The Scottish Association for Marine Science | **NEWSLETTER 32**

SCOTTISH ASSOCIATION *for* MARINE SCIENCE

SAMS

ISBN 1475-7214

Scottish Marine Science in Europe

September | 2006

diary

North Atlantic Climate and Ecosystems: A Current Threat?
11-12 September 2006
Reykjavik, Iceland
www.hafro.is/symposium

Challenger Society for Marine Science
UK Marine Sciences Conference 2006
11-15 September 2006
SAMS, Oban
www.sams.ac.uk/challenger

Fjords workshop
15-16 September 2006
SAMS, Oban
E: John.Howe@sams.ac.uk

ICES Annual Science Conference
19-23 September 2006
Maastricht, Netherlands
www.ices.dk/iceswork/indexasc.asp

Rapid: Climate Change
24-27 October 2006
Birmingham
www.noc.soton.ac.uk/rapid/rapid2006

Scottish Marine Group
Climate Change & the Future for the Marine Environment
26 October 2006
University of Stirling
Convenor: s.chambers@nms.ac.uk

The Arctic – workshop
31 October 2006
City Conference Centre, London
E: technical@imarest.org

SAMS AGM and SAMS UHI Graduation
6 November 2006, 4.15 pm
SAMS
www.sams.ac.uk

17th Annual Newth Lecture
Professor Julian Dowdeswell
6 November 2006, 5.15 pm
www.sams.ac.uk

SOLAS open science conference
6-9 March 2007
Xiamen, China
www.uea.ac.uk/env/solas/ss04.html

Oceans '07 Marine Challenges: coastline to deep sea
18-21 June 2007
Aberdeen
www.oceans2007europe.org/

Change in Aquatic Ecosystems: Natural and Human Influences
4-6 July 2007
Plymouth, UK
www.mba.ac.uk/conferences

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Front cover: © P. Provost, SAMS.

Dear SAMS member

Dr Anuschka Miller, EDITOR

The marine environment faces many anthropogenic challenges: from climate change and pollution to the overexploitation of living resources. Resolving these issues in a fluid environment that does not stick to national borders requires regional and international cooperation between politicians as well as scientists. This Newsletter issue therefore focuses on a selection of research projects which SAMS scientists undertake with colleagues from across Europe, and which are funded by the European Union.

Beyond the shared environmental problems, science benefits fundamentally from international exchanges and collaborations. The different ways of thinking and looking at the world that are prevalent in different cultures and communities enrich the interpretation of scientific results, and are critical for a thorough testing of hypotheses. This Newsletter was written by authors working largely in Scotland, but originating from all over the world: from Europe, Asia and Australia. It will be distributed to colleagues living and working on all continents. Science, where progress is achieved through constructive criticism and reasoned, evidence-based, confident debate, thrives through multiculturalism and internationalism.

One challenge facing all European scientists is how to engender excitement for science and commitment to stewardship of the environment in the next generation. The article on page 5 describes some of the approaches taken by Europe's deep-sea research community to achieve greater awareness of their research activities. Before we can expect democratic societies to extend greater protection to sensitive marine environments, and to invest more resources to develop a more detailed understanding of their functioning, we – the research community - have to do more to make people care: by distributing our knowledge in an accessible way, and by stimulating and participating in public debates and dialogue. This Newsletter hopes to make a little contribution in this huge venture.

Designed by Design Links Edinburgh / Glasgow

SAMSnews

Professor Graham B. Shimmield, DIRECTOR

UHI: TOWARDS UNIVERSITY TITLE

As many of you will know, SAMS is one of fifteen partners of the UHI Millennium Institute, a collegiate Higher Education Institution aiming to become the University of the Highlands and Islands. In August last year UHI applied for taught degree awarding powers, and has been scrutinised by a panel of external assessors concerning the suitability of its governance, management, quality assurance, administrative systems and academic staffing to validate and award its own taught degree programmes. At SAMS we have had two visits from assessors. The scrutiny process has now been completed and we are awaiting the assessors' report.

UHI has recently submitted its application for university title. It has set 2007 as its target year to be granted university title by the Privy Council.

25 NEW SCIENTIFIC STAFF FOR SAMS

As part of the initiative to develop research within the UHI portfolio, and raise the international quality of marine science at SAMS, a multi-funder bid (Addressing Research Capacity, ARC) has been successful. UHI received an £11.4 million funding package from among others Highlands and Islands Enterprise (£5 million), the Scottish Funding Council (£3 million) and the European Regional Development Fund (£1.45 million). Of this sum SAMS receives £5.6 million to employ an additional 14 academic and 11 technical support staff, and to further develop our facilities to house these new staff and their research requirements. As the largest research institute within UHI, SAMS was fundamental to the success of the proposal to the Scottish Funding Council, and I would like to particularly mention the input of Dr Axel Miller in securing this funding. We advertised the academic posts earlier this year, and interviewed a range of excellent national and international candidates. We are now in the final process of appointing our future colleagues. Support staff will be appointed in the coming months.

SAMS has nearly doubled its number of employees in the past decade, and the new positions will increase the staff base by a further 20%. This provides SAMS with wonderful opportunities of expanding and deepening our research portfolio and abilities.

MARINE POOLING

Over the past year there has been considerable activity amongst the Scottish university and research institute community to develop the concept of "marine pooling". Essentially, by combining intellectual and operational resources in a cognate research area, the Scottish research community can raise its collective profile. This strategy has the financial endorsement of the Scottish Funding Council. Under the chairmanship of Professor Ian Boyd (Director, Sea Mammal Research Unit) an exciting portfolio of strategic science sitting between blue skies research activity and the needs of the regulatory bodies (SEERAD) is being proposed. If successful, the opportunity for Fisheries Research Services (FRS), SAMS, SMRU and the universities to work together, and to obtain some strategic staff positions, will truly improve Scottish marine science. SAMS is fully committed to using all its staff and resources to aid this venture with the working title "Marine Science Scotland".

SAMS is already successful in another pool, SAGES (Scottish Alliance for the Geosciences, Environment and Society), led by Edinburgh University, and is currently advertising a Lectureship and Senior Research Fellow in palaeoceanography and climate change (see www.sams.ac.uk for details).

UPDATE ON SAMS UHI STUDENTS

I would like to congratulate our successful under- and postgraduate students for their academic achievements. The latest cohort of undergraduate students on the BSc (Hons) Marine Science has just left us and will be graduating in November. It is rewarding to watch the tremendous progress that these young people have made during their four years at SAMS. Four of our research students – Drs Pei Sun Loh, Adam Hughes, Craig Sanderson and Jennifer Beaumont – successfully defended their PhD vivas and most have already found posts that will allow them to continue in academic careers. I'd also like to welcome our latest intake of PhD students: Christian Lonborg and Emily Venables.

SCOTTISH MARINE GROUP NEWS

The Scottish Marine Group organises biannual meetings since 1988 to allow those with an interest in the marine environment, in marine science and affairs to come together at varying locations around Scotland to learn about and discuss latest developments. The SMG acts as an umbrella for all marine science related organisations in Scotland, and includes marine scientists from all sub-disciplines. Dr Hamish Mair from Heriot-Watt University organised and convened these meetings since 1999 but stood down at the end of 2005. Hamish thought up a number of excellent and inclusive themes, organised meetings effortlessly, and brought panash to the chairing of the proceedings. As course leader of an MSc, Hamish was always making sure that students felt sufficiently confident to contribute to discussions and to ask questions. I'd like to say a warm and personal thank you to Hamish on behalf of SAMS and the entire marine science community in Scotland for having convened this group for six years. At the same time I'd like to welcome Susan Chambers from the National Museums of Scotland, who has stepped into the role of convenor for 2006. Susan organised her first SMG meeting focussing on postgraduate research topics in May of this year, which was hosted by the National Museums of Scotland in Edinburgh. We now look forward to the autumn SMG meeting in Stirling on Climate Change and the Future of the Marine Environment, to which I would like to invite you warmly.

Dr Hamish Mair

Susan Chambers

Dr Simon Stanley: Obituary

Dr Tom Pearson, SAMS Fellow

Dr Simon Stanley, a former Assistant Director of the Dunstaffnage Marine Laboratory, died from a sudden heart attack on 26th April 2006 whilst attending an Industry Review Meeting of the Vineyards Association of Tasmania.

After obtaining a doctorate in marine microbiological studies Simon joined the staff at what was then the Scottish Marine Biological Association's new Oban laboratory in 1969. He immediately initiated a series of studies on the role of marine bacteria in metabolising detritus and dissolved organic material in marine systems. Over the next ten years these studies developed into a series of projects involving a wide range of collaborators both in-house and in other institutions and university departments. From the beginning his work focused on the need to understand the microbial degradation of organic contaminants in marine systems. Early themes explored the nitrogen cycle in marine bacteria and the assimilation pathways of nitrate reduction. These developed into studies of the bacterial assimilation and excretion of animo-acids and the biodegradation of organic contaminants in marine sediments. In 1975 – 76 it was becoming obvious that within sediments the nitrogen cycle, levels of microbial activity and organic degradation rates were closely linked to the activities of multi-cellular sedimentary organisms.

