SAMS

APRIL 2001
NEWSLETTER 23
THE SCOTTISH ASSOCIATION FOR MARINE SCIENCE

Loch Etive- keys to past and present environmental change

See page 5

SAMS Research Vessel *Calanus* working in upper Loch Etive.

SAMS Board

Invitation

To JOIN SAMS

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Ordinary: Individuals interested in marine science

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Subscriptions - £60 p.a.

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Email:ebw@dml.ac.uk

New Book

Environmental Impacts of Aquaculture

Sheffield Biological Sciences, Volume 5

Edited by Dr Kenneth D. Black, Dunstaffnage Marine Laboratory

This book covers a wide range of issues, such as marine fish and freshwater finfish cage culture, shellfish cultivation, culture in ponds/lagoons, modelling impacts and genetic impacts of aquaculture, as well as integrated coastal management.

Sheffield Academic Press
ISBN 1-84127-041-5. £69
+44 (0) 114 255 4433

Next SAMS AGM

6 November 2001

Nominations for Council Members should be sent to Mrs. Elaine Walton (address col 1) by 30 September 2001.

Underwater Optics Conference

9 October 2001
at
The Institute of Physics
London
Contact: Derek Pilgrim
University of Plymouth
01752 232457

Symposia

Achievements of the Continuous Plankton Recorder Survey
70th Anniversary
7 August 2001

and

2nd ICES Decadal Symposium
8-10 August 2001

both at the
Royal College of Physicians
Edinburgh

Contact: Professor J.B.L. Matthews, SAMS. E-mail:jama@dml.ac.uk

Contents

As I am retiring, I would like to thank all of you who have helped me over the years, especially Clive Craik and Robin Harvey who have contributed greatly to the production of this Newsletter, and Gary Kidd and staff at Design Links. In particular, I would like to thank Graham Shimmield for all he has done for me and the Laboratory. Due to his drive and stimulating leadership, the past five years have been the best in my working life.

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Designed by Design Links, Edinburgh

SAMS News

Professor Graham B. Shimmield

Director of SAMS and Dunstaffnage Marine Laboratory

With this Newsletter, SAMS marks the retirement of Helen Anderson as Activities Manager and Editing Chief for the SAMS Newsletter and Annual Report.

Over the past five years we have all seen immense improvement in the quality of the Newsletter and Annual Report due to Helen's unstinting effort in raising the standards and content. It has now become the benchmark against which the other Associations judge their own periodicals. But Helen has done more than edit the Newsletter and Annual Report; she has provided SAMS Council with superb support through many difficult issues as well as managing the membership and public relations activities. It is fair to say that she has done more to raise the profile of SAMS than any other member. We are all sad that she has decided to depart for fresh challenges but know that she will always be a friend and supporter of our activity.

I would also like to say a personal thank you to Helen for all her effort and support and to wish her and John Anderson every success for the future. We will miss you Helen.

Recent months have demonstrated significant scientific and infrastructure developments for SAMS research.

On the scientific side we have seen the first underwater off-axis holograms of deep-living microscopic organisms called copepods. This work is part of Dr John Watson's (University of Aberdeen) contribution to developing new optical instruments for marine biology and oceanography. The work was funded by the EU programme HOLOMAR and used the Laboratory's Research Vessel *Calanus* in Loch Etive to capture these astounding photographs as deep as 100 metres. We look forward to future collaboration with John under the AutoMERS Project (Autonomous Marine Environmental Research Stations).

AutoMERS is funded by the Joint Infrastructure Fund and is led by Professor Monty Priede, also of the University of Aberdeen. As I look out of my window I see the new Lander Building nearing completion. This building will enable construction and development of new generation autonomous benthic instruments to be developed and deployed from Dunstaffnage with our collaborators at Aberdeen, St Andrews and Bristol Universities. ▶

Keith Tipping (Southampton Oceanography Centre), John Watson (University of Aberdeen), who designed the camera, Geraint Tarling (SAMS) and Oli Peppe (DML) beside the advanced holographic camera which took the first ever deep water off-axis holographic pictures of microscopic organisms (at 100 metres). © Stewart Fair, Oban Camera.

SAMS News continued

UHI Datawarehouse Wing

We have completed the UHI Datawarehouse wing, constructed within the inner courtyard of Dunstaffnage Marine Laboratory.

This rather palatial open plan suite of offices and instrument laboratories houses the digital heart of the UHI project. Chris Rydings has joined us as the Datawarehouse Manager and has brought considerable skills and enthusiasm to the task ahead. We are all absolutely delighted that this development places Dunstaffnage and SAMS at the centre of the electronic hub spanning the Highlands and Islands of Scotland.

New Developments at the Laboratory

Not content with these developments, SAMS has pushed ahead with a radical and innovative approach to the refurbishment of the existing laboratories.

With the assistance of our preferred developers, ERDC in Partnership, and the architects, Davis Duncan of Glasgow, we submitted plans to Argyll and Bute Council for a new three-storey laboratory and European Marine Biotechnology Centre to be constructed on the existing car park. I am absolutely delighted to report that this application received planning permission on 8th February. Our next hurdle is to complete an application for the European Regional Development Fund (ERDF) to be submitted at the end of March. Should this be successful, a combination of NERC, HIE, ERDF and private finance will enable the green light to be given to this £7 million project.

Artificial Reef

I would like to end with some comments on another project which has completed the series of hurdles necessary to get it off the ground. Over two years ago we started a programme to investigate the potential for artificial reefs in west coast waters as a means of studying fundamental marine processes of habitat selection and colonisation, as well as investigating sustainable opportunities for mariculture that do not require fixed cage locations. The Artificial Reef has now been granted a licence by the Scottish Executive to deploy blocks made from the dust of aggregate production from the Glensanda Super Quarry owned by Foster Yeoman. It is with their support that we now look forward to the most rigorous and largest Artificial Reef deployment in Europe. Given the issues now surrounding the finfish aquaculture industry, this development marks a milestone in the creation of a sustainable fishery.

