



SCOTTISH  
ASSOCIATION  
*for* MARINE  
SCIENCE



**HIGHLIGHTS 03-04**



## SAMS OFFICE-BEARERS AND BOARD 2002-2003

President	Dr Ian J Graham-Bryce
Vice Presidents	Professor Sir Frederick Holliday Professor AD McIntyre Sir David Smith Dr JH Steele Professor Sir William Stewart Professor SA Thorpe
Council	Mr W S Balfour Professor GS Boulton Professor MJ Cowling Mrs M Crawford Dr AC Goodlad Professor R Ormond Mr R Sankey Dr P Thompson Professor CD Todd Dr AW Tudhope Mrs J Twelves (Observers: Mr A Munro, Dr P Newton)
Board Members	Professor R Cormack Professor R Crofts Professor A Miller Sir Matthew Farrer
Director	Professor GB Shimmield

# HIGHLIGHT



The Scottish Association for Marine Science (SAMS) conducts a wide range of marine science, from the deep ocean to the intertidal zone, and from the Arctic to the tropics. A unifying theme for our studies is the Northern Seas Programme, a core strategic grant from the Natural Environment Research Council. This five-year programme is conducted under the Collaborative Research Centre status of SAMS, and aims to evaluate and predict the impacts of natural and man-induced environmental change on a selected number of environments and locations from the west coast of Scotland to the high Arctic around Svalbard. Much of this work is also supported by our Commissioned Research programme, funded by a number of sponsors, for specific fixed-term projects.

Across the organisation, SAMS espouses interdisciplinarity to achieve the project objectives. Linking scientific disciplines can produce significant rewards in our understanding of marine science. This year we added the expertise of Professor Peter Wadhams and his Sea Ice Group from the University of Cambridge.

A characteristic of our research programme is the strong dependence and practice of sea-going science. We have maintained a very high ratio of sea-days for our staff, despite ever increasing costs and the continuing demand for advances in

the marine technology required to support the science. Perhaps the highlight of the number of cruises mounted was Cruise 75 of the RRS *James Clark Ross*, the scientific icebreaker operated by the British Antarctic Survey. On a four-week cruise in June and July from Leith to Stornoway, we travelled the length of the Norwegian margin to the waters off west Svalbard and the Fram Strait, achieving the farthest north latitude for this ship (81° N).

Below are vignettes of our scientific discoveries made in 2002-3. More details may be found in an accompanying CD-ROM, as we use new media to illustrate the range of research carried out at SAMS.

# 2

## SEA ICE AND POLAR OCEANOGRAPHY RESEARCH

In January 2003, Professor Peter Wadhams and his research group joined the laboratory from the University of Cambridge. As well as contributing to the future Northern Seas programme, the Sea Ice Group is conducting a number of stand-alone projects.

A radical change occurred a decade ago in Arctic atmospheric circulation, associated with a switch in phase of the Arctic Oscillation (AO), which produced a different forcing field for Arctic sea ice motion. There is a critical region north of Greenland where this should have resulted in a major change in ice characteristics.

An EU-funded project called GreenICE takes advantage of the presence of a series of winter ice camps (GRASP camps), installed by the Danish Government, to carry out an integrated set of geological and glaciological studies of this region. Sediment cores retrieved at the camps will map the climatic

# EVALUATING CHANGE

record for at least the last 2,000 years. The camps will be the base for a multilevel study of ice thickness and dynamics, involving *in situ* measurements of ice thickness, properties and thermodynamics; airborne measurements of thickness and roughness; buoy deployments to yield ice dynamics and monitor area-averaged thickness; and satellite remote sensing studies of past and present ice conditions. An existing dynamic-thermodynamic sea ice model will be improved in its representation of ice deformation, and used to assess basin-wide changes of which these regional changes form part. The aim is to form a complete picture of the total change in ice conditions which accompanies an AO reversal, and to match this change to the concurrent climatic change itself. Hence, by reference to the complete climatic record from the region for the last 2000+ years, we aim to understand the nature and



## SEA ICE AND POLAR OCEANOGRAPHY RESEARCH

magnitude of the changes to Arctic sea ice that have been associated with observed climatic variability, and estimate the role that these changes have played and are playing in our environment.