Changes in marine science funding priorities then encouraged ecosystem studies. Simon, in cooperation with benthic ecologists in the laboratory, thus developed a comprehensive project to study the ecological basis for the degradation of cellulose fibre in the sediments of Loch Linnhe and Loch Eil, which received discharges of pulp mill wastes. The effects of these discharges on the macrobenthic sedimentary populations of the loch system had been monitored regularly, providing a wealth of background data. The project rapidly expanded into an extensive ecosystem study of the system carried out over the subsequent five years and involving a number of colleagues from the laboratory together with groups from the Universities of Dundee, Strathclyde and North Wales. It was at this time that he met and married his wife Isobel, who had joined the research team and continued to work closely with him throughout his time at Dunstaffnage.

In addition to his involvement in the Loch Eil Project between 1979 and 1981 Simon jointly coordinated surveys of the impact of the developing oil terminal in Shetland on the sedimentary environment of Sullom Voe and of the effects of sewage sludge deposition on the sediments in the Firth of Clyde. In each case the monitoring surveys were combined with studies of the microbial degradation of organic material and nitrogen cycling and methane formation in the sediments. In 1981 the Loch Eil project came to completion with the publication of twelve scientific papers involving twenty authors in the Journal of Experimental Marine Biology and Ecology.

Simon was then appointed Assistant Director of the Dunstaffnage Laboratory and over the ensuing three years his activities became increasingly dominated by administrative duties. However, he maintained his scientific interests by coordinating a multidisciplinary baseline survey of the marine environment of Mina al Fahal, a bay in Oman, which was threatened by the possible contamination by waste discharges from the construction of a new oil refinery. This survey stimulated his interest in the microbial degradation of oil in the marine environment and led to further work on this subject in cooperation with colleagues in the laboratory and at Dundee University. In 1983 he was elected to the Institute of Petroleum and was involved in the development of the Kuwait Action Plan for the control of oil pollution along the Gulf coast.

In 1984 Simon left Dunstaffnage for a year's sabbatical at the Australian Institute of Marine Science, where he worked on a project assessing nutrient productivity in mangrove ecosystems. He returned in 1985 to a period of crisis at the laboratory. Funding cuts brought about a major revision in research priorities and led to the termination of many inshore ecology programmes including the sedimentary biogeochemistry projects. This resulted in the retirement or resignation of many of the senior scientists associated with those projects, including Simon.

In 1986 Simon and Isobel emigrated to Tasmania, where he took up a position as Assistant Director in the Tasmanian Department of Sea Fisheries. Atlantic salmon aquaculture had just been introduced to Tasmania and Simon created a group to assess the environmental issues arising from this development. He put together the Tasmanian Marine Farming Legislation that now controls the development of all marine farming leases in Tasmania and sets out a system of environmental impact assessment for all new marine farming proposals. He was also instrumental in initiating the bi-annual Tasmanian Aquaculture Conference and Workshop.

He retired from the department in 1997 and proceeded to develop an entirely new career in viniculture. He and Isobel bought a plot of land in a favoured situation in the south of the island and, following the construction of a new house, immediately began to plant and develop a commercial vineyard. He approached this venture with typical energy and resource. He joined the Vineyards Association of Tasmania, was elected to the Executive Committee of the Association and was later appointed Chairman of its Technical Committee. His scientific background was invaluable in allowing him to assess the soil characteristics and nutrient requirements of differing grounds and thus suiting particular grape varieties to appropriate areas and conditions. Attention to such detail and hard work resulted in production of the first commercial crop in 2004. Wines from his vine yard won commendations and medals in the following year.

Simon will be sorely missed by his many friends and colleagues in both Britain and Tasmania. He leaves an impressive legacy of achievements in both microbiology and viniculture. Would that we all could finish on a high note with the production of a fine wine… ●

Deep-Sea Education and Outreach group:
Awakening Europe to the Abyss

Dr Bhavani Narayanaswamy, SAMS (bn-t@sams.ac.uk)

FACTFILE

Title: The Deep-Sea Education and Outreach group (DESEO)
Organiser: European Census of Marine Life
Partners: Census of the Diversity of Abyssal Marine Life (CeDAMar)
Biogeography of Deep-water Chemosynthetic Ecosystems (ChEss)
Continental Margin Ecosystems on a Worldwide Scale (CoMargE)
Patterns and Processes of the Ecosystems of the Northern Mid-Atlantic Ridge (MAR-ECO)
Funders: Stavros Niarchos Foundation, Argyll and the Islands Enterprise
Website: www.eurocoml.org

Census of Marine Life scientists are developing comic books, school initiatives and exhibitions in a new initiative to educate European citizens about the deep-sea environment.

> School children are rarely taught in school about the deep sea, in part because of a lack of good teaching resources. We plan to engage with teachers and jointly produce schools packs that can enthuse the next generation.

The European Census of Marine Life (EuroCoML) project office recently funded an Education and Outreach workshop held at the National Oceanography Centre, Southampton. The workshop brought together four European-led Census of Marine Life (CoML) field projects with a deep-sea component to discuss ideas and form collaborations for education and outreach activities that would complement and benefit all projects. The **DE**ep-**S**ea **E**ducation and **O**utreach group was set up to coordinate and organise a number of exciting projects to promote the deep sea within Europe, some of which are summarised below.

GETTING THE DEEP SEA ONTO EUROPE'S SCHOOL CURRICULA

Interaction with schools is a key priority of the CoML education working group. The MAR-ECO project (Patterns and Processes of the Ecosystems of the Northern Mid-Atlantic Ridge) had already initiated a schools network, which will now be expanded to cover all deep-sea areas. The overall aim is to get the deep sea as the planet's largest ecosystem onto the national curriculum in schools throughout Europe. To achieve this, DESEO will initially organise a workshop for a group of science teachers from different European countries with DESEO scientists. This new working group will develop and produce teaching materials that can be used throughout schools in Europe. The teaching packs will include deep-sea project related case studies as well as access to new data collected by the projects.

A TRAVELLING EXHIBITION

MAR-ECO is developing a travelling exhibition called "*Deeper than Light*", which will open in Bergen (Norway) in April 2007 and may then travel to Edinburgh, Horta (Azores) and other European locations. This exhibition will focus on the research undertaken at the Mid-Atlantic Ridge, and will employ a variety of scientific, artistic and historic approaches to illustrate the information. Well known photographers and artists, such as wildlife cameraman David Shale and Norway's distinguished contemporary landscape painter Ørnulf Opdahl, participated in one of the expeditions to the Mid-Atlantic Ridge and will display work inspired by this experience. Historical drawings will feature alongside real specimens. While the exhibition is on show, the local organisers will run public lectures about MAR-ECO and the deep-sea ecosystem at the exhibition site. A guidebook will complement the exhibition and provide more comprehensive information about the deep-sea environment and the deep-sea CoML projects. In the longer term the travelling exhibition hopes to be expanded with information on other CoML deep-sea projects.

EDUCATION BY COMIC BOOKS

Comic books are very popular throughout Europe and are an excellent way of conveying information to both children and adults. The book will be scientifically based, but will be told through a fictitious story. The Biogeography of Deep-water Chemosynthetic Ecosystems (ChEss) project office suggested creating a comic book on the history of discovering hydrothermal vents and seeps. We hope that this will be the first of a series of comics that introduces the different deep-sea environments currently investigated by the Census of Marine Life. ●

> Cartoons are an entertaining means of illustrating information - including science - in a fun way that children and adults love to engage with. Science cartoons are a prime example of innovative edutainment that can create enthusiasm and knowledge.

On thin ice:
Discovering the state of Arctic sea ice

Dr Jeremy Wilkinson, SAMS (Jeremy.Wilkinson@sams.ac.uk)

> The GreenICE team established the first European research sea-ice camp on the Arctic Ocean. (© M. Doble)

Significant change is occurring in the Arctic, which is warming faster than any other region of the global ocean. Sea ice is a highly sensitive barometer of change. Over the past few decades we have observed a continued reduction in extent of sea-ice cover year-on-year. At the same time we measured a decrease in ice thickness of over 40% since the 1970s. Computer climate models predict even faster changes in the future, including the complete disappearance of summer sea ice by 2050. This may represent the most fundamental change in the environment in thousands of years.