And a Warm Welcome to SAMS New Council Members

Professor Mike Cowling is Professor of Marine Technology at the University of Glasgow and Director of Glasgow Marine Technology Centre. He is also a Member of the Marine Foresight Panel, an independent member of the Inter-Agency Committee on Marine Science and Technology, Chairman of the UK Marine Environmental Data Advisory Group and former member of SAMS Council (1993-1999).

Dr Alistair Goodlad currently holds senior international business development and consultancy positions in the private and public sectors, specialising in fisheries, aquaculture and SME management. He owns a number of companies with interests ranging from fisheries management, salmon farming, fish processing, and port management to warehousing and is currently an Elected Member of Shetland Islands Council.

Dr Rupert Ormond is Director of the University Marine Biological Station Millport and Visiting Professor at the Institute of Biological and Life Sciences, University of Glasgow. Previously, for 25 years, he was Senior Lecturer (and Director of the Tropical Marine Research Unit) at the Biology Department, University of York. He was involved in establishing and advising on the Ras Mohammed and other Marine National Parks in the Egyptian Red Sea.

Mr Richard Sankey is consultant to Tropical Marine Centre, which he started in 1970 — importing and wholesaling marine fish and invertebrates. He is also a Board Member and Chairman of the Livestock and Technical Sub-Committee of Ornamental Aquatic Trade Association which represents some 800 UK businesses. He has an interest in Lower Oykel Fishings, Sutherland, and The Kyle of Sutherland District Fishery Board.

Mrs Jane Twelves is a Partner in Salar Ltd, Lochcarnan, South Uist, a fish farming company which grows salmon through the whole life cycle. Eggs and fry are sold from the hatchery and over 500 tonnes of salmon harvested a year from the sea. Some fish are used in the production of 'Salar flaky smoked salmon', a produce which has won six food awards. She has served on a number of committees of the Scottish Salmon Growers Association, including Council, Scottish Quality Salmon and Technical Committee.

SAMS News continued

SAMS On-Line

www.sams.ac.uk

If deep sea fisheries, artificial reefs or the impacts of aquaculture have caught your attention in the news and you want to find out more, then www.sams.ac.uk is the site for you.

The Scottish Association for Marine Science announces the launch of its new website to highlight its research work, provide information about marine environmental issues and promote science events in Scotland and beyond. It features over 100 research projects, contact names and items on SAMS staff, SAMS Newsletter, highlights of past and future science events, and the SAMS Schools Zone, including careers advice.

The site provides links to marine science institutes and relevant organisations throughout the world, including Dunstaffnage Marine Laboratory (www.nerc-oban.ac.uk/dml) and the University of the Highlands & Islands Millennium Institute Marine Science Degree (www.nerc-oban.ac.uk/dml/UHI).

Liz Cook
(SAMS Webmaster)

Scottish Sea Lochs - keys to past and present environmental change

Ken Jones and Kenny Black, Dunstaffnage Marine Laboratory

About 10,000 years ago, at the end of the last glacial period, the ice covering Scotland retreated leaving the highly indented western coastline. This is characterised by glacially over-deepened fjordic basins, the sea lochs, which are separated from the coastal seas by shallow rock barriers known as sills. The relationships between loch size, basin and sill depth and the density of the loch's vertical water layers, controlled mainly by terrestrial freshwater runoff, determine the extent of exchange of water between these sea lochs and adjacent coastal seas.

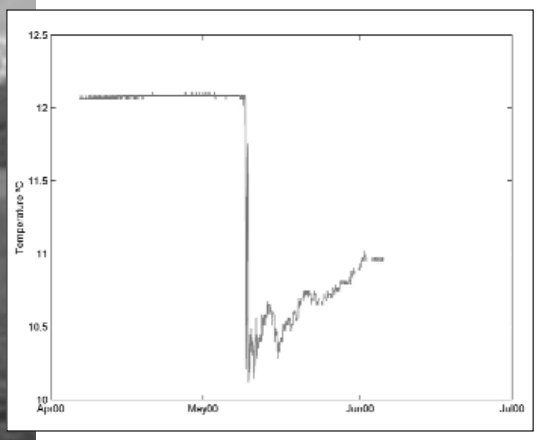
In many of the smaller sea lochs, water is renewed within weeks, but in the larger deeper basins (e.g. Firth of Clyde, Loch Fyne and Loch Etive) the residence time of water may extend to many months.

Scientists at Dunstaffnage are using the topographic and hydrographic attributes of these larger basins to explore past environmental change and to understand the way marine ecosystems respond to man-made disturbance by investigating the palaeogeochemistry of loch sediments and using these systems as experimental mesocosms to study ecosystem processes.

Of all the Scottish sea lochs, Loch Etive has perhaps the longest water residence time — studies during 1999-2000 showed that the deep water can stagnate for 2-3 years. The deepest water in the loch is in the upper basin, between Bonawe and the head of the loch, where depths of up to 145 m are reached in a long, steep-sided channel. Together the Rivers Awe and Etive bring water from a vast catchment of 1,350 square kilometres giving over 3,000 million cubic metres of fresh water per year. This vast inflow of water, together with the restrictions to water exchange with the Firth of Lorne, means that the salinity of the surface waters is markedly reduced except during exceptionally dry spells. This low salinity water is more buoyant than coastal seawater and so forms a layer over the surface of the loch. As this layer is usually deeper than the sill depth (only 20 m at Bonawe), the water within the upper basin can be trapped for long periods.