The SITHOS (Sea Ice Thickness Observing System) is another EU funded programme the group is involved in. The overall objective of SITHOS is to develop a European monitoring system for sea ice thickness and related parameters for climate change detection, support to sea transport and offshore operations, as well as environmental protection in polar regions. We are involved in the development and testing of an ice buoy system as one element in an Arctic basinwide ice thickness mapping programme designed to test models of Arctic ice changes as well as under ice submarine work. It is co-ordinated by the Nansen Environmental and Remote Sensing Centre in Bergen. SITHOS will test two designs of buoys during the RV *Polarstern* and Beaufort Sea field programmes, using strainmeters and tiltmeters respectively.



The IRIS (Ice Ridging Information for Decision Making in Shipping Operations) programme, is co-ordinated by Dr Mikko Lensu of the Ship Research Laboratory at the Helsinki University of Technology. This has a more practical purpose; that of improving the routing and design of Arctic shipping by improving the way that pressure ridges are represented in ice mechanics models. New methods will be developed to determine and forecast the extent of ridging, then these parameters will be included in ice information delivered to ships and used to improve on-board route selection. The delivery will be via a graphics system called IceView, which permits satellite images of ice to be displayed on a map and analysed automatically on-line to produce an optimum route to destination. Data linking satellite imagery, pressure ridge dimensions and forces on ships will be collected from field programmes in the Baltic Sea (using the tankers and cargo vessels of the two shipping companies involved, Fortum and Wagenborg) and the Arctic Ocean. We will also carry out pressure ridge analyses from our extensive collection of under-ice profile data collected from British submarines.

# 4

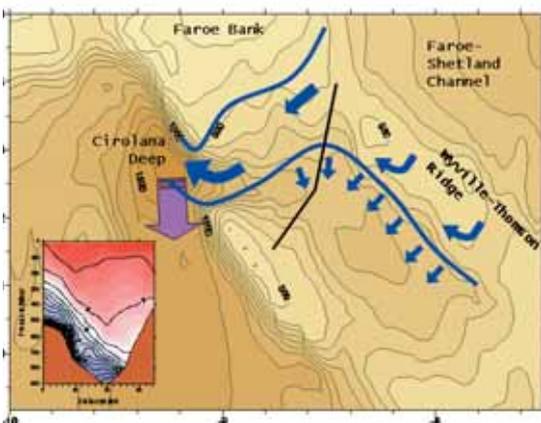
## MARINE PHYSICS

In situ measurements of water column properties made throughout the year, including the critical ice melt and ice formation episodes, are very sparse in the Arctic Ocean. To better understand the physics and biogeochemistry of Arctic fjords, two successful deployments and recoveries of an instrumented mooring were made in Kongsfjord, Svalbard (79° N) with 100% data return for temperature, salinity, currents, sedimentation, and acoustic backscatter. A new horizontal Acoustic Doppler Current Profiler for internal wave (water mixing) studies has been evaluated and a field experiment will take place in 2003.

Model predictions of Climate Change have highlighted the importance of the ocean currents that border the Scottish Shelf.

The phrase 'thermohaline exchange' describes the mechanism that helps to maintain the mild climate of northern Europe. Surface currents transport (relatively) warm salty water into the Arctic where it loses heat and is diluted with fresh water from northern shores. Deep colder fresher currents carry the return flow into the Atlantic. SAMS is a partner in MOEN, an EU project with collaborators from seven northern European countries who are studying the thermohaline exchange across the Iceland - Scotland Ridge. The Wyville-Thomson Ridge is an important branch of this ridge because it provides a partial barrier to the return flow.

A cruise on the FRV *Scotia*, owned by Fisheries Research Services (our UK collaborators), mapped in detail a large outflow of cold Norwegian Sea Deep Water across the top of the western end



of the ridge and into the Rockall Trough. The current flowed north-westward along the ridge before being turned down a narrow gully that discharges into the Cirolana Deep. This huge flow was about 6 times the normal flux across the ridge.

