affect the rate of net basal melting from Antarctic and Greenland ice shelves?
- What are the processes of sea ice formation beneath and near ice shelves?
- What controls the distribution, deformation and thickness of sea ice, and what is the role of sea ice in forming dense shelf waters?

#### **Marine Geology and Geophysics**

- How do we interpret the sedimentary record left by ice shelves in past climates?
- What are the sediment discharge rates at ice shelf grounding lines?
- What is the bathymetry beneath perennially ice covered regions?

#### **Biology**

- How does the ice cover affect the ecosystem of the continental shelf waters, and what impact does this have on the sedimentary record?

To address these questions, work will focus on water masses, circulation, and ice formation beneath ice shelves and in adjacent continental shelf waters, the seasonal and perennial sea-ice covers, air-ice-ocean interaction in sea ice regions, ice-ocean interaction beneath ice shelves, and the structure of the seabed and nature of the sedimentary record left by past and present configurations of the ice sheet and sea ice. In addition, it is noted that the programme should gain unprecedented access to a largely unexplored marine region, providing an opportunity to address more open-ended questions.

Fieldwork will be conducted over three seasons in Greenland and Antarctica using Autosub. The likely candidate areas for research are ice shelves and proximate continental shelf areas are:

- Near the 79N Glacier at the eastern margin of the Greenland Ice Sheet
- In the eastern Pacific sector of Antarctica, in the vicinity of Pine Island Glacier and Wilkins and George VI ice shelves
- In the Weddell Sea sector of Antarctica, beneath and north of the Filchner-Ronne Ice Shelf

Field investigations are scheduled to run from 2002 to 2004 in the respective summer seasons in each hemisphere. An ice-capable research vessel will be the launch and retrieval platform for the Autosub, and will also act as a platform for additional science measurements in the support of the science programme.

All equipment to be used with the Autosub will be integrated and tested in a field trials anticipated to take place in Loch Etive, Scotland, in advance of the first field season. Cruise planning workshops will also take place before each field season to consider logistic and operational issues with a view to optimising the use of ship and Autosub time. This planning will also acknowledge the gradient of risk inherent in the penetration of the sub-ice shelf environment.

#### **4. PROGRAMME DELIVERABLES**

The performance targets of the programme are:

- To attain the scientific objectives stated above, through an integrated programme based on interdisciplinary collaborations and an international perspective.
- To develop a data management system for the archiving and collation of data collected by the programme, and to facilitate the eventual exploitation of this record by the community.
- To provide high quality training to develop national expertise in the use of autonomous vehicles in the collection of data from remote environments and the integration of such tools in wider programmes of research.
- To stimulate and facilitate the parameterising of sub-ice shelf processes in climate models, and to further demonstrate the value of autonomous vehicles as platforms for data collection among the wider oceanographic and polar community.

#### **5. PROGRAMME FUNDING AND IMPLEMENTATION**

The AUI thematic programme is funded by the Natural Environment Research Council (NERC) at £5.8m over *c.* 5 years. Approximately £1.5m of the AUI funds are available for individual research projects through a single call for proposals. Outline bid proposals were requested for this call, with a deadline of 23 June 2000. Full proposals were subsequently invited with a closing date of 01 November 2000. It is anticipated that the initial phase of projects will be awarded in late September / early October 2001.

## **6. TRAINING AND COMMUNITY DEVELOPMENT**

The training of PhD students is recognised to be an important component of the AUI programme. Two parallel elements of building the AUI community and involving the wider community will be addressed through a range of activities as follows:

### **Meetings and workshops**

A Town Meeting was initially held (21 March 2000, Geological Society, London) to present the aims and objectives of the AUI programme to the scientific community, invite comments and foster collaborative links between prospective researchers. An initial workshop is proposed to bring together successful grant applicants to exchange information about their projects and gain familiarity with technical aspects of Autosub operations. During the programme, annual Science Progress Meetings are anticipated to provide a forum for established researchers, post-doctoral scientists and post-graduate students to interact and exchange information among themselves and with the wider scientific community. Targeted workshops and focus groups may also be employed to address specific aspects of the programme and to explore any partnership or co-funding opportunities that may arise.

### **Website and newsletter**

Programme news and information will be posted regularly on the AUI webpages to ensure effective transfer of information among programme participants and the wider community. As part of this effort, it is anticipated that a programme newsletter be produced and disseminated electronically to facilitate rapid communication of results and news of opportunities.