Issues associated with climate and environmental changes transcend national boundaries and can only be tackled by joining resources and expertise across countries. The European Union thus encourages member states to form consortia to address climate change issues and awards funding for the best science proposals. The Sea Ice Group at SAMS was funded for three Framework-5 programme and one Framework-6 programme projects, which are briefly summarised below.

FRAMEWORK 6: DEVELOPING ARCTIC MODELLING AND OBSERVING CAPABILITIES FOR LONG-TERM ENVIRONMENT STUDIES (DAMOCLES)

DAMOCLES aims to (1) identify the on-going changes concerning sea ice, atmosphere and ocean in the Arctic; (2) evaluate our capability to simulate these changes and to improve the level of confidence for predicting extreme events affecting the Arctic environment; and (3) evaluate the socio-economic impacts of a drastic retreat of the Arctic perennial sea ice or even its disappearance in a near future. DAMOCLES works towards a real breakthrough in understanding and protecting our environment in preparation for the 2007 International Polar Year (IPY) and leaving a legacy to future generations.

While the project is coordinated by France, SAMS is playing a key role in unravelling the variability of Arctic sea ice.

FRAMEWORK 5: GREENLAND ARCTIC SHELF ICE AND CLIMATE EXPERIMENT (GREENICE)

GreenICE is a 6-partner study of the ice thickness distribution in a little-observed region north of Greenland and Ellesmere Island, combined with a coring-based investigation of past ice conditions. During this programme we established possibly the first European sea-ice camp on the Arctic Ocean, from where the SAMS team deployed five sensitive tiltmeter buoys in May 2004. These buoys monitor the directional spectrum of flexural-gravity waves passing through the ice. These wave spectra have been proposed to be related to ice thickness, which may allow for remote measurements of ice thickness. Data collected by the buoys was relayed back to SAMS using the Iridium satellite system. The buoy data was validated by overflights from a Danish swath-sounding laser profilometer and a German helicopter with ice-sounding electromagnetics, as well as by drilling. A geological team from Denmark took sediment cores to establish sedimentation rates over the past few thousand years, an indicator of changing ice conditions. GreenICE was coordinated at SAMS.

FRAMEWORK 5: ICE RIDGING INFORMATION FOR DECISION MAKING IN SHIPPING OPERATIONS (IRIS)

IRIS investigated the mechanics of sea-ice ridge building and ridge structure, and the relationship between ridging parameters and ice resistance forces on vessels. Our work included the statistical analysis of ridge shapes from submarine sonar data sets, deriving sea-ice ridge parameters from SAR and *in situ* sampling. Over a number of seasons we drilled through ridges in the Gulf of Bothnia and simultaneously profiled these with electromagnetic systems. IRIS was coordinated by Finland.

FRAMEWORK 5: SEA ICE THICKNESS OBSERVING SYSTEM (SITHOS)

The objective of SITHOS was to develop a European monitoring system for sea ice thickness and related parameters for climate change detection, and to support sea transport, offshore operations and environmental protection in polar regions. We developed and applied tiltmeter-accelerometer systems that can monitor areas-averaged ice thicknesses by the wave resonance method. We further collected, analysed and assessed upward looking sonar (ULS) data from autonomous underwater vehicles (AUV) and from submarines.

> These ice-buoys carry tiltmeters that may allow the remote measurement of ice thickness. (© D. Mercer, SAMS)

> Nick Hughes was a civilian guest scientist onboard a British Naval submarine to measure ice thickness using upward looking sonar as part of the SITHOS project.

Sustaining coastal ecosystems and aquaculture

Averil Wilson (Averil.Wilson@sams.ac.uk) & Dr Kenny Black (Kenny. Black@sams.ac.uk), SAMS

European marine aquaculture is expanding rapidly, bringing societal benefits to coastal areas where traditional employment opportunities are declining. In Scotland, it has halted rural depopulation by providing year-round employment in coastal communities. Figures released for Scottish aquaculture in 2005 show that one job in aquaculture supports an additional 2.6 in related and ancillary industries. Total European aquaculture production has increased by approximately 40% in each of the last two decades.

FACTFILE

Title: An Ecosystem Approach for Sustainable Aquaculture (ECASA)
Funder: EU Framework Programme 6 RTD
Co-ordinator: Dr Kenny Black, SAMS
Partners: 16 partners from 13 EU member states
Website: www.ecasa.org.uk

AN ECOSYSTEM APPROACH TO AQUACULTURE MANAGEMENT

In 2002 the European Commission recognised the need to address the sustainability of this industry. The Common Fisheries Policy, which covers European aquaculture developments, recognises that the way forward to a sustainable industry is through an ecosystem based approach, 'where the integrated management of land, water and living resources must promote the conservation and sustainable use of marine resources in an equitable way'. An ecosystem approach to aquaculture management is not about managing or manipulating ecosystems but is concerned with ensuring aquaculture management decisions do not adversely affect ecosystem function and productivity, so that marine resource use is sustainable in the long term.

ECASA'S AIM AND OBJECTIVES

One of the main objectives of the EU strategy for sustainable aquaculture is to ensure an environmentally sound industry and to develop specific criteria and guidelines for Environmental Impact Assessments of aquaculture developments. The aquaculture industry has made significant improvements in the efficiency of feed and nutrient utilisation, reducing the associated environmental pressure, but further impact mitigation can be achieved by optimal site selection. This is the focus of the ECASA project: to provide industry and regulators with tested tools and methods for assessing assimilative capacity and for predicting ecosystem effects in an environment forced by economic and climatic variability.

The objectives of the ECASA project are to:

- identify quantitative and qualitative indicators of the effects of aquaculture on the environment and *vice versa*, and to assess their applicability.
- assess and develop operational tools, including models, to establish and describe the relationship between environmental conditions and aquaculture activities over a range of ecosystems and aquaculture production systems.
- develop effective environmental impact assessment and site selection methods for coastal area management.

FIELDWORK IN NINE COUNTRIES

The indicators of the main drivers of ecosystem change will be identified and assessed, and their applicability shall be tested throughout Europe in the 2006 field campaign. Fifteen different study sites in nine European countries have been proposed for the ECASA field campaign representing an array of environmental conditions and cultivated species: from a Norwegian site north of the Arctic Circle all the way south to a site on the Greek Isle of Crete (see map). Both fin-fish and shellfish production systems are included in the study.

> 16 organisations from 13 EU countries work together in the ECASA project to improve the sustainability of European aquaculture.

THE ECASA 'TOOL-BOX' FOR REGULATORS AND MANAGERS

Environmental models will be developed that can examine the relationship between the environment and aquaculture activities. These models will help inform regulatory decisions on where it may be best to conduct monitoring programmes and how to improve husbandry practices to optimise productivity in a sustainable way.

Our 'Tool-Box' will contain a suite of indicators and predictive models. These will help to assess the suitability of proposed sites for aquaculture activities and will provide a consistent framework for conducting Environmental Impact Assessments that produce coherent and relevant Environmental Statements.

The 'Tool-Box' will advise on:

- the merits of the chosen indicator set including the best methods to collect, analyse and interpret environmental samples.
- the recommended set of models, including the criteria of how to choose the most appropriate model, depending on the spatial scale and the size of the farm.
- the use of models to estimate the assimilative capacity of the site and water body as well as the level of sustainable production.
- the reliability of model predictions.

PAN-EUROPEAN COMMUNICATION WITH INDUSTRY AND REGULATORS

We interact regularly with industry and regulators to ensure that our work has practical relevance and that the user community achieves ownership of the project's outputs. The 'Tool-Box' of indicators and models for effective Environmental Impact Assessment and site selection will be demonstrated at an international conference and workshop in September 2007. For the first time, this will bring together regulators and industry from across Europe to consider the best methods for achieving the sustainable development of marine aquaculture. ●

FISH BEHAVIOUR IN DEGRADED ENVIRONMENTS

Dr Robert Batty, SAMS (Robert.Batty@sams.ac.uk)

FACTFILE

Title:	The effect of turbidity and hypoxia on the behaviour of coastal marine fishes (ETHOFISH)
Funder:	EU Framework Programme 5
Period:	2002 - 2005
Co-ordinator:	Dr Paolo Domenici, International Marine Centre, Italy
Partners:	SAMS, University of Copenhagen (Denmark), Centre de Recherche en Écologie Marine et Aquaculture (France), University of Bergen (Norway)
Website:	www.ifremer.fr/ethofish/

> SAMS scientists studying Killer Whale and Herring preditor-prey interactions in Tysfjord, Norway (© R Batty, SAMS).

Anthropogenic disturbances in European marine coastal ecosystems have been increasing extensively throughout the last decades. Yet, the potential impact of degraded environments on coastal productivity is poorly understood. The ETHOFISH project investigated how fish respond with their behaviour to two important, man-enhanced environmental conditions: increased water turbidity and reduced oxygen availability. Our pan-European ETHOFISH team studied three aspects of how fish interact with their environment: habitat selection, predator-prey interaction, and schooling behaviour. We looked at Herring, Grey Mullet, Cod, Plaice and Dover Sole. The last two species were chosen because they are particularly vulnerable on their intertidal nursery grounds.