On the Scottish shelf, the Tiree Passage between the islands of Tiree and Mull is an important channel for detecting periodic incursions of Continental Slope Water onto the shelf. These waters carry higher levels of nutrients, but lower quantities of human-produced contaminants. The characteristics of the Scottish coastal waters, which in many areas are designated as Special Areas of Conservation, but are also used for aquaculture, are influenced strongly by these incursions. Understanding the frequency and magnitude of such incursions is clearly important

to the prediction of the health of Scottish coastal waters. The long-term SAMS instrumented mooring here has been reinstated and is now serviced quarterly. Analyses of incursions of slope water onto the shelf have been made revealing the common occurrence and timing of these events. Technology to transmit data from the Tiree Passage site via the mobile phone network has been developed and will become operational during 2003/4.

## GEOCHEMISTRY AND MARINE GEOLOGY

Contamination of the Arctic by the products of industrial activity in Europe and Russia is of grave concern. Heavy metals, such as copper, zinc and lead, are transported by several pathways, but little is known about the relative magnitude and importance of these transport routes to the Eurasian Arctic. 2002 saw the first intensive field campaign by SAMS in the waters around Svalbard (79° N). Two visits to the area aimed to determine concentrations of pollutant metals in sediments, their sources, and rates of sediment accumulation. Comparison of chemical profiles for copper, zinc and lead in sediment cores from inside and outside Kongsfjord showed higher concentrations outside the fjord, suggesting that these metals had possibly been transported from a distant North Atlantic or Arctic source. Comparative studies are also in progress using cores from ice-covered lakes to contrast heavy metal deposition from

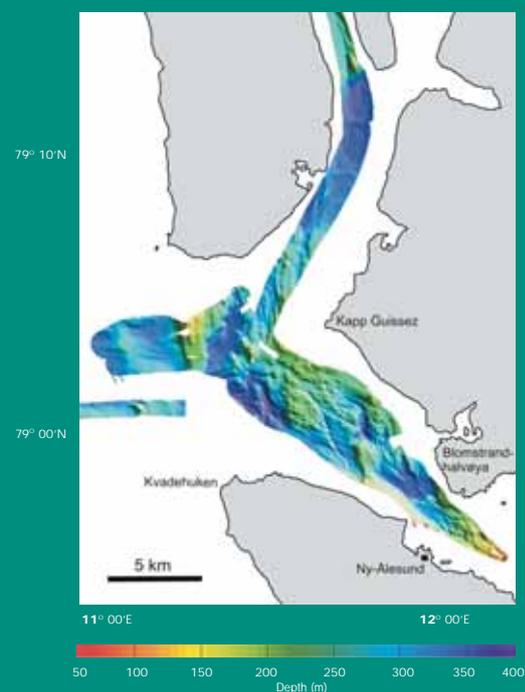


atmospheric sources and pathways in comparison to the nearby fjordic and coastal sediments influenced by marine transport. Using mass-spectrometry techniques it has been possible to identify the isotopic characteristics of gasoline, industrial and natural lead sources, and to recover the history of lead

deposition from these sources using dated sediment cores.

During the James Clark Ross cruise, we obtained the first detailed seafloor maps of Kongsfjord and Crossfjord on the west coast of Svalbard, using high resolution swath bathymetry coupled with sub-bottom profiling. These techniques reveal the depressions, channels and moraines left by advancing and retreating glaciers within the fjords.

Central and outer Kongsfjord were found to be dominated by a 30km<sup>2</sup> outcrop of bedrock, with a thin (<10m) sediment cover. The bedrock has been scoured during the glacial re-advance, termed the Weichselian, 20,000 years ago. The seafloor was again influenced by ice during the Little Ice Age, only 550-200 years ago. An uneven seafloor has been produced, with mounds of glacial debris termed drumlins and flutes being common across the floor of Kongsfjord; typically 1.5-2.5 km long by less than 100m wide and rising up to 10m high in water depths of less than 100m. These features have subsequently been smoothed by bottom-currents. The sub-bottom profile data show that the deepest basins of both fjords have Holocene-age fine-grained sediments up to 30m thick. The sediments of outer and central Kongsfjord, are characterised by gas-rich homogenous muds with many burrowing animals.



