OCEAN

Challenge

The Challenger Society for Marine Science

Volume 7, No. 2, 1997

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The Magazine of the Challenger Society for Marine Science

SCOPE AND AIMS

Ocean Challenge aims to keep its readers up to date with what is happening in oceanography in the UK and the rest of Europe. By covering the whole range of marine-related sciences in an accessible style it should be valuable both to specialist oceanographers who wish to broaden their knowledge of marine sciences, and to informed lay persons who are concerned about the oceanic environment.

***Ocean Challenge* is sent automatically to members of the Challenger Society.**
For more information about the Society, or for queries concerning individual subscriptions to *Ocean Challenge*, please contact the Executive Secretary of the Society at the address given on the inside back cover.

INDUSTRIAL CORPORATE MEMBERSHIP

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Acknowledgements
Going anticlockwise around the spiral, from smallest picure to largest, the images are: (1) A false-colour visible wave-band image based on *SPOT* data showing the mouth of the Gironde Estuary in western France and illustrating the distribution of suspended particulates. Image produced by Ian Robinson from UNESCO educational material provided by P. Castaing and J. Froidefond. (2) *EOSAT* image showing turbidity in the northern Adriatic off the coastal lowlands of Albania. The processed and enhanced image is by courtesy of the British Geological Survey. Reproduced by permission of the Director, BGS, NERC. All rights reserved. (3) Modelled mean lagrangian velocities and long-term trajectories in the Channel, from the EU MAST project Fluxmanche. Reproduced by courtesy of J.C. Salomon, Ifremer, Brest. (4) Part of a global image of sea-surface temperature observed by the Along-Track Scanning Radiometer (ATSR). The data have been extracted from the ASST CD-ROM produced by the Rutherford Appleton Laboratory. Image produced by Ian Robinson. (5) Sea-surface temperature in the North Sea during early summer, showing a coastal fringe of warmer water, derived from data obtained by the NOAA AVHRR sensor. Image produced by Ian Robinson. (6) *ERS-1* ATSR image showing sea-surface temperature of the western Channel. © Rutherford Appleton Laboratory/NERC/ESA/BNSC. The central globe was produced by Tom Van Sant, Geosphere Project, and made available through the Science Photo Library.

Forthcoming Events

Events in 1998

Designing and building dynamic coasts and wetlands: What are the implications for research and management? 20 January, University of London, SOAS, Russell Square. A one-day interactive workshop chaired by Prof John Pethick, Newcastle University Centre for Coastal Management, Dr Sian John, Posford Duvivier Environment, Dr Richard Leafe, English Nature. £95 *Contact* Bob Earle, +44-(0)1531-890415.

WOCE (Joint Challenger Society and Royal Meteorological Society). 21 January, Imperial College, London. *Contact* Trevor Guymer at Southampton Oceanography Centre. Email: T.Guymer@soc.soton.ac.uk

The History of Marine Meteorology (to commemorate the International Year of the Oceans 1998) (Joint Meeting of the Challenger Society and the History Group of the Royal Meteorological Society). 14 March, University of Bristol. *Contact* Malcolm Walker, Dept of Maritime Studies, University of Wales, Cardiff, PO Box 907, Cardiff, CF1 3YP; Tel. +44-(0)1222-874271; Email: walkerjm@ cardiff.ac.uk

Oceanology International 98: The Global Ocean 10–13 March, Brighton, UK (*see full-page advert opposite*).

Underwater Optics III (The Applied Optics Division Conference at Congress 98). 16 March, The Brighton Centre. Topics to include all light measurements, ocean colour, plankton identification and counting, laser-based