HABITAT SELECTION IN HYPOXIC AREAS

Low oxygen levels elicit mostly either of two responses from fish: active avoidance or "sit and wait" until conditions improve. Sole displays both behavioural strategies when they encounter hypoxia. Which strategy they choose depends on the time of day or the state of the tide: Sole feed mainly at night, and when they come across areas of low oxygen they show avoidance behaviour and actively seek out and then stay in areas with more oxygen. During the day, however, they are less active and are unmoved by hypoxic conditions. This refined response allows them to make the best of any situation. It is likely that they have evolved this behaviour to cope with small patchy areas of hypoxia rather than more extensive areas of reduced oxygen.

Grey Mullet often experience low oxygen levels in Mediterranean lagoons. They usually respond by ascending to the surface to gulp air. They thereby obtain more oxygen but also increase their risk of being caught by predatory birds.

SCHOOLING BEHAVIOUR IN HYPOXIC CONDITIONS

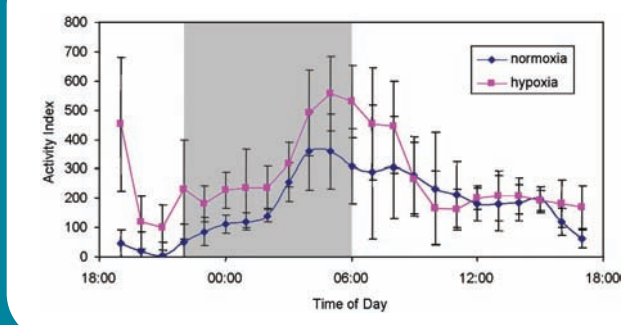
In the Øresund (between Denmark and Sweden) hypoxic conditions exist every year in late summer. There we studied the schooling behaviour of Herring in response to hypoxia using a stereo underwater video technique that enabled us to visualise the 3-dimensional structure of the schools. Rather than coming closer to the fully oxygenated surface like the Grey Mullet, Herring schools become less dense. This allows the fish to extract oxygen from a larger volume of water, just as laboratory experiments had predicted.

In Tysfjord in northern Norway Killer Whales attack Herring. In response Herring schools become more dense, which then leads to a reduction in oxygen saturation.

MAN-ENHANCED TURBIDITY INCREASES OXYGEN STRESS

Large scale oyster culture on the Atlantic coast of France has led to an increase in both hypoxic and turbid conditions. Here, turbidity is not just particulate matter in the water, but is combined with exopolysacharides exuded by the oysters. This makes the sediment more viscous. Our colleagues demonstrated that this decreases water flow through the gills of flatfish and so exacerbates any effect of reduced oxygen saturation. Although this may not be lethal, it reduces the metabolic rate, so that fish cannot afford to be very active, feed less and grow more slowly.

> Stereo underwater video reveals the structure of fish schools (© R.Batty, SAMS).



> Juvenile Sole activity increases at night and dawn when fish are searching for normoxic conditions. During midday, on the other hand, they prefer to sit and wait in hypoxic (25% saturation) conditions rather than searching for more oxygenated areas. This behaviour is related to feeding cyles.

TURBIDITY PROVIDES REFUGE FROM PREDATION

Depending on fish size and diet, turbidity can be beneficial. We found that some species, including juvenile Plaice, actually prefer turbid water, where they spend more time than in perfectly clear water. They will also take more food in slightly murky water as long as they feed on non-active prey. Juvenile Plaice largely feed on sessile animals like the siphons of bivalve molluscs, which they nip off. Turbidity, however, reduces feeding on more active prey, such as small crustaceans.

In a related project at SAMS we found that larval Halibut feed better in turbid conditions because their prey are better contrasted against their background. Clearly there is a scale effect: the smaller the animal is, the more it benefits from turbidity. Its prey are smaller and closer but its predators are larger and more distant.

The conclusion is that turbidity provides a refuge from predation for small fish while having less effect on their foraging. ●

> Many shores – like this one outside the SAMS laboratory – are dominated by brown seaweeds like *Fucus*. This study investigates the role of pathogens in controlling populations of these key organisms.

FACTFILE

Title:	Exploring the immune system of brown algae
Funder:	EU Framework Programme 6 HRM: Marie Curie Fellowship
Period:	2006-2008
Co-ordinator:	Drs C Gachon and F Küpper
Partners:	SAMS and Université Paris-Sud/CNRS

Sick seaweed:

Exploring the immune system of brown algae

Drs Claire MM Gachon, Université Paris-Sud / CNRS (Claire.Gachon@sams.ac.uk) and Frithjof C Küpper, SAMS (Frithjof.Kuepper@sams.ac.uk)

What looks to the innocent tourist like a peaceful Scottish sea shore may actually be seen as a battlefield, where innumerable organisms kill, maim, harm and evict one another. Among the risks seashore creatures face are diseases that may weaken or kill them. At SAMS, we have just started a new project that intends to better understand how brown algae defend themselves against such disease-causing agents.

Brown algae make up most of the biomass on cold and temperate rocky shores. Like any other organism, they may suffer from diseases caused by pathogens including fungi, bacteria and viruses. Although their importance in the field is certainly underdocumented, a number of reports point to epidemics responsible for the periodic decimation of entire populations.

In terrestrial ecosystems, it is well known that epidemics caused by pathogens shape natural populations. On a longer time scale, pathogens exert a tremendous selection pressure on their hosts and drive the evolution of species - and sometimes even their extinction. In spite of this, the field of algal diseases remains largely unexplored and many questions still await to be tackled.

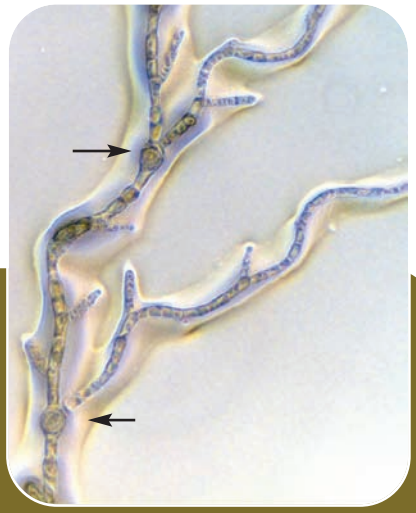
A COSMOPOLITAN ALGA: *ECTOCARPUS SILICULOSUS*

We will use a small filamentous brown alga, *Ectocarpus siliculosus*, as a model to explore the immune system of brown algae. *E.siliculosus* occurs worldwide in temperate and cold seas, and is small and easy to cultivate in the laboratory. For these reasons, it is probably the best-studied brown alga: Over the last century, its life cycle, genetics, pheromones, cell biology and virus infections have been intensively studied. It has also recently gained renewed attention on the international scene because it is becoming the first brown alga of which the entire genome is being decrypted.

A MARINE SUPERBUG: *EURYCHASMA*

As a model pathogen, we use the oomycete *Eurychasma* – in fact, we isolated our first culture from Shetland waters in 1996. Oomycetes – which include a number of devastating crop and animal pathogens, including the causative agent of the 1840s potato blight disaster in Ireland and Scotland – were long considered fungi. Yet, they are actually related to brown algae and diatoms, although they cannot harvest sunlight for photosynthesis. For their survival, most of them parasitize on other organisms. *Eurychasma* can be considered their most ancient representative. Its study has thus the potential to reveal some clues as to why this group has produced so many devastating disease-causing agents. Also, it is probably the most abundant pathogen of brown algae in the field (apart from viruses) and can arguably be called a marine superbug since it infects practically all brown algal species.

> *Ectocarpus* is a small filamentous brown alga easily cultivated in laboratory conditions.



> The brown alga *Ectocarpus* is infected by *Eurychasma*: The infected bulging algal cells will eventually die and release new pathogen spores (arrowheads).

THE *ECTOCARPUS / EURYCHASMA* INTERACTION AND CCAP

At SAMS, the Culture Collection of Algae and Protozoa hosts almost 300 different *Ectocarpus* strains originating from all over the world, some of them being sensitive, some others being resistant to infection by *Eurychasma*. Taking advantage of this unique genetic resource, we intend to address the following questions: How do resistant brown algae overcome disease? Reciprocally, how do pathogens succeed in infecting sensitive brown algae?