## DEEP-SEA BENTHIC STUDIES

The rain of organic particles settling down from the sun-driven production at the surface of the ocean largely fuels the community of mostly small organisms living in the muddy seabed of the ocean. Their utilisation of these particles is globally important because it helps to re-mineralise much of the settling organic matter, re-creating dissolved nutrients which will eventually upwell to fuel the surface production. Only a small fraction of these particles becomes buried in the sediment, but it is from this fraction that a record of past climate change can be decoded from markers associated with the chemistry of the organic matter. The burrowing and other activities of deep-sea benthic animals are important because they disturb the sediment and thus disrupt this sediment record. Such biogenic sediment reworking - bioturbation - can also much enhance geochemical exchanges across the sediment/water interface and hence intensify

biogeochemical cycling at the local scale.

Work on RRS *James Clark Ross* focused on this bioturbation, data being collected along two intersecting transects; south-north along the Norwegian Sea continental margin, and fjordic to deep-sea from the inner Kongsfjord to the Svalbard continental slope. At each station, quantitative macrofaunal samples were collected, burrowing depths of fauna measured and seabed images taken. The signatures of larger burrowing animals termed megafauna can be recognised as characteristic marks, or 'traces', such as pits, mounds and burrow openings, that show up in seabed images. Initial results suggest major contrasts between stations along both transects. These seem to reflect differences in organic flux to



the seabed. Benthic biomass is high at the northern and southern extremities of the continental margin transect on the Vøring and Yermak Plateaus, with much lower faunal densities at the Bear Island Fan and Svalbard margin.

Dense macrofaunal populations and intensely-bioturbated sediments were found in the Kongsfjord, reflecting high seasonal pelagic production in this high-latitude fjord. In contrast, offshore stations at 1400m and 2500m had a very sparse benthic fauna suggesting that little of the inshore production is transported into deep water across the continental slope.

In July 2002 the SAMS photo-lander was deployed from the James Clark Ross beside the 14km long Sula Ridge cold-water coral reef complex. Over the three weeks it was on the seabed, the photo-lander recorded the activity of the diverse animal community found there and logged near bed current flow, water temperature and the movement of particles close to the bottom. These are the first long-term environmental records from the Sula Ridge and represent an important step in understanding the dynamic environmental conditions around cold-water coral reefs. This information is vital to understand the ecology of the reefs and to design strategies for their conservation.

## DEEP-SEA FISH RESEARCH

Estimating deep sea fish abundance is notoriously difficult. In August, SAMS participated in the *Vital* cruise on board the French IFREMER research vessel *I'Atalante*. The main objective was to visually estimate fish abundance using the remotely operated vehicle (ROV) *Victor* along a series of transects in the Bay of Biscay, at depths between 1100 and 1500m. Of the three sites chosen, only one has been subjected to significant commercial fishing. The other sites are either only lightly or, in the case of the canyon, never fished. Other estimates of abundance were obtained from a baited lander and from a chartered commercial trawler operating in the fishable areas. SAMS data on the abundance of small fish species in the nearby Porcupine Seabight compare favourably with the visual estimates.

Data collected by SAMS in the Rockall Trough and Porcupine Seabight between 1978 and 1992 have been used as part of a

study to compare biomass composition and size-related structure in Atlantic and Mediterranean deep-water fish assemblages. The results of the study indicate differences in abundance, species richness and composition of the fish fauna. Some of these differences may be linked to factors such as the availability of organic matter at the sea floor, food-webs, local topography, and the more recent origin of the Mediterranean deep-sea fauna.

The subject of stock identification has been addressed through an EC shared cost FAIR project entitled *Otolith microchemistry as a means of identifying stocks of deep-water demersal fish* (OTOMIC). This project used Inductively Coupled Plasma Mass Spectrometry (ICP-MS) to quantify the levels of trace elements present in some deep-water fish otoliths (ear bones) to assess their usefulness for stock discrimination. Otoliths were obtained from *Nezumia aequalis*, a small macrourid fish found at depths ranging from about 500m to 1700m throughout the northern Atlantic Ocean and the Mediterranean Sea. Results obtained from the microchemical analysis of dissolved whole otoliths indicate that there were some differences between sampling areas. Otoliths from the Reykjanes Ridge (SW Iceland) were characterized by having higher concentrations of most elements, particularly lithium and strontium, compared to samples from other areas. It may be that hydrothermal activity or seawater interactions with the basaltic and ultramafic rocks of newly-formed oceanic crust are responsible for higher concentrations of these elements in the surrounding water.