In comparison with other coastal waters, Loch Etive is unusual in that the slow exchange rate, coupled with the low tidal action within the loch, favours high accumulation of particulate inputs into the sediments. Recent seismic surveys carried out from the DML's Research Vessel *Calanus* revealed that sediments in the deepest parts of the loch are 30-50 m thick. This is consistent with a steady rate of increase of sediment depth of 0.7 cm y^{-1} caused by a rain of sinking particulate material since the ice retreat. The sediments contain terrestrially derived material brought in by rivers, organic material produced by animals and plants within the loch and particles from atmospheric and external marine sources. A change in the abundance and chemical composition of some of these materials down through ▶

DML's buoy is monitoring year to year changes in the water exchange system of Loch Etive's deep upper basin. © John Anderson, Highland Image.



Deep water in Loch Etive had been isolated from the open sea since at least the summer of 1999. Renewal is indicated by an abrupt temperature decrease on 11 May 2000.

the sediments tells us about conditions at the time of sediment deposition. Finding known time markers within the sediment which relate to identifiable events, such as Chernobyl, nuclear bomb tests, or the introduction of lead additives to petrol, makes it possible to construct a chronology of climatic and man-made change over the past 10,000 years, rather like reading the rings of a tree.

Science relies heavily on controlled experiments to advance knowledge of processes. However designing controlled experiments to understand ecosystem function is problematic. Enclosing parts of the ecosystem raises issues of scale and exclusion of key parts of the system, whilst experiments in the open sea bring the difficulties of advection and accounting for all inputs and outputs. In sea lochs the ability to estimate physical exchange precisely and thereby determine accurate mass balances at "whole basin" scale provides the opportunity to test quantitatively hypotheses about the functioning of the marine ecosystems or its parts.

We have been using Loch Etive as a natural large-scale mesocosm allowing us to surmount most of the above difficulties. We used the water isolated in the deep basin of the loch during 1999-2000 to study the biogeochemical processes controlling oxygen and nutrient budgets and the cycling of manganese. During the course of the field studies, we measured, by laboratory experiments, the rates of pelagic and benthic oxygen consumption and used these to determine an oxygen budget for the deep basin. At the same time, changes in *in situ* oxygen and nutrient concentrations along with oceanographic structure of the water column were monitored for a period of 10 months, during which only slow oxygen replenishment to the deep basin could take place by slow turbulent diffusion through a strong density gradient just below sill depth. Oxygen concentrations near the bed fell to <1.5 mg l^{-1} (<20% saturation). The experiment ended in April/May 2000 when a complete renewal of the deep water took place (see figure) as a direct consequence of the dry weather reducing freshwater inputs.

Budgets constructed from experimentally derived biological rate estimates and independently measured vertical mixing rates agreed showing the importance of the pelagic particulate fraction in organic remineralisation within the loch. Comparisons of this budget with "whole loch" changes in oxygen concentration were in good agreement, providing independent validation of the experimentally determined rate measurements.

The use of sea lochs as mesocosms will continue within the recently awarded EU funded OAERRE (Oceanographic Applications Eutrophication in Regions of Restricted Exchange) project (Drs K.J. Jones, R. Leakey, M. Inall) which will focus on refinement of horizontal and vertical exchange measurements using new technology for current and turbulence measurement.

Professor Graham Shimmield and Dr Tracy Shimmield have obtained EU funding for the HOLSMEER (late HOLocene **S**hallow **M**arine **E**nvironments of **E**u**R**ope) Programme, which will enable further work to be carried out in Loch Etive in collaboration with St Andrews University and eleven other institutes within the European Community.

Dr Ken Jones is Deputy Director of Dunstaffnage Marine Laboratory (DML) and Head of the Biogeochemistry Group.

Dr Kenny Black is Head of the DML's Coastal Impact Research Group

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Scottish Marine Group
SMG

Autumn Meeting 26 October 2000 University of Stirling

Sustainable Development in the Marine Environment

Dr Hamish Mair of Heriot-Watt University, SMG Convener, is congratulated on organising this exceptionally successful and well attended meeting. Abstracts of three of the presentations are featured here-by Professor David Mackay (Scottish Environment Protection Agency, North Region), Professor John Harwood (Centre for Conservation Science, University of St Andrews), and Professors Paul Jowitt and Jon Side, (Heriot-Watt University). Other presentations were given by Dr Liz Rogers (BP UK Exploration and Production) - *Beyond petroleum; implications for the marine environment*, Mr Ben Yeats (Wavegen) - *An introduction to LIMPET, the Islay Wave Power Project* and Dr John D.M. Gordon (Scottish Association for Marine Science) on *Are deep-water fisheries sustainable?*

Thank you

We would like to thank Dr Donald McLusky and the Universtiy of Stirling for hosting this event.

Many thanks are also due to the Centre for Conservation Science at the University of St Andrews, Heriot-Watt University and the Scottish Environment Protection Agency, North Region, for financially supporting the publication of the following abstracts.

Fish Farming -
Does it have a future?

David W. Mackay
Scottish Environment Protection Agency (SEPA)

The rearing of Atlantic salmon *Salmo salar* in cages of netting suspended in the sea has become big business on the west coast and islands of Scotland with current annual output of 120,000 tonnes per annum, employment of over 6,000 people, often in remote areas, and a turnover of £230 million.

The industry provides undoubted commercial and social benefits but has come under severe attack from environmental campaigners because of suspected damage to other interests and components of the natural environment.

Allegations include the virtual elimination of wild salmon and sea trout on the west coast through proliferation of parasitic sea lice, the spread of disease, and displacement of natural stocks by escapees.

Furthermore, the waste materials from farms, in particular nitrogenous wastes, are claimed to distort the natural production cycle of our coastal waters and produce toxic algal blooms, which among other adverse effects, can render scallops and other shellfish toxic to humans. The range of 'medicines' used to control sea lice are so powerful that they threaten other species and especially young crustaceans such as lobsters and prawns, if not used strictly in accordance with SEPA's licence conditions.

The evidence put forward by the campaigners against salmon farming is highly selective and in my view ▶

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A Hong Kong inlet similar to a Scottish sea loch.

lacks the balance appropriate to scientific decision-making.