THE BROWN ALGAL IMMUNE RESPONSE

There are some indications that an infection attempt by *Eurychasma* triggers some defence responses comparable to the animal or plant immune systems: using cutting-edge technologies such as protemics and metabolomics, we intend to characterise in depth the molecules produced by *Ectocarpus* in response to infection. Apart from their fundamental interest, these studies may eventually lead to the identification of bioactive compounds of pharmacological interest. In fact, many similar natural products isolated from terrestrial plants have therapeutic properties and are used in drugs.

This work will set a basis for future comparisons of how algae, animals and terrestrial plants defend themselves against infection. We already know that algae have some specificities, like the production of halogenated (iodinated or brominated) defence compounds which contribute to the scent of coastal air and which are a natural source of ozone-degrading compounds. In this respect, our work is at the crossroads between several disciplines including chemical ecology, atmospheric chemistry and molecular biology. ●

BOOK REVIEW

James Lovelock and The Revenge of Gaia

Dr Toby Sherwin, SAMS (Toby.Sherwin@sams.ac.uk)

What is the enduring legacy of James Lovelock? His concept of Gaia as a living planet is as revolutionary and inspiring today as Darwin's theories of natural selection were in the 19th century. But whereas Darwin tried to avoid controversy, Lovelock has courted it.

Lovelock's vision is of a sentient planet in which all life, from the smallest plankton upwards, works holistically to maintain an ambient environment. Thus life does not exist on Earth because conditions are right, but because Gaia has made it that way. Life began, and Gaia was born, when the sun was a lot cooler than today. Since then as the sun's radiation has increased, Gaia has worked to keep itself cool, and thereby provided mankind with a benign environment. The key to Gaia's survival has been the systematic removal of carbon from the atmosphere and its burial underground.

Now well into his 80s Lovelock's overriding concern is for the future of mankind which, by its reckless use of fossil fuels, is abusing its welcome. He worries about 'the great peril that faces us', and that as 'tribal carnivores' we are destroying the Earth. It is too late for international agreements, he argues; instead individual nations should take action to save themselves. Britain must act alone, as it did in 1939.

In a wide ranging, well written and compact book Lovelock reviews the Gaia concept, explains how the latest research can predict significant increases in global temperature over the next century, reviews energy sources and analyses farming practices. He concludes that our only recourse is for the immediate use of nuclear power, the one form of energy that can satisfy our needs without producing carbon emissions. In the long run, however, we need a mix of energy sources. Although Lovelock is desperate to appease Gaia, he is also an optimist. He calls for a reduction in the amount of land used by agribusiness and 'industrialisation' (including wind farms) and envisages a utopian Britain divided into three: part city and industry, part agriculture, and part Gaia.

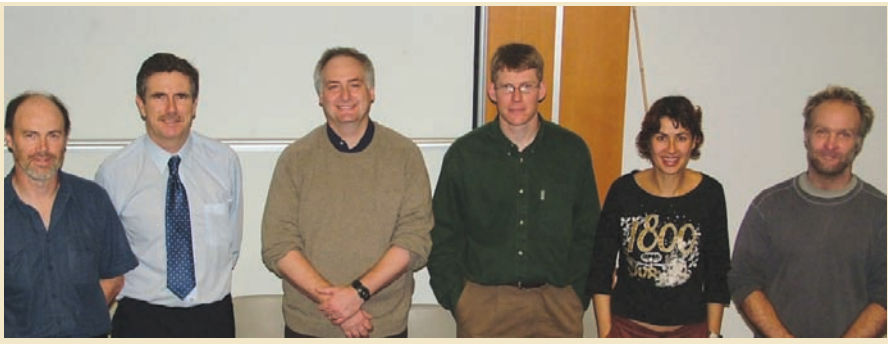
Lovelock's legacy is as difficult to judge as predicting future climate scenarios. Part of this difficulty is down to Lovelock himself and his almost wilful need to challenge and confront. He is a complex thinker who enjoys promoting the concept of Gaia with its New Age connotation, even though it has brought him outright criticism; but his advocacy of nuclear power, and other ideas, confirms his 1950s scientific heritage. He can't resist, even in his twilight years, taking sideswipes at modern icons - Mother Teresa, alternative remedies, 'ecofascists'. Equally his solutions for our present predicament are not always consistent: for example he berates city dwellers yet wants us to live in cities. For all that, this reviewer believes that one day Lovelock will be considered Darwin's peer. In the meantime we should read this book and take his warnings seriously. Even if he doesn't have all the answers, he certainly understands the problem.

Scottish Marine Group activities

Dr Hamish Mair from Heriot-Watt University organised his last SMG meeting before stepping down as convenor on 'Scottish Marine Science Overseas' on 27th October 2005 at Stirling University.

The presentations took participants on a tour around the world, from the North Pole to the Southern Ocean, from Eastern Asia, Tahiti, the Gulf of Panama, the Caribbean to the Mediterranean, describing Scottish research projects from ocean drilling to aquaculture, marine mammal migration to ecosystem mapping. Dr Mair had been invited to present some of his own work at the meeting, a summary of which is given on the next page.

Late in 2005 Susan Chambers, curator for marine invertebrates at the National Museums of Scotland, agreed to take over as convenor for 2006. She organised the spring meeting for postgraduate marine science researchers at the Museum in Edinburgh, where nine postgraduates from seven Scottish universities presented their work. Faridah Mohamad from Glasgow University was awarded the £100 SAMS prize for the best postgraduate presentation (see Page 12).



From left: Colin Graham (BGS), Dr Hamish Mair (Heriot-Watt), Dr Trevor Telford (Stirling), Dr Finlo Cottier (SAMS), Dr Evanthia Karpouzli (Scottish Executive), and Dr Martin Biuw (Gatty) were the speakers at the 'Scottish Marine Science Overseas' meeting of the Scottish Marine Group.

The £100 SEPA prize for the best visual presentation went to Jack Fasham of Heriot-Watt University.

SAMS would like to thank Hamish and Susan for organising the meetings, and Stirling University and the National Museums of Scotland for hosting them.

Marine survey findings from Las Perlas Archipelago, Panama

Dr Hamish Mair, Heriot-Watt University (J.M.Mair@hw.ac.uk)

Scientists and postgraduate students from Heriot-Watt University and the Smithsonian Tropical Research Institute in Panama (www.stri.org) have been collaborating for the past three years to gather the scientific information on the marine environment of the Las Perlas Archipelago in Pacific Panama that is required to manage areas of Las Perlas that are to be designated for protected status.

THE DARWIN INITIATIVE PROGRAMME

The project was funded by the Darwin Initiative Programme (www.darwin.gov.uk), which aims 'to assist countries rich in biodiversity but poor in resources with the conservation of biological diversity and implementation of the Biodiversity Convention' and 'to draw on British expertise in the field of biodiversity.' Since 1993 the Darwin Initiative has committed £45m to over 400 projects in around 100 countries with the main aims of assisting in institutional capacity building, training, research, work to implement the Biodiversity Convention, and environmental education. Darwin projects typically consist of activities that may lead to the preparation of biodiversity management plans, of analytical work that may support conservation and/or sustainable use of natural resources, or of initiatives that support local communities in enhancing biodiversity. Other Darwin projects have improved the information base on a particular species, focusing on neglected areas of research and providing data for long-term studies, or have developed tools to measure biodiversity change.

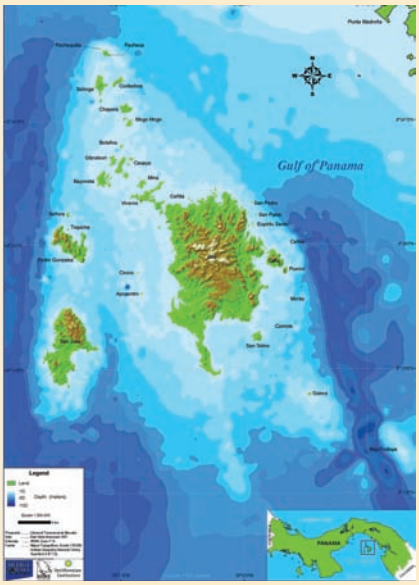
CORAL HABITAT MAPPING

For her doctorate research Sarah Benfield mapped marine habitats in Las Perlas using optical remote sensing and alternative image classifiers and studied the community structure of reef-associated fish. She undertook the first known comparison of the discrimination abilities of Landsat ETM+ and Quickbird satellite sensors for coral reef mapping. Her main conclusions from these comparisons are:

- Quickbird is significantly more accurate than Landsat at mapping habitats. Landsat, however, is more cost effective for resource mapping at coarse to intermediate descriptive resolutions.
- An object-oriented image classification technique produces more accurate habitat maps than pixel-based methods for both sensors. This is the first known application of this method for coral reef mapping by remote sensing.
- Area calculations from the Landsat image show that live branching coral reefs dominate in the northern part of the archipelago, whereas coral communities (rocky areas with coral colonies not forming a reef framework) are concentrated in the south. Both habitats have conservation importance, but coral communities are more diverse in coral and reef fish species than coral reefs.