## NUTRIENT AND PELAGIC COMMUNITY STUDIES

The recycling of nutrients within the oceans is vital to ensure their productivity. SAMS has conducted nutrient regeneration experiments, aimed at determining the rate and quantity of nutrient regeneration by protozoan predators ingesting phytoplankton prey of different 'quality'. These differences may result from changes in inorganic nutrient availability e.g. nitrogen, phosphorus and silicon, to the phytoplankton. Results have shown that nitrogen regeneration can vary significantly for different prey species and is related to the physiological state of the phytoplankton prey as indicated by their carbon:nitrogen ratio.

Analysis of bacterioplankton, small (<20  $\mu\text{m}$ ) phytoplankton and protozooplankton from samples collected in Kongsfjord, Svalbard, have revealed a clear increase in abundance from the head of the fjord to the open sea, corresponding to changes in local water masses. Analysis of large (>20  $\mu\text{m}$ ) phytoplankton and protozooplankton will be completed in 2003.

Experiments were also conducted in the Gullmar fjord (Sweden) to investigate the importance of changes in light and nutrient conditions (induced by wind-mixing) in controlling phytoplankton production in fjords. Although natural plankton communities after the spring bloom were affected by changes in light regime, nutrient availability seemed to play the major role in regulating the primary production. This contrasts with the Clyde Sea where primary production in summer was mainly influenced by light conditions rather than nutrient availability. This discrepancy in results from the two locations may be due to differences in phytoplankton composition and associated physiology: the Clyde Sea was dominated by autotrophic flagellates including silicoflagellates, while Gullmar fjord was dominated by the diatoms *Chaetoceros* spp. These studies highlight the importance of both the natural



## NUTRIENT AND PELAGIC COMMUNITY STUDIES

light conditions **and** planktonic species composition in governing the fate of nutrient inputs to the coastal zone.

### Marine sulphur biogeochemistry

Compounds of sulphur are important in many chemical cycles in the oceans and may play a part in the control of global climates. Although the oxidation of dimethyl sulphide to dimethylsulphoxide (DMSO) had been shown to occur in anaerobic cultures, it was not known whether significant biotic production pathways existed in oxygenated marine waters. To establish if micro-environments, such as sedimenting particles, could represent sites for **anaerobic** processes, including the production of DMSO, sediment traps were deployed for a maximum of 24 hours in the northern North Sea. After

recovery, samples were taken immediately and analysed for levels of methylated sulphur compounds. Any remaining trap material was incubated in the dark at *in situ* seawater temperature for a maximum of 120 hours.

Results from the incubation experiments proved very exciting, demonstrating that the downward flux of one sulphur compound (DMSP) is underestimated due to its degradation within the trap material. Furthermore, up to 21% of the DMSP lost may be oxidised. These results demonstrate for the first time that DMSO is generated within sedimenting material. In addition, we have



shown that phytoplankton may produce DMSO directly. Thus, significant biotic pathways that influence the sulphur cycle do exist in oxygenated surface waters, which has far reaching consequences for our understanding of the role DMSO plays in this.

### Marine microplankton

As on land, marine ecosystems depend to a large extent on bacteria to recycle nutrients. Bacterial community species composition and activity are thought to be controlled by a dynamic mix of nutrient limitation and predation by viruses and protozooplankton. In coastal waters, where nutrient concentrations are relatively high, it is thought that mortality factors may exert the most influence over bacterial communities. By contrast, nutrients may be more important in oceanic waters where their concentrations are generally lower. Bacterial communities are complex, however, and we have little understanding of how these factors affect individual populations.