Many opponents of fish farming address the issues from the standpoint that the marine environment should be free of any influence by man. This is not only unrealistic but also impossible to achieve. SEPA operates on the basis that aquaculture, like agriculture, will produce change to the natural environment. Our task is to ensure that the changes imposed are acceptable in terms of the environmental quality desired by the community at large, expressed through the political system, and imposed by the regulators. The standards of this generation are much more demanding than those of previous generations. They vary widely throughout the world and there is little doubt that future generations who can afford it will have still higher aspirations.

The problem posed by organic deposition may be brought into perspective by recalling that until a couple of years ago the organic sewage sludge, combined with many industrial wastes, from the whole of central Scotland was dumped offshore from vessels. At Garroch Head in the sheltered waters of the Firth of Clyde over a million tonnes per year were deposited, for nearly a century, within a mile or two from the beautiful isle of Cumbrae.

Extensive research over many years failed to identify major environmental impacts from what would now be accepted as a gross insult to the environment.

Toxic algal blooms occur world-wide and some ten years ago in face of considerable public concern this author was privileged to lead a comprehensive study of the relationship with fish farming in Hong Kong. The conclusions of that study were as follows:

"Despite the high organic and nutrient loadings generated by marine fish farming activities, the impacts on water quality and sediments at all sites were localised and did not appear to extend beyond a distance of 1-1.5km from the fish rafts. Results of the present study also do not support the suggestion that marine fish farming activities have caused eutrophication on a large scale."

Until now there seems little evidence to suggest that the situation in Scotland is fundamentally different and indeed work in 1976 [Ref] supports the view of comparability.

The damaging relationship between sea lice and natural stocks of salmon was recognised formally by SEPA two years ago and strenuous efforts have been made since then to alleviate the problems by co-ordinated use of medicines at appropriate times, by definition of sensitive areas where salmon farming will be prohibited and by partnership approaches with relevant authorities.

Like all major industries, caged fish farms present problems for the environment and for regulators but by sound regulation and good management practices sustainable coexistence can be achieved.

Reference: Mackay and Leatherland: Chemical Processes in an Estuary Receiving Major Inputs of Industrial and Domestic Wastes

Professor David W. Mackay is Director of North Region of the Scottish Environment Protection Agency (SEPA) and Chairman of SEPA's Fish Farming Advisory Group

Hong Kong - Fish farm and floating town

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Coping with uncertainty when managing marine resources

John Harwood
Centre for Conservation Science and
NERC Sea Mammal Research Unit, University of St Andrews

Most developed nations have now signed up to the concept of sustainable development, and seem happy with the Bruntland Commission's definition that it is "development that meets the need of the present without compromising the ability of future generations to meet their own needs". But how can we achieve this?

The usual approach is to apply the Precautionary Principle, which is the basis for all EU environmental law but isn't defined in any EU legislation! The first Ministerial Conference on the North Sea agreed that "where there are significant risks of damage to the environment, precautionary action ... is taken, even where scientific knowledge is not conclusive, if the balance of likely costs and benefits justifies it". But many scientists dislike this definition because it appears to give unsubstantiated suspicions the same weight as scientific evidence. Non-governmental organisations feel that it is too vague because there is no definition of what constitutes a "significant risk" nor any indication of how the balance between costs and benefits is to be achieved. Nevertheless, this definition heralds a major shift in the burden of proof from those who oppose a development on environmental grounds onto the developers themselves.

However, interest groups often disagree about the likely environmental outcomes of a particular development. Because there is always uncertainty about which outcomes are more or less likely, this can lead to confrontation, with each interest group focusing on only one possible outcome.

Risk analysis offers an objective and rigorous way out of this impasse, because "risk" is the probability that something undesirable will happen and that probability depends on the levels of uncertainty. If there is no uncertainty about the outcome of any particular action there is no risk. For risk analysis to work, the interest groups must agree on the scientific information that is available and on the associated uncertainties. They must then identify the environmental outcomes that should be avoided and a range of scenarios which describe the way the development could be managed. The probability that these outcomes will occur under each scenario can then be calculated. If the probabilities are similar, or their distributions overlap extensively, then there is clearly insufficient evidence to judge between the different scenarios. More research must be commissioned or the development should only be approved if it is strictly controlled. However, in many cases one scenario has a much lower risk than any other.

The US Environmental Protection Agency has developed a formal framework for assessing environmental risks. This involves identifying the environmental hazard, quantifying exposure to that hazard, and then determining the relationship between different levels of exposure and a harmful response. This approach has been used to evaluate methods to reduce the bycatch of harbour porpoises in fishing gear in the North Sea. Exposure of porpoises to this hazard could be reduced by closing parts of the North Sea to particular types of fishing, but this might have serious consequences for the fishing industry. The response of porpoises to exposure to dangerous gear can be improved by fitting alarms to the nets, so that porpoises can detect them more easily. The uncertainty here involves the need to ensure that alarms are fitted and correctly maintained, and that the alarms don't drive porpoises out of important habitat areas.

Further reading:

Foster, K.R., Vecchia, P. and Repacholi, M. H. 2000. Science and the Precautionary Principle. Science 288: 979-981.

Harwood, J. 2000. Risk assessment and risk evaluation in conservation. Biological Conservation 95: 219-226.

Around 7,000 harbour porpoise die each year as a result of entanglement in fishing gear in the North Sea. Risk assessment techniques are now being used to determine the best way to reduce this bycatch. © Nigel Godden, NERC Sea Mammal Research Unit.

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Science and Technologies and their influence on Marine Resources - "Fishing for Solutions"

Professor Paul Jowitt and Professor Jonathan Side
Heriot-Watt University

This presentation was given jointly by Professors Jowitt and Side.