Other Darwin project studies in Las Perlas included:

- Analysis of the historical effects of environmental variables on vermetid molluscs within coral reefs from Pacific Panama
- Assessment of *Argopecten ventricosus* population recovery after a collapse almost two decades ago
- A qualitative & quantitative assessment of the small-scale Snapper fisheries of Las Perlas Archipelago, Panama
- A study of the reef fish communities of Las Perlas Archipelago, Panama



> Map of Las Perlas

- Sponge diversity in coral frameworks and coral communities within the Las Perlas Archipelago, Panama
- Changes in land use cover in Las Perlas Archipelago: proposal for a protected area
- The role of local communities in the designation of a marine protected area in Las Perlas Archipelago, Panama
- An assessment of metal contamination in marine sediments in Las Perlas Archipelago, Gulf of Panama
- The seasonal up-welling and primary production of the Panama Bight estimated from satellite data: ENSO implications

The results of several of these studies were presented at the Darwin project conference in Panama in March 2006 and are currently written up for publication in scientific journals.

At the March Conference we were notified that the Darwin project in Panama has obtained two more years of funding from the Darwin Initiative to continue its work until March 2008. ●

For more information on the work of the project, please see the following websites:
http://striweb.si.edu/darwin_initiative/
http://www.darwin.gov.uk/news/projects/las_perlas.html

> Benthic sampling around Las Perlas

> Measurements of Red Snapper landings on Las Perlas

> The British Ambassador, Jim Malcolm (centre), and his deputy visit the research team on board the STRI vessel

Manganese in the swimming crab *Liocarcinus depurator* (L.) from Scottish inshore waters

Faridah Mohamad, University of Glasgow (f.mohamad.1@research.gla.ac.uk)

MANGANESE CONTAMINATION IN SEA LOCHS

Some sea lochs on the west coast of Scotland experience high levels of manganese (Mn) compared to the open sea as it leaches from Mn-rich rocks on the land. Loch Fyne is one such sea loch, with bottom water Mn concentrations of around 1ppm, which is ca 100 times higher than in the Clyde Sea area. The Loch Fyne Mn concentration is further increased during hypoxic or anoxic conditions, when Mn from sediments is released into the water and becomes bioavailable.

The amount of metal in an area can be measured directly in the water and sediment. Such measures, however, provide no information about the metal's biological impact on living organisms. Bioavailable metal is better estimated by measuring the concentration in an organism that accumulates it. Only this bioavailable fraction is transported along the food chain, and is therefore considered to be of greater ecological importance.

THE SWIMMING CRAB – A BIOMONITOR FOR MANGANESE?

The swimming crab *Liocarcinus depurator* (L.) possesses many features for a biomonitor species: it is widely distributed from Norway to West Africa and appears in all lobster trawl catches in the Clyde Sea. It grows up to 55mm carapace width, providing sufficient material for analysis by Atomic Absorption Spectrophotometry (AAS). But no studies have yet associated L. *depurator* with metal accumulation. This investigation aimed to assess the potential of L. *depurator* as a biomonitor for manganese in Scottish inshore waters.

The study was conducted in three stages: Initially I conducted a comparative survey of Mn concentration in crabs from Loch Fyne and the Clyde Sea area. Then I studied Mn accumulation in the exoskeleton of crabs in an exposure experiment, before investigating how much Mn is retained in the exoskeleton after a depuration period.

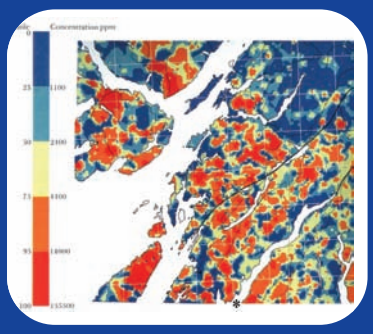
MANGANESE IN CRABS FROM DIFFERENT LOCATIONS

The results of a survey of 247 crabs from Loch Fyne and the Clyde Sea area found that Loch Fyne crabs carry more Mn in their tissues than Clyde Sea crabs. Manganese is unevenly distributed between body tissues: Hard tissues such as the carapace and gills harbour the highest concentrations, followed by the hepatopancreas, while Mn concentrations in muscle tissues and gonads are relatively low. Differences between hard and soft tissues are greater for Loch Fyne than Clyde Sea crabs and may be due to the fact that both carapace and gills are in direct contact with the surrounding water. It is known that crustaceans take up metal across such exposed surfaces.

The survey results thus suggest that L. *depurator* reflects the Mn concentrations in the surrounding waters.

MANGANESE ACCUMULATION

To further explore these field results laboratory trials were conducted on crabs from the Clyde Sea area to investigate the rate and extent of Mn uptake. I measured Mn in crab tissues after exposing the animals to seawater containing 10ppm of Mn. To measure the progressive uptake of Mn in the exoskeletons, I initiated leg autotomy (self-release) in the crabs at intervals over a period of 21 days of exposure. At the end of the experiment the crabs were sacrificed, so that internal tissues could also be sampled. Mn concentrations in the leg exoskeleton rose to six times the original value over the exposure period. Increases also occurred in soft tissues.



> Manganese concentrations in many sea lochs reflect the concentrations in the surrounding rocks, here Loch Fyne.

> The swimming crab, *Liocarcinus depurator* (L.), may be a good biomonitor species for Mn in inshore waters. (© Douglas Neil)

Such changes correspond approximately to the differences between the values for crabs from Loch Fyne and those from the Clyde Sea area. These observations therefore confirm that *L. depurator* accumulates Mn following exposure to the metal.

MANGANESE RETENTION

In a further experiment crabs were exposed to 10ppm Mn sea water for seven days, and were then removed to depuration seawater tanks for 47 days. Their legs were autotomised before and after exposure and during the depuration period. The experiment found that the high post-exposure Mn concentrations in the exoskeleton remain high throughout the depuration period. This retention of accumulated Mn within the exoskeleton suggests that it can provide a record of the history of exposure of the animal to the metal over the period of time since its previous moult.

In contrast, Mn accumulated during exposure in the soft hepatopancreas tissue returned to control values over the depuration period. In this case the hepatopancreas is providing an indication of the current levels of Mn in the surrounding waters.

L. DEPURATOR: A BIOMONITOR SPECIES

This study identifies the ability of *Liocarcinus depurator* to accumulate Mn within its body, in particular the exoskeleton. It also demonstrates that the accumulated Mn is retained within the exoskeleton even after depuration. The survey results confirm that crabs from a place with high concentration of Mn show high concentration of the metal in their tissues when compared to those from a 'cleaner' site. This leads to the conclusion that L. *depurator* holds the potential to be used as a biomonitor species for manganese in Scottish inshore waters. ●

Acknowledgements
I would like to acknowledge the following people for their assistance throughout this project: Douglas Neil, Alan Taylor, Sebastian Gunther Gornik and Amaya Albalat.

16th Annual Newth Lecture, 7 November 2005 at SAMS

Towards Ecosystem-Based Fisheries Management

Dr Michel J. Kaiser, School of Ocean Sciences, University of Wales Bangor (michel.kaiser@bangor.ac.uk)

FAILING FISHERIES MANAGEMENT: WHO IS TO BLAME?

For the last hundred years, marine fisheries biologists have traditionally focussed on two key questions: How many fish are there in the sea? How many can we catch without damaging their future sustainability? Research in this field has had a major influence on population ecology in general. Despite this distinguished history the commonly held prognosis is that current fisheries management systems have failed to prevent declines in many iconic fish species such as Atlantic Cod, although there are also some success stories (*e.g.* Haddock and Herring). In Europe, the failure to manage fish stocks successfully is rooted in a lack of political will to impose the rigorous reductions in fishing effort advised by scientists. Politicians and fishermen argue that the error in scientists' estimates of fish stock biomass is a valid reason to ignore their advice. But as fish abundance declines, so estimates of fish stock biomass become less and less precise and thereby perpetuate this negative cycle. This situation forms the background against which scientists are currently tasked with providing the science to achieve ecosystem-based approaches to fisheries management, a challenging prospect given the present rates of environmental change.

WIDER ECOSYSTEM EFFECTS OF FISHING

The focus on counting fish in the sea has absorbed considerable scientific effort at the expense of understanding the wider ecosystem effects of fishing. This has now become a rapidly expanding and fast moving field of research in which I've been privileged to play a part. Most fishing activities occur on continental shelves and it is here that their effects are most obvious. In the 1980s, Dutch scientists were the first to suggest that the disappearance of reef forming taxa such as oysters and tube worms was directly linked to bottom fishing activities. There is now unequivocal evidence that towed bottom fishing gears significantly reduce the biomass and production of seabed biota, although this varies according to levels of environmental forcing that act in each habitat. Recent modelling approaches have enabled us to identify those areas that are least resilient to fishing disturbance. Not surprisingly, these tend to be relatively deep or sheltered areas of the seabed that have low levels of wave and current stress. The ability to predict where these vulnerable areas occur means that we could effectively mitigate the negative effects of fishing by excluding the most disruptive types of fishing activities from these areas.