Previous studies undertaken at SAMS have recorded higher bacterioplankton production near salmon farm cages in Loch

Fyne when compared to values at a control site away from the cages in the same sea loch. Such enhanced activity is to be expected as a response by bacteria to inorganic and organic nutrient additions derived from fish feed and excreta. In contrast to bacterial production, however, concurrent estimates of bacterial biomass and total organic nutrient concentrations were similar at both sites, while grazing of bacteria by protozooplankton was lower (<100% of production) near the cages. Contrary to expectations, the results revealed a similar high degree of bacterioplankton diversity at both sites within Loch Fyne. However, there was a difference between the sites in the composition of the bacterioplankton communities. A dominant taxon of bacteria was identified from the open water site, away from the cages, whereas the relative abundances of the different taxonomic groups at the mariculture site were more evenly distributed. The significance of these initial results will be clarified by DNA sequence analysis to identify the different taxa; a further step towards identifying their potential role in nutrient cycling. In the meantime the data indicate that organic nutrient inputs influence the quantitative importance of different bacterioplankton taxa.

## ANIMAL-ENVIRONMENT

Construction of the Loch Linnhe experimental artificial reef commenced in late 2001 and is ongoing. The monitoring programme and associated research into the environmental impacts of the reef are well underway. In April 2002, a high-resolution sidescan sonar survey was carried out to ascertain the spatial distribution of habitats at the reef site and surrounding seabed. A comprehensive seabed grab survey was conducted, based upon the output from the sidescan, to identify characterising assemblages of seabed species within the region. These data will form part of a regular monitoring programme to assess near and far-field effects of the reef on soft sediment benthic communities. Hydrographic surveys of the reef site were also conducted in the summer of 2002 using

moored instruments including current meters deployed at selected stations around the reef site. This survey will be repeated on an annual basis, to monitor any changes in water flow around the site that may occur as the reef structure develops. Work has also commenced to monitor the development of faunal communities on the surface of the reef blocks. The composition of the faunal assemblages will be assessed over time to determine their rate of development, and this will give an indication as to the impact of the reef on seabed productivity



## ECOLOGY AND BEHAVIOUR

at the site. In addition, trials are also underway to compare faunal community development on other potential artificial reef building materials.

In 2001 and 2002, a series of 26 beaches from the Clyde to Wester Ross was sampled in order to determine whether patterns in growth of young-of-the-year plaice showed regional or local differences. When plaice length in August is compared amongst beaches and between the two years a similar pattern of variation is observed, significant differences being seen between different beaches and years. A preliminary analysis of the 2002 data showed that growth differences are partially explained by beach wave exposure, tidal range, temperature, particle size of sand and abundance of the lugworm *Arenicola*; all factors having a positive effect on growth. The density of newly settled young plaice had no effect on their growth, nor did the abundance of the brown shrimp *Crangon crangon*, indicating that there is neither a density-dependent limitation of growth nor a trade-off between predator exposure and foraging.

A similar study was carried out on rocky shores using digital photography of common animals. Although the final statistical analysis remains incomplete, regional patterns have emerged

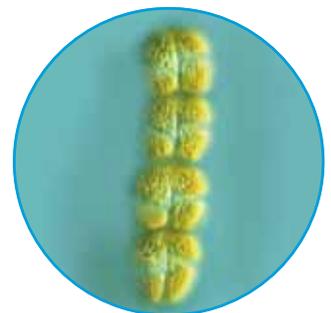
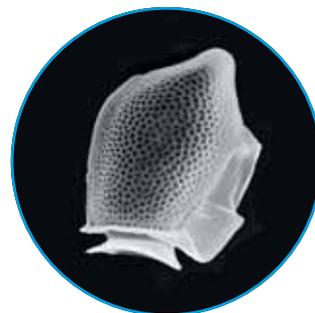
from the data so far analysed. Size distributions of adult barnacles were markedly smaller at more southern sites in 2002. The 2001 year class was particularly strong in comparison to previous years, and this cohort numerically dominated the adults measured in 2002. Initial analyses of patterns of abundance and average size of limpets suggest considerable variability on a regional scale. Overall, open coastal sites of both barnacles and limpets appear to be characterised by smaller, more abundant individuals. Reduced, or more sporadic, larval supply within sea lochs may reduce the effects of density dependence on growth, leading to the larger mean sizes seen there.