### **Co-ordination and linkage**

Given the global interest in the polar regions, international linkages are also encouraged. Links between research groups with complementary expertise are strongly encouraged within the programme. The Science Co-ordinator will also play a role in community liaison and the stimulation of wider linkage. This objectives will be achieved through regular visits to PIs and representation of the programme at appropriate national and international meetings.

### **Science and Society activities**

The Science Co-ordinator will draft a media plan for programme publicity, to be implemented in collaboration with NERC Communications Directorate where appropriate. Opportunities for more direct communication and interaction with the publication through talks and events are also anticipated. Appropriate promotional material such as posters, exhibits and articles will be prepared for such events. Following the model adopted for other thematic programmes, an end of programme event will be considered to highlight and showcase its achievements.

## **7. DATA MANAGEMENT PLAN**

It is NERC policy that thematic programmes ensure the long-term availability of data collected by award holders to maximise the application and exploitation of their results. All

data and reports submitted under the programme must be made available in an electronic format. This will maximise ease of future retrieval and exploitation.

In most cases, NERC Designated Data Centres are used, both for quality control and archiving, with costs covered from central programme funds. After a period of sole access by PIs for publication preparation, such data are made available to other programme participants and the wider community.

A Data Management subcommittee has been established with the approval of the AUI Steering Committee to draw up a detailed Data Management Plan. This will involve communication with other related thematic programmes, such as Autosub Science Missions and ARCICE.

## **8. EXPLOITATION**

As with data management, it is NERC policy that all thematic maximise the application and exploitation of the results. All data and reports submitted under the programme must be made available in an electronic format. This will maximise ease of future retrieval and exploitation.

The Science Co-ordinator should liaise with PEPD to draw up a detailed Exploitation Plan. This plan should include proposals on dissemination of results (e.g. CD-ROM, End of Programme Event), Intellectual Property management, knowledge and technology transfer.

## **9. MONITORING AND REPORTING**

Individual projects will be monitored by the Science Co-ordinator through regular visits to award holders and contact at annual meetings and workshops. Each PI will be required to complete annual Output Performance Measure (OPM) forms summarising progress. A synthesis of each year's OPMs and publications will form the basis for an Annual Programme Report to NERC and the AUI Steering Committee, along with a summary of progress, achievements, Science Co-ordination activities and plans for the following year. A final programme report will be compiled to provide a record of overall achievements and outputs.

## **10. OWNERSHIP AND EXPLOITATION OF INTELLECTUAL PROPERTY (IP)**

Ownership of IP and IP Rights arising from NERC awards lies with the grant holding body (university, NERC Research Centre or other NERC-approved institution). Whilst all recipients of NERC funding must endeavour to ensure that the outcomes of their research are used to the advantage of the UK, NERC retains the right, for a limited period, to exploit IP in partnership with grant recipient organisations to the benefit of the UK and the organisations. This is to avoid circumstances where fragmentation of IP would reduce the likelihood of exploitation.

## 11. PROGRAMME MANAGEMENT

The *AUI Steering Committee* is responsible for directing and integrating the programme science and for recommending the award of research funds. The Committee also has responsibilities for co-ordinating data management arrangements, and for promoting the transfer of the outcomes of the research to the user community. The AUI Steering Committee is chaired by Professor Steve Ackley, Visiting Research Professor at Potsdam University, New York; e-mail: sackley@pol.net; tel: +1 210 341 6556

The *AUI Programme Administrator* has responsibility for all aspects of the day to day programme administration and for enquiries concerning the programme. Contact information: Dr Fiona Knight, NERC Polaris House, North Star Avenue, Swindon SN2 1EU; e-mail: f.knight@nerc.ac.uk; tel: 01793 411751; fax: 01793 411502.

The *AUI Science Co-ordinator* assists the Steering Committee in the co-ordinated implementation of the programme's science objectives, through liaison with award holders and other bodies. Contact information for Science Co-ordinator: Dr Jon Copley, School of Ocean and Earth Science, University of Southampton, Southampton Oceanography Centre, European Way, Southampton SO14 3ZH; e-mail: jtc@mail.soc.soton.ac.uk; tel: 023 8059 6621, fax: 023 8059 3059