FISHERMEN: THE TOP PREDATOR

It is equally important to understand where fishermen go and why they go there. The advent of vessel monitoring systems on larger vessels has shown us just how patchy fishing activity is distributed across large areas of the sea. Naturally fishermen aggregate where they get good catches of fish, but other important factors include a lack of seabed snags or the ability to follow accurately a seabed feature such as a sand bank or reef that may harbour particular fish species.

Some areas of sea are fished repeatedly yet still yield good catches: why should this be? The fact that fishermen focus their activity in restricted areas of the seabed minimises the amount of seabed that is degraded by fishing activities and leaves surrounding areas relatively unaffected. However, when fish stocks are declining, fishermen have to fish for a greater length of time to achieve their quota, and under these circumstances they spread out into new areas as they seek fewer and fewer fish.

Fishing pristine habitat causes the greatest damage and we know that these areas of the seabed can take from one to >10 years to recover. This knowledge has helped us understand that the use of marine protected areas needs to be considered with care. When used to protect fragile habitat MPAs are effective management tools. However, imposing them in the middle of already heavily fished grounds has the effect of potentially displacing fishing activity into areas that are possibly more adversely affected by fishing.

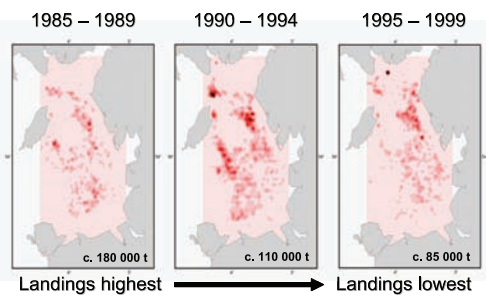
INTEGRATE FISHERMEN INTO MANAGEMENT PROCESS

Our ability to limit the ecosystem effects of fishing can only be achieved by moderating fishing activities in the sea. However an arrogant 'command and control' approach has consistently led to failure to achieve management objectives. Integrating fishermen into the management process is critical and has yielded significant insights into what makes management systems work. Fishermen are the top predators in the ecosystem, to deny the necessity to understand how they behave in relation to their prey and our attempt to control their behaviour is clearly folly. ●

For further information, visit www.sos.bangor.ac.uk/~oss405/kaiser.htm

> Area closures off the coast of New England have been particularly successful for sessile species such as scallops that have increased their biomass by x14 in a five year period. Fishermen now catch their daily quota after only 20 minutes of fishing. (© M. Kaiser)

> Landings of demersal fish in the Irish Sea were highest from 1985-1989 and declined steadily though to 1995-1999, but fishing effort was highest in 1990-1994. The greater effort is reflected in more vessel sightings, as they spread out into previously unexploited areas. As effort declined in 1995-1999, vessel sightings largely contracted back to previously fished grounds.

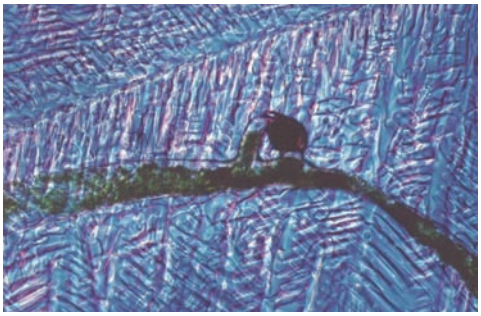


Conserving microalgae

Dr John Day, SAMS

FACTFILE

Title:	Conservation of a vital European scientific and biotechnological resource: microalgae and cyanobacteria (COBRA)
Funder:	EU Framework Programme 5 RTD
Co-ordinator:	Dr John Day, Culture Collection of Algae and Protozoa, SAMS
Period:	November 2001 – March 2005
Partners:	University of Abertay, Unstituto do Mar (P), Universität Göttingen (D), Institute of Soil Biology (Cz), Institute of Botany CAS (Cz), Institut Pasteur, Paris (F), and SME AQUAARTIS (F).
Website:	www.cobra.ac.uk



> Deep-frozen cultures of microalgae do not change genetically with time and are less work-intensive to maintain than strains that have to be kept in a constantly growing state. One objective of COBRA was to increase the number of strains culture collections can keep in cryopreservation.

Like a botanical garden for marine plants, culture collections of microalgae collect, keep and study strains of living organisms. They act as a resource for scientists who use algal cultures for physiological, biochemical, genetic or biotechnological research. The COBRA project developed a physical and virtual European Biological Resource Centre based on existing algal culture collections. In addition, molecular and biochemical stability tests were developed to ensure that the equivalent strains of microorganisms supplied by different culture collections give high quality and consistent performance.

These developed methodologies were validated by external labs and across the consortium.

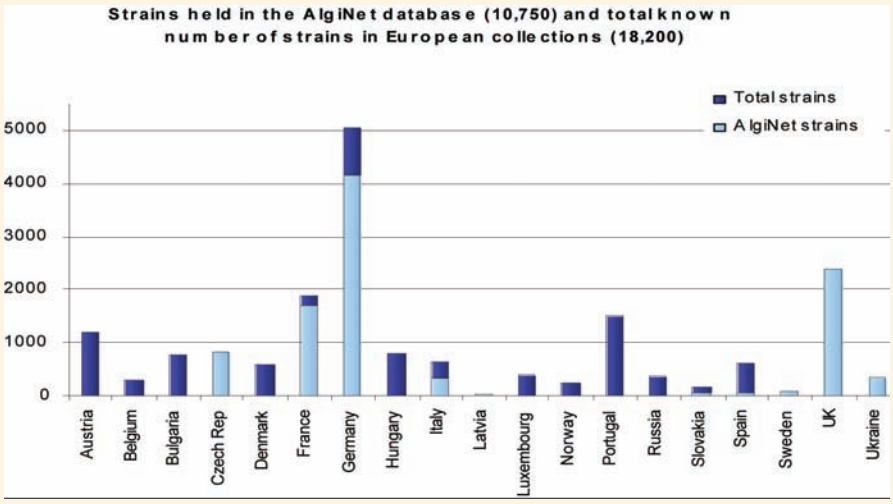
Maintaining algal cultures in a healthy, growing state requires much work and with time will see evolutionary changes that are significantly reduced if the culture can be maintained in a cryo-preserved state. In total >3000 strains are now held in cryo preservation in European collections. Many strains of microalgae and cyanobacteria, however, cannot be kept in such suspended deep-frozen animation as they suffer damage during the process and do not return to a healthy state when defrosted. COBRA aimed to extent cryopreservation methodologies to preservation-recalcitrant strains, and investigated how and when cells are damaged during cryo-preservation. Fundamental and applied knowledge of stress physiology was used to optimise the methods for preserving a wider range of algae.

AlgiNet – towards algae as chemical factories

Dr John Day, SAMS

FACTFILE

Title:	AlgiNet: Microalgae as cell factories for chemical and biochemical products
Funder:	EU Framework Programme 5
Co-ordinator:	Dr Mark Pullinger, Chalex Research (UK)
Partners:	36 scientists from 14 countries
Website:	www.search-labs.com/Alginet/index.html



> The AlgiNet project has combined information of 10,750 strains of the 18,200 strains identified to exist in European culture collections.

Microalgal research is focused in five main regions: the EU, Israel, USA, Japan/East Asia and Australia. European research has by far the largest budget, but this investment has not, to date, resulted in significant levels of economic development in this area. Many centres of excellence exist throughout Europe specialising in various fields of microalgal research, and AlgiNet was developed to improve communication between these centres. It also aimed to develop a common direction for European microalgal research that helps to develop new markets for microalgal products.

At SAMS - in collaboration with the Universities of Caen (F) and Göttingen (D), and companies Quadrate Research (IRL) and Evaflor (F) - we worked to improve access to algal cultures by developing a database and one stop shop for users of microalgal strains. We identified over 100 micro- and macro-algal culture collections across Europe, ranging from private collections with <50 strains to the major service collections with >1000 strains, which add up to more than 18,000 algal strains. The Alginet database holds information on around 10,750 of these.