Paul Jowitt outlined their attempts to predict changes and trends in future UK marine resource development and management -

Our presumptions about both living and non-living marine resources and the way in which they should be used are changing. These changing presumptions might not only preclude certain activities at sea — even where technologies are well developed and available (e.g. disposal or more pejoratively "dumping" at sea) — but would also act as drivers to the development and application of new and existing technologies (e.g. wave, tidal and offshore wind, power generation devices).

Changing Presumptions

- Demands for "Cleaner Seas": Major factor for new and existing industries.
- Marine Habitat and Biotope Mapping: Acoustic-imaging technologies will have a substantial influence on marine resources management.
- Fish Farming: Finite limits to fishmeal supplies may demand innovation in feed technologies. Increasing concerns over environmental effects in shallow waters.
- Renewables: Future developments being actively encouraged and seem assured.
- Traditional Fisheries: Increasingly fragile despite fisheries management. Co-operation in decision-making more critical than catching efficiency technologies.
- Sea Level Rise: Huge challenge - managing its consequences demands innovation.

Conflict Resolution

Of particular importance is Conflict Resolution. Given the changes in presumptions about our use of the seas, one over-riding conclusion is that the sustainable development of marine resources and the conservation of priority habitats and species (for both the local seas and global oceans), must involve sustainable mechanisms for conflict resolution and decision-making between the various stakeholders.

Traditional Fisheries

Jon Side then examined in more detail the issues affecting the development and conservation of traditional fisheries — an industry where technological advances are often damaging to the management of the resource.

Fish-finding sonar and development of power blocks for purse seine vessels have increased the fishing efficiency and at the same time contributed to the over-fishing of some fish stocks. This trend is likely to continue. The Common Fisheries Policy is failing to achieve the dramatic reductions in fishing power of the European fleets necessary to save North Sea fishing stocks. For those who doubted the technical efficiency of traditional fisheries, a compelling statistic is that of the estimated 12 million tonnes of fish in the North Sea, some 2.5 million tonnes are landed annually (excluding discards). There is an increasing risk that if these stocks, and the fisheries that involve their capture, are not managed effectively, some species may disappear completely.

Fishery Management Measures

Are fishery management policies a function of scientific orthodoxy or can science support a different and more innovative approach?

Jon outlined a novel fishery model that they have been developing which takes account of the spatial nature of fisheries and explores the consequences which such a model might predict in terms of spatial restrictions and closed zones.

The model appears to show that such a management model could provide a more stable, resilient and self-regulating fishery and therefore one less prone to collapse from over-fishing. The development of this fishery management model is continuing and it is hoped to publish the results in due course.

Meanwhile, Jon and Paul will continue "Fishing for Solutions"...

Paul Jowitt is Professor of Civil Engineering Systems at Heriot-Watt University, Edinburgh, and Director of the Scottish Institute of Sustainable Technology. His research interests concern the issues of sustainability and risk and the development of systems-based solutions within civil engineering and environmental management.

Jon Side is Professor of Sustainable Development at Heriot-Watt University and is Director of the International Centre of Island Technology based at the University's Orkney Campus in Stromness. The focus of his research and teaching has been the sustainable development of marine resources.

The Newth Lecture
University of Aberdeen, 6 November 2000

A Marine Science Plan for Europe: Scientific Issues to be addressed

Graham B. Shimmield
The Scottish Association for Marine Science, Dunstaffnage Marine Laboratory

In this article I present, from a personal viewpoint, some of the key challenges facing marine science over the next 10 years. It is my opinion that the future of marine science is in the hands of the scientists themselves. Future policy legislation, implementation and compliance will all depend on the independence of quality marine science.

I suggest that the four key drivers of future scientific direction are Energy, Abrupt Climate Change, Aquaculture and Sustainability, and Ocean Health Ecosystem Management.

Energy covers a wide range of issues. Exploitation of fossil fuels has led to issues of waste disposal, such as increased production of carbon dioxide and other gases in the atmosphere, and the drill cuttings around offshore oil platforms. In turn major research programmes are now envisaged for improving carbon sequestration from the atmosphere and removal from the global biogeochemical cycle. Obviously new energy technologies in the field of renewables are wind, waves and potentially solar power, all of which are important in marine science. Offshore wind farms using abandoned oil installations in the North Sea would provide one such appropriate approach.

North west Europe faces the very real possibility of abrupt climate change triggered by perturbations in the thermohaline circulation. We know from the fossil record of deep sea sediment cores and ice cores, as well as the terrestrial records derived from the lakes and peat bogs, that the North East Atlantic and polar regions are sensitive barometers to climate change. Whilst these records clearly show us that such change is possible, it does not help us to identify the required improvements in both observation and modelling. Recent emphasis is now placed, appropriately, in deriving hypotheses for the scientific community to test.

Aquaculture and sustainability are two very topical words in marine science. In June 2000, a synthesis paper by Naylor *et al*. discussed the downside of fish farming in the scientific journal, *Nature*. ▶

Fish cages in Saulmore Bay with Dunstaffnage Marine Laboratory to the left and mountains of Mull beyond. © John Anderson, Highland Image.

It has drawn considerable attention to the dilemma of the source of protein and energy necessary to sustain carnivorous fish for human consumption, such as salmon. The importance of the Naylor *et al*. paper is to draw attention to the way in which wild fish and farmed fish are used to sustain animal feed and human food production. One approach which, although not novel, but nevertheless has only recently been rigorously investigated, is the potential for using artificial reefs. A new approach started off the west coast of Scotland will lead to the world's largest experimental reef complex and may offer a key to developing new aquaculture such as lobster ranching.

The fourth area of consideration as a driver of science direction is the issue of ocean health and ecosystem management. This has become the priority for the non-governmental organisations, particularly Greenpeace and the World Wildlife Fund. By using the public fascination for charismatic species (whales, dolphins, coral reefs) there is a ready-made visual key for attracting public interest in the state of the oceans. However, such an approach holds some dangers, not least because many people only believe that harm is being done when single large species are threatened. More widespread and chronic impacts, such as seabed trawling over wide areas or extensive use of persistent organic pollutants, achieve less notoriety.

In Europe we have seen the increase of environmental issues driven by the Framework Directives. These conventions and directives rely heavily on science knowledge. The question is - have we established the right mechanisms of science transfer to policy makers? In a rush to see implementation of such legislation, there is significant danger that poor or compromised science will assume precedence. It is vital that we retain an arm's length relationship between scientists involved in regulation and legislation and those involved in fundamental research. In this way, the peer review mechanism and the appropriate moral standpoint on ethical issues will achieve appropriate balance. Achieving a level standard across Europe and ensuring best scientific practice are goals that scientists and administrators alike should address. I am confident that a 'Marine Science Plan for Europe' is the way forward in the 6th Framework to offer significant benefit to the whole of Europe.

Island of Lismore, Firth of Lorne, Argyll - the proposed site of DML's artificial reef is close to the small islet on the left. This experimental reef complex may offer a key to developing new aquaculture such as lobster ranching.
© John Anderson, Highland Image.

David Newth

SAMS President

1973-79

Alasdair D. McIntyre

David Newth had a distinguished scientific career at the interface between biology and medicine, working initially at University College, London, and the Middlesex Hospital Medical School. Thereafter, he was Regius Professor of Zoology at the University of Glasgow from 1965 until 1981. He was a most urbane individual, excellent company and a wonderful raconteur.

When he became SAMS President in 1973, he faced a considerable challenge. The decade of the 1970s was difficult for the Association. A significant part of SAMS finance from the Science Vote of the Department of Education and Science was transferred to other government departments and projects had to be identified that would win contracts from them. Large collaborative research programmes were coming into vogue, while fish farming on the west coast was growing rapidly and the offshore oil industry was developing. At the same time, the climate of opinion was swinging against science.

In his six years of office, David Newth steered the Association with a strong and sure hand. Thereafter he served as a Vice-President until his death in 1988.

As a fitting memorial, the Association initiated a series of Newth lectures, to be delivered each year at the SAMS AGM.

Sir Frederick Holliday gave the first of these in 1990.

Professor Alasdair D. McIntyre was SAMS President from 1988 to 1993 and is a SAMS Vice-President.

Marine Environmental Data

A New Approach via OceanNET.org

Mike Cowling

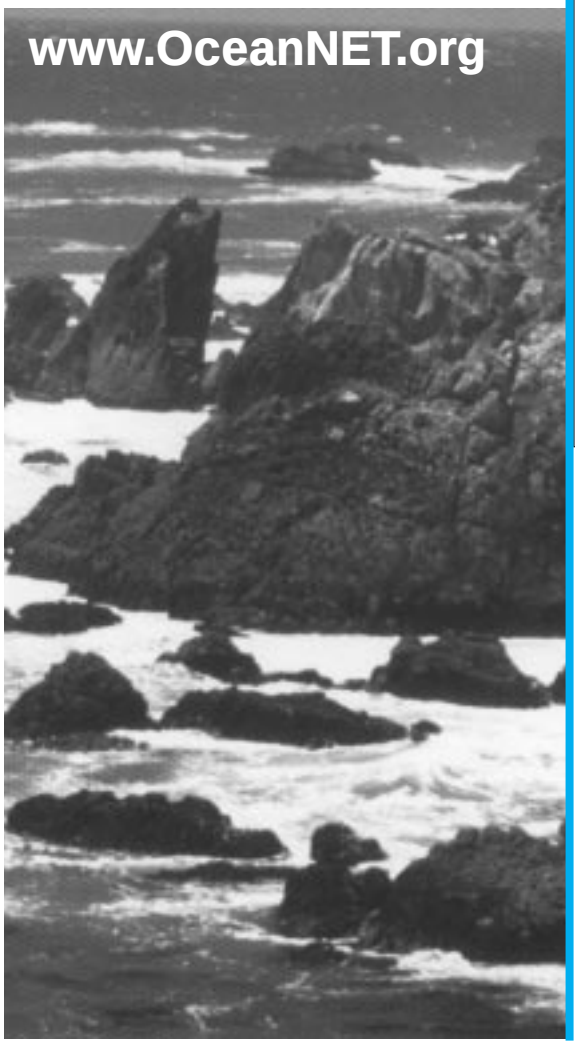
Do you need marine environmental data? Are you unsure where to start looking? Would you like a short-cut? Then www.OceanNET.org can probably help you.

What is OceanNET.org? It is the latest tool to raise the visibility of an activity that has been ongoing for some time, and now undergoing major expansion.

The Inter-Agency Committee on Marine Science and Technology (IACMST) established a Marine Environmental Data Action Group (MEDAG) in 1996. The Group comprises representatives of relevant government departments and agencies, and user groups. One of the initial MEDAG activities was to establish a jointly funded UK Marine Environmental Data Network activity, including a coordinator (Dr. Lesley Rickards), based at the British Oceanographic Data Centre. After a successful pilot project, the activity has been expanded with increased resources and person-power.

The OceanNET web-site acts as a portal to data and information about the marine environment. It includes comprehensive catalogues, with many thousands of entries, some going back three decades. The size and number of the catalogues is constantly growing as the network responds to demand and more data are entered. The next few months will see the establishment of a dedicated section of OceanNET for coastal data and there are plans for a fully comprehensive approach to such coastal information. If you try OceanNET.org and find it useful, or have suggestions for improvements, then all feedback will be gratefully received.

Professor Mike Cowling is a member of SAMS Council, an independent member of IACMST and chairman of MEDAG. (mikejc@eng.gla.ac.uk)



SAMS AGM

at the University of Aberdeen 6 November 2000

At this AGM Professor M.J. Cowling, Dr A.C. Goodlad, Dr R. Ormond, Mr. R. Sankey and Mrs. J. Twelves were elected to Council.

SAMS membership rates were agreed as follows as from 1 April 2001:

Corporate £60, Ordinary £12, Staff £10, Student £5, Unwaged £5.

Sir David Smith was thanked for his outstanding Presidency of SAMS and presented with a painting by Glynn Gorick.

Dr Ian Graham-Bryce, SAMS President, thanked the University of Aberdeen for hosting SAMS meetings and the Newth Lecture.

About SAMS

SAMS, based at Dunstaffnage Marine Laboratory, promotes research and education in marine science, and scientists from both organisations work together on national and international science programmes.

SAMS is funded principally by a grant-in-aid from the Natural Environment Research Council, private sector, donations and subscriptions. Membership, — about 500 — comprises members of the public, academics, professionals, students, etc.

Biodiversity

Putting studies into practice

David Hughes
The Scottish Association for Marine Science

David Hughes (left) on fieldwork in Loch Sween, Argyll, with Jon Chamberlain, University Marine Biological Station Millport. The equipment (centre) is designed to measure the exchange of dissolved chemicals between the seabed and the overlying water.

Biodiversity means the number of different kinds of organisms occurring in a particular place. The recent upsurge of interest in this subject stems partly from studies in environments as different as tropical forests and deep-sea muds, which have shown that huge numbers of plant, animal and microbial species remain undescribed by science. A further stimulus to research has been the ever-growing human impact on the natural environment and rising awareness of the threats posed by this. Because of its importance as a source of food, pharmaceuticals and other natural products, and its role in keeping ecosystems healthy, biodiversity is now a major field of study worldwide.

The sea's resources are economically important, particularly to Scotland, and SAMS and DML's work on marine biodiversity has already had important practical applications. The data collected during our pioneering work on the fishes and invertebrates of sea lochs and deep waters to the west of Scotland, dating back to the 1970s, are becoming increasingly important. As deep-water trawling intensifies and commercial extraction of oil and gas reserves along the Atlantic margin looms closer, data from the Rockall Trough area collected by SAMS over a thirty-year period, are a vital background for attempts to detect and mitigate the effects of these activities. SAMS original deep-sea studies in the Rockall Trough area also form the basis of a continuing research programme which now encompasses the fauna of cold-water coral reefs and the animal communities of the Faeroe-Shetland Channel.

We are also at the forefront of research measuring the environmental impacts of aquaculture and plan to increase the variety of local marine habitats by introducing an experimental artificial reef off the island of Lismore in the Firth of Lorne. The effects of small disturbances to the seabed are being studied experimentally in sea loch sediments and by observing the colonisation of differently shaped concrete blocks placed on the shore.

All biological research requires accurate identification of organisms and DML's Culture Collection of Algae and Protozoa is the UK's major reference collection for these groups of organisms.

Biodiversity studies typically generate huge amounts of data on species abundances, to which a bewildering array of mathematical analyses can be applied. SAMS has developed the BioDiversity Pro software package as a user-friendly aid for handling such data, and this has been widely used by researchers all over the world.

SAMS and DML have played a major role in the UK Marine Special Areas of Conservation Project, an EU-funded initiative aimed at protecting the most important marine habitats. We are also closely involved in the partnerships set up to devise local Biodiversity Action Plans.

The sea pens Virgularia mirabilis *(left) and* Pennatula phosphorea *(right), are common on muddy bottoms in sea lochs. Marine sediments in both shallow and deep water conceal a surprising level of biodiversity beneath the surface.*
© Tom Wilding, DML.

An illustration of one of the rich animal communities occurring in Scottish sea lochs: corkwing wrasse Crenilabrus melops *in a clump of sea squirts, bushy hydroids and soft corals.*
© Tom Wilding, DML.

Overall, our aim is to continue to carry out high quality research in order to ensure the continued health of the marine environment and its sustainable use.

Dr David Hughes is an ecologist, working for the past three years with the SAMS Deep-Sea Benthic Dynamics Group. He has also worked on the ecology of burrowing invertebrates in sea lochs and written literature reviews for the UK Marine SACs Project.

Member's View

Salmon, sea trout and science

Hugh Raven
Chairman of the Lochaber Fisheries Trust

To the north and west of Dunstaffnage is the beautiful corner of Inverness-shire that contains what used to be some of the best sea trout rivers in Scotland. Shiel, Moidart, Ailort and Aline are anglicised Gaelic names evoking thoughts of scenery and sport. But in each of these rivers, the runs of fish are a fraction of their levels even six or seven years ago.

The Lochaber Fisheries Trust is a charitable partnership of angling groups, businesses, fisheries proprietors and fish farming companies that joined together to root out the causes of decline. Our main purpose is research, for which we employ a full-time fisheries biologist, Dr Jon Watt, to conduct field research and provide fishery management advice.

Our stocks of wild salmonids are at unprecedentedly low levels. The declines in Scottish salmon are now well-documented and, at last, publicly recognised. But the stock collapses in many west coast fisheries are of a different order — and we have recent evidence that in several local rivers that recently contained healthy stocks, salmon may be threatened with extinction. For sea trout, the picture is just as bad.

We are trying to understand the causes, before it is too late. For the first time, we are piecing together robust scientific insights into what is going on in our freshwater fisheries, showing the severity and reasons for the declines, and looking forwards at how to reverse them.

We are funded by fisheries proprietors, who contribute to us roughly the sum they formerly paid to the local authority in sporting rates. As a charitable trust, we can increase this money from charitable donors, which we then increase further from statutory sources. For every £1 raised from proprietors we spend around £2.50 on research to benefit Lochaber's fisheries.

That pays for a wide variety of work. We are establishing broodstocks, both to save the genetic material indigenous to each of our significant rivers, and to provide juveniles for re-stocking. Thus for one river, with the help of Marine Harvest, we hold 200 adult sea trout. We hope to make another an index river for Lochaber, assessing both freshwater production (smolts per adult), and marine survival (adults per smolt).

We conduct habitat surveys, assess the chemical environment, and research the incidence and impact of sea-lice. With the Dunstaffnage Marine Laboratory, we have trawled Loch Linnhe for post-smolts, to count sea lice burdens and assess their condition (though sadly caught too few to reach any conclusions!) We are developing restoration programmes for our rivers, and working with the Lochaber Fisheries Board and river owners in putting them into practice.

Our work has had a substantial impact on factors affecting west coast fish populations: it was our evidence that persuaded Scotland's Fisheries Minister to establish the Tripartite Working Group of wild fisheries interests, fish farmers, and the Scottish Executive. That initiative, in turn, has led to an emerging agreement on fish farm escapes, and the formation of Area Management Groups to promote fish health and the control of sea-lice.

Our stocks remain threatened and our anglers' sport is a shadow of what it was. But alongside the gloom, we are making progress with the science. We may not have the answers, but at least freshwater fisheries management in Lochaber is no longer based on anecdote and hunch. We have a lot yet to do - and we hope to continue to do it in partnership with Dunstaffnage.

Anglers on Loch Shiel - angling makes a valuable and sustainable contribution to the Highland economy.

Sea Ice and the Earth's Climate

Oli Peppe
Dunstaffnage Marine Laboratory

The Marine Technology Group at Dunstaffnage has teamed up with sea ice specialists at the Scott Polar Research Institute, University of Cambridge, to develop a new piece of equipment - a novel drifting buoy - to help study the formation of sea ice in Antarctica.

Each autumn as the sea begins to freeze over, the swell from Southern Ocean storms causes the young ice to form into flat circular clumps known as 'pancakes'. As the freeze continues, the pancakes grow (often up to 5 metres in diameter) and then consolidate into pack ice.

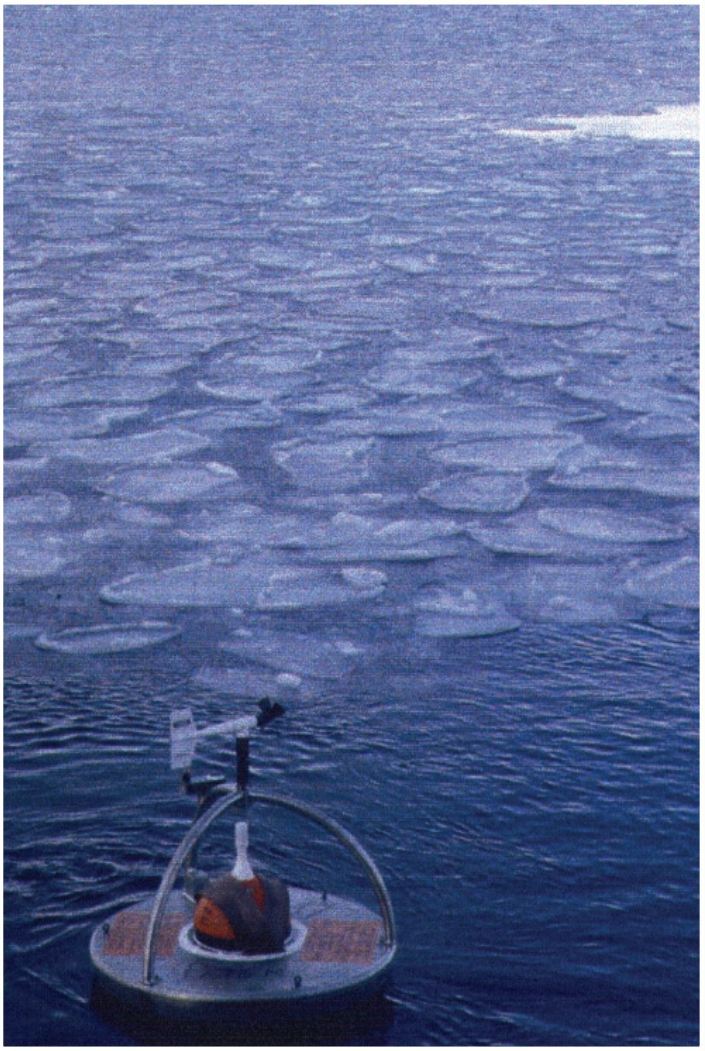
Our project, known as STiMPI (Short Timescale Motion of Pancake Ice), uses an array of buoys to measure the deformation of the young ice pack and its response to wind forcing and wave action. The improved understanding of the mechanisms of sea ice growth will help to assess the influence of sea ice on the Earth's climate.

The buoys developed for this project mimic a typical 'pancake' so that they move with the pancake ice rather than being driven through the young pack by winds or currents. The buoys take meteorological, wave and precise position measurements. They have sloping sides to allow them to rise up and avoid being crushed between floes. The data are transmitted back to Dunstaffnage via the new Orbcomm satellite system.

In March 2000, Oli Peppe (Dunstaffnage Marine Laboratory) and Martin Doble (Scott Polar Research Institute) sailed from Capetown on the RV *Polarstern* to deploy six of these buoys in the pancake fields of the Weddell Sea.

After a frantic few weeks preparing the buoys for deployment, the first buoy slid down the stern ramp at dawn on 17th April. The data started pouring in to Dunstaffnage a few hours later. By December, five of the six buoys had completed transmissions — the critical period of ice growth and consolidation had been successfully monitored.

Already, analysis of the data is giving valuable information on both sea ice dynamics and on the performance of the new and relatively untested Orbcomm communications link.



Drifter buoy measuring the deformation of the young pancake ice and its response to wind and wave action in the Weddell Sea, Antarctica. © Oli Peppe, DML.

Oli Peppe (DML), Max Coon (North West Research Associates, Seattle) and Martin Doble (Scott Polar Research Institute, University of Cambridge) with a drifter buoy ready for deployment down the stern ramp of the R.V. Polarstern *in the Weddell Sea, Antarctica.*