## TOXIC ALGAE RESEARCH

The dinoflagellate *Gymnodinium catenatum* is linked to paralytic shellfish poisoning (PSP). It has been shown that *G. catenatum* has an obligate requirement for either of two specific groups of marine bacteria, without which the cells do not grow following excystation. The addition of individual bacterial isolates to sterile dinoflagellate cells allows the cells to grow and re-establish a vegetative cell population in culture. We have shown that the key 'symbiotic' bacteria required for growth by *G. catenatum*, do not influence the production of the PSP toxins. An experiment is underway to help establish if 'gene-silencing' of toxin production may explain the phenomenon of some *G. catenatum* cultures becoming non-toxic in the laboratory.

A second toxic dinoflagellate, belonging to the genus *Dinophysis*, is being examined for genetic variability. This dinoflagellate is responsible for Diarrhetic Shellfish Poisoning (DSP) which has caused considerable economic problems for the shellfish industry in Scotland. Sensitive new protocols have been developed for the analysis of DNA extracted from single algal cells isolated from either fresh samples or preserved material. This latter development may enable analysis of archived samples. The generation of genetic data from which species-specific molecular tools can be designed may enable the *in situ*



ECONOMIC

## EROSION

discrimination of toxic and non-toxic *Dinophysis* species.

TRANSFLUX is a study examining the influence of sediment mixing due to burrowing animals (bioturbation) along an organic carbon gradient away from a salmon farm. We are seeking to determine relationships between mixing intensity and the burrowing (infaunal) community responsible for this bioturbation with fluxes of inorganic materials into and out of the sediment. Newly developed *in-situ* benthic chambers were used to determine oxygen and nutrient fluxes and mixing parameters were derived from down-core profiles of chlorophyll *a*.

The deep sea *in-situ* erosion chamber was deployed at three of the 4 stations in Loch Creran in order to estimate the erodability of the sediments at each of the sites. It was hypothesised that sampling stations 1 and 2, rich in organic matter and closest to the farm, would be highly erodable but this did not prove to be the case. Instead, the critical erosion velocities were the same for each of stations. Post-erosion particle settling rates were roughly similar. Although local currents are relatively weak, these results show that these are able to mobilise sediments periodically. The lower erosion rates at station 1, under the fish farm, may result from the



## COASTAL IMPACTS RESEARCH

sediment stickiness caused by the large amount of organic matter present and by the massive abundance of small polychaete worms reworking this material, thus contributing biogenic structure.

#### Modelling marine processes - DEPOMOD

The ability to predict the impacts of aquaculture activity on the environment can only be achieved through field-validated models. SAMS has been developing DEPOMOD over a number of years

in conjunction with SEPA. Recent work has focussed on oxygen quality in the overlying water column. The results of this study were encouraging in that a good approximation between modelled and observed fluxes was achieved with no optimisation of the original assumptions and parameterisation. Without including a re-suspension function in the model, however, this simulation can only be applied to sites such as Loch Creran, where currents are generally low to moderate and re-suspension is likely to be intermittent.

#### Urchin grazing impacts

The impact of sea urchin grazing on macro-algal cover is well documented in the literature, but *Psammechinus miliaris*, and some other echinoid species, are known to be opportunistic omnivores.

We explored the possibility that these urchins are important regulators of sessile invertebrate communities as well as algae. In the laboratory, we investigated the foraging decisions sea urchins make, by presenting them with either the barnacle *Semibalanus balanoides* or the mussel (*Mytilus edulis*) as food items. *P. miliaris* exhibited a clear preference for smaller barnacles, consuming on average 16.8 barnacles per day. The urchins adopted a different strategy when feeding on mussels, shifting their preference to attack the most abundant size classes. Consumption of mussels reached a plateau when urchins were offered >10 per day and large urchins ate up to

5 or 6 mussels a day. The consumption rates suggest *P. miliaris* is likely to significantly influence both the abundance and size distribution in barnacle and mussel populations. We then investigated how these findings related to natural populations by creating replicated zones on the shore either with or without urchins. Urchin removal was associated with a significant increase in the biomass of algae, mussels (*M. edulis*) and a decrease in the biomass of the horse mussel (*Modiolus modiolus*) and some herbivorous grazing species.



## ADVANCES IN MARINE

New communications technologies now allow us to collect and download data from remote sampling sites. We have tackled both the in-water and above-water segments of the communications link this year. In-water techniques normally employ acoustics, and we have procured two sets of state-of-the-art acoustic modems from LinkQuest Inc. One set has been customised to allow full access to diagnostic information about the acoustic path and to permit our attached processors to exercise full control over data transactions. As regards the above-water segment, we have piloted applications using both terrestrial communications (cell phone) and satellite systems (*Argos*, *Orbcomm* and *Iridium*). In the latter case we have been privileged to be one of the three non-US groups to be selected by NOAA to participate in the evaluation of *Iridium* modems for oceanographic applications.



Pioneering work on the use of the *Orbcomm* satellite communications system in the polar regions, part-funded under a NERC research grant on the development of an innovative ice buoy, drew to a close early in the reporting period. This work showed that it was possible to transfer several kilobytes per day of wave spectral and other data from very remote platforms. We have now moved to using the more powerful *Iridium* system, successfully transferring large image files between the RV *Polarstern* in the high Arctic and SAMS during the spring of 2003.

Seabed landers are crucial platforms for gathering a wide range of physical, chemical and biological data. This year we have developed OXYSTAT, a system to maintain oxygen levels in the lander's benthic chamber during incubations. Other achievements include the design of an interfacial water sampler to sample water very close to the seabed in deep water, and the redesign of the lander feet and ballast arrangements for use in very soft sediments.

## COMMERCIAL ACTIVITIES

## EXPERTIS

SAMS Research Services Limited started trading in early 2002 with the primary aim of providing a conduit for both the commercialisation of research ideas and for the operation of commercial activities on behalf of the SAMS group.

Throughout this formative year, activities ranging from projects that draw on the expertise and knowledge within SAMS, to the hire of excess vessel and equipment capacity have been undertaken, as desk, laboratory or field-based studies.

In addition to the utilization of existing assets there are now several projects underway within the SAMS group that seek to have, as their primary output, an economic or commercial gain. Funding through initiatives such as the Highlands & Islands Enterprise Research Challenge Fund, Scottish Enterprise Proof of Concept Fund, and the Natural Environment Research Council Small Business Research Initiative has been secured to drive these projects forward. The market-focused strategy will ensure that these projects have a truly commercial goal, whilst building on our scientific expertise and in-house research capability.



In tandem with the activities of SAMS Research Services Limited, there has been considerable effort directed towards our newest venture – the European Centre for Marine Biotechnology (ECMB), conceived with a dual role in mind.

ECMB will spearhead the applied marine biotechnology activity at SAMS, with the focus being on marine-derived natural products from the flora and fauna, which populate the Northern waters of our globe. To this end funds have been secured from a number of sources to ensure that strong research foundations are established on which to build a commercially robust programme.

ECMB's primary role is to provide physical facilities and infrastructure in an incubator-style environment, to a range of commercially orientated ventures working in, or in association with, the marine biotechnology sector. Businesses requiring incubation will include home-grown and incoming start-up companies, international marine groupings with a desire to create a Scottish base, and established biotechnology businesses with a specific interest in the marine environment

# 2003

THE YEAR THE VISION FOR THE NEW

DUNSTAFFNAGE MARINE LABORATORY

BECAME A REALITY





PHOTOGRAPHY

The Scottish Association for Marine Science © All Rights Reserved



SCOTTISH  
ASSOCIATION  
*for* MARINE  
SCIENCE

THE SCOTTISH ASSOCIATION FOR MARINE SCIENCE  
DUNSTAFFNAGE MARINE LABORATORY  
OBAN · ARGYLL · PA37 1QA · SCOTLAND  
T: (+44) (0)1631 559000 F: (+44) (0)1631 559001  
E: [info@sams.ac.uk](mailto:info@sams.ac.uk) W: [www.sams.ac.uk](http://www.sams.ac.uk)