MY PhD

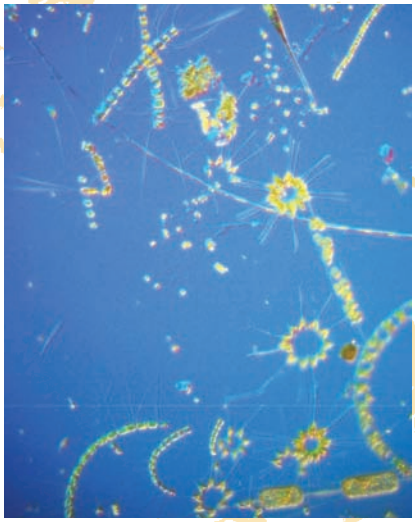
THE USE OF ORGANIC NUTRIENTS BY MARINE MICROBIAL COMMUNITIES

Romain Pete, SAMS UHI

Microbes such as bacteria, phytoplankton and zooplankton make up around 75% of marine biomass and thus contribute massively to the transfer of energy and material in the ocean. These microbial organisms range in size from a ten thousandth up to a tenth of a millimetre, and to study them I have had to use a diversity of approaches, from analytical chemistry to molecular microbiology and microscopy.

Marine microbial communities are a complex network of interacting organisms. To live and grow they need light and specific source materials of carbon, nitrogen, phosphorus, oxygen and other vital microelements, many of which may be available in inorganic and organic forms. Science has gained a much better understanding of how these communities respond to changes in inorganic rather than organic nutrients. My project therefore seeks to investigate the role of dissolved organic matter in driving the dynamics of microbial communities in Scottish coastal waters. These waters experience location-specific nutrient inputs from both natural and anthropogenic terrestrial sources modifying inorganic and organic nutrient stoichiometry, and in turn also microbial community dynamics.

To study the microbial community I collected fortnightly seawater samples in three contrasting locations on the west coast of Scotland between April 2004 and September 2005. The first station is a marine site in the Lynn of Lorne, while the other two sampling stations are located within an area of restricted exchange within Loch Creran. One of the Loch Creran sites is located close to a working fish farm, while the other experiences riverine influences. I studied microbial community composition alongside the organic and inorganic nutrient regime and the prevailing physical parameters including temperature, salinity and density. This allowed me to develop a comprehensive picture of the coastal microbial ecosystem. Seasonal patterns were in agreement with previous observations, but I found an unexpected relationship between dissolved organic carbon and nitrogen and both the biomass of heterotrophic bacteria and bacterial production. This result suggested that bacterial populations are driven not only by their resource availability (inorganic and organic nutrients) but that there is a strong effect of heterotrophic grazing and the lability of the organic nutrients available.

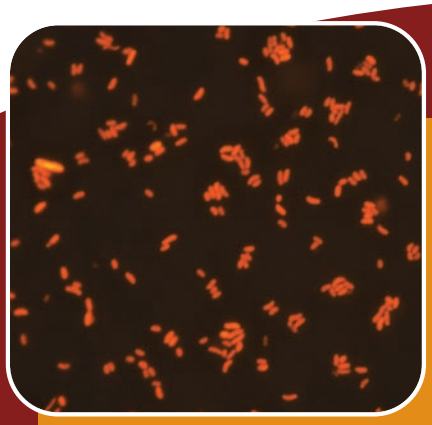


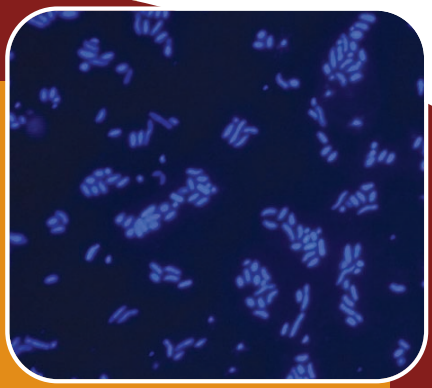
> Phytoplankton can be identified with a light microscope. © C. Campbell, SAMS

Following on from these results I carried out controlled laboratory experiments that studied bacterial community composition using molecular probes, and compared the nutritional status of natural microbial assemblages from the contrasted locations. Preliminary results suggest that organic nutrient stoichiometry affects bacterial growth and bacterial C:N ratios, and highlight the role of heterotrophic grazers in the control of bacterial populations.

All of these elements of my work will, hopefully, contribute to a better understanding of the functioning of microbial food webs in temperate coastal waters. The data I collected will eventually be integrated as parameters into a simple boxed model for Loch Creran. ●

Romain is a final year PhD student from France supervised by Drs Keith Davidson, Ray Leakey and Axel Miller from SAMS.





> My project found that bacterial populations in Scottish coastal waters are driven by inorganic and organic nutrients, the lability of the organic nutrients, and heterotrophic grazing.

To count bacterial populations, parts of their cells are visualised with epifluorescent stains: Total bacteria are visualised with 4 ,6-diamidino-2-phenylindole (DAPI) that stain the DNA blue (right). On the left are an important sub-set of marine bacteria, the Gamma-proteobacteria, as revealed by a specific RNA staining molecular probe. © M. Hart, SAMS

Towards a sustainable aquaculture industry

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In economic terms, aquaculture accounts for more than a quarter of the EU fishery sector output. While the European Commission has set a target of 4% growth rate, it also stresses the need for any growth to be sustainable, particularly with regard to environmental impacts. SAMS research on new species and systems, as well as on alternative sources for feeds, is an essential part of the drive towards a fully sustainable aquaculture industry.

SAMS is one of the key research institutes involved in the AAAG. The group is lead by Dr Maeve Kelly and includes Dr Liz Cook, Dr Symon Dworjanyn, and Ms Coleen Suckling. We focus on developing practical methods for mitigating the environmental impacts of the aquaculture industry.

SEAWEED FARMS CLEAN UP NUTRIENTS

We have been testing the potential of seaweeds to absorb nutrients around salmon farms on the north-west coast of Scotland, and are investigating the economic viability of a salmon – seaweed integrated system. Initial research has focused on the growth and chemical composition of the commercially valuable macroalga *Palmaria palmata* (commonly known as 'dulse'). We measured that the production of dulse increased by up to 50% in the vicinity of cages, and more so in summer when ambient nutrient concentrations were low. Nitrogen isotope levels in the plants suggest uptake of farm-based nitrogen by macroalgae up to 200 m from the cages. A mass balance budget for nitrogen found that a moderate-sized seaweed farm would significantly reduce fish farm derived nitrogen. The integrated system further proved economically viable.

> Sea urchins grown underneath salmon cages grow fast, and are a luxury food item. For experimental purposes they were grown in small bags, but for commercial production are kept in larger net structures.

> Seaweed, here *Laminaria saccharina*, showed increased growth rates when grown in association with salmon farms, and proved to take up nitrogen released by the fish.

FACTFILE

Title:	Atlantic Arc Aquaculture Group (AAAG)
Funder:	Interreg IIIB (ERDF)
Co-ordinator:	Dr Jonathan King, University of Wales, Bangor
Partners:	24 researchers from five nations and partners including Bangor, SAMS, IFREMER – La Tremblade, University College Cork, Centro de Investigación y Formación Pesquera y Acuicola
Website:	www.arcaqua.org

> Researchers from France, Ireland, Scotland, Spain and Wales collaborate to develop new aquaculture methods that make the industry more sustainable.

NEW DIETS FOR SEA URCHINS AND ABALONE

Sea urchin roe and abalone are highly prized delicacies, so there is plenty of incentive to develop reliable and cost-effective culture techniques. At SAMS, we are addressing one particular constraint – the absence of cost-effective diets – by running feeding trials with protein-enriched, macroalga-based diets. We found that dulse, with a protein content of up to 30 %, enhances growth rates in the sea urchin *Paracentrotus lividus* and the European abalone *Haliotis tuberculata*. Such a diet could achieve market-sized produce in less than three years. Dulse has the added bonus of containing high levels of eicosapentanoic acid, an essential fatty acid that is considered beneficial in reducing the risk of heart disease. When fed on dulse the sea urchin roe and the muscular foot of the abalone reflect the dietary fatty acids. So this seaweed diet not only increases their growth rates, but produces a high value, luxury food item with a healthier lipid profile.

SEA URCHINS AS BIOREMEDIATORS

Sea urchins can act as bioremediators for particulate wastes in integrated aquaculture systems, when nutrient extracting species (*e.g.* urchins) are grown together with a nutrient-producing species (*e.g.* salmon). Preliminary results suggest that urchins suspended in nets under the walkways of fish farm cages exhibit enhanced growth rates compared with urchins grown at a distance from salmon cages. The urchins also appeared to benefit from the shelter afforded by the cages.

Sea urchins and seaweed, however, are not the whole story. Members of the AAAG are working on a wide range of species and techniques including improving the disease resistance in the Flat Oyster (*Ostrea edulis*) in France, looking at indigenous Arctic Charr (*Salvelinus alpinus*) as potential broodstock for commercial charr production in Wales, and using salt marshes to extensively culture the flatfish Senegal Sole (*Solea senegalensis*) in Spain. ●