

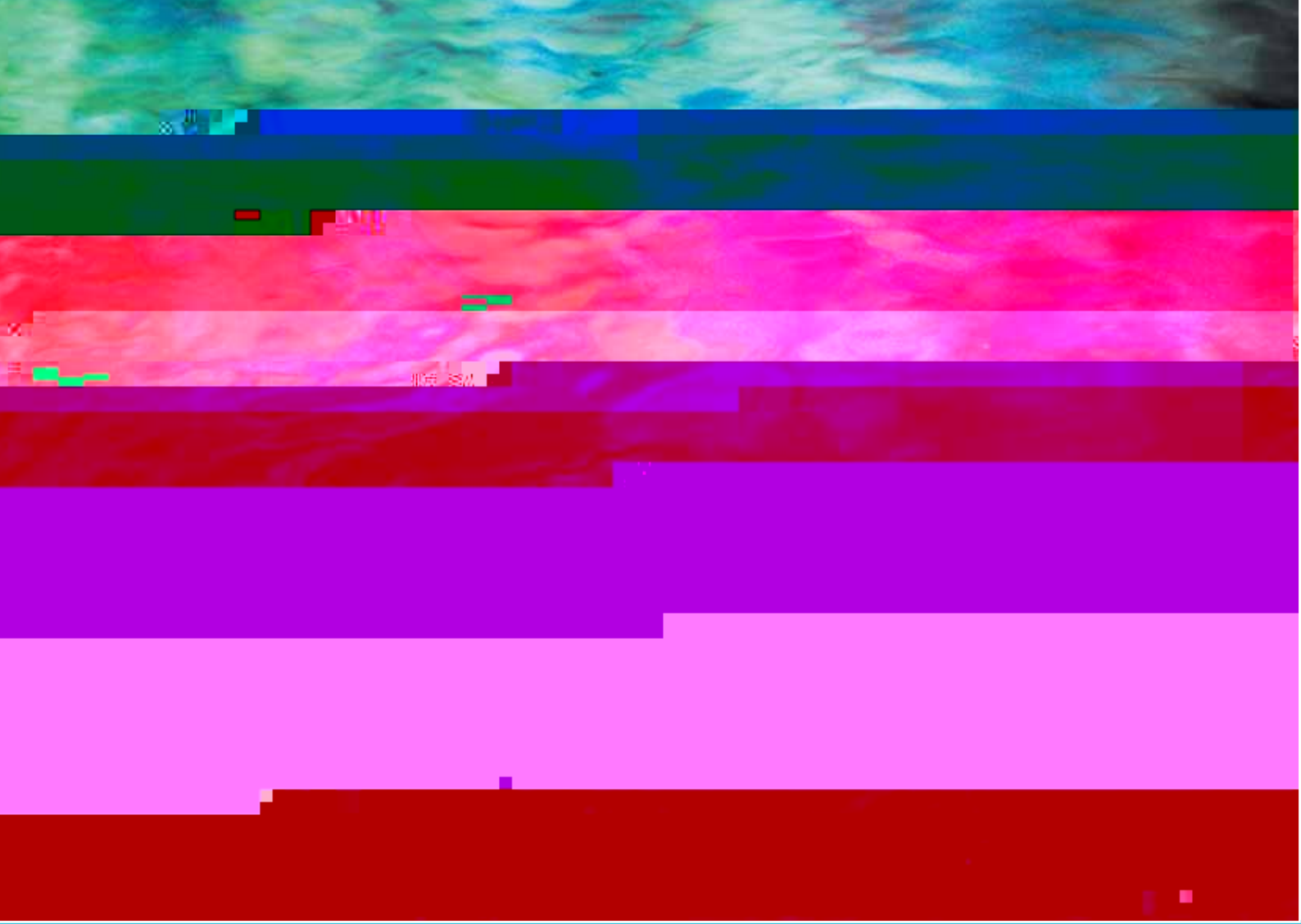

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SEA ICE AND POLAR OCEANOGRAPHY RESEARCH

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.

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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 (79º 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

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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.

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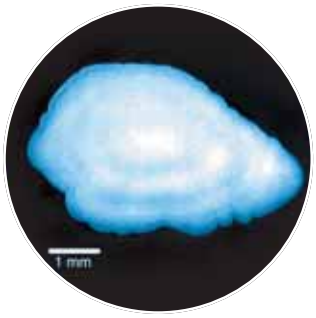
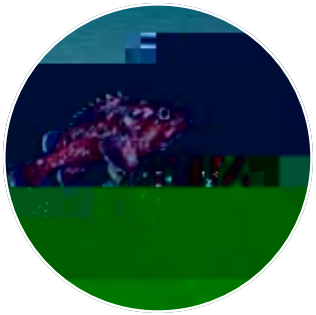
FOR PROJECT DETAILS IN FULL PLEASE SEE OUR WEBSITE
www.sams.ac.uk/projects

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 *l'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 n 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.

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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 μm) 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 μm) 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

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TOXIC ALGAE RESEARCH

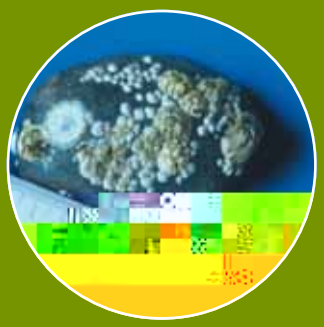
The dinoflagellate *Gymnodinium catenatum i*s linked to paralytic shelfish poisoning (PSP). It has been shown that *G. catenatum* has an obligate requirement for either of two specific

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

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.

M - 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.



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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.

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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

COMMERCIAL ACTIVITIES

E PERTIS

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

PHOTOGRAPH

T S A M S A R R

SCOTTISH
ASSOCIATION
for MARINE
SCIENCE

THE SCOTTISH ASSOCIATION FOR MARINE SCIENCE
DUNSTAFFNAGE MARINE LABORATOR
OBAN ARG LL PA37 1QA SCOTLAND
T: (+44) (0)1631 559000 F: (+44) (0)1631 559001
E: @ . . P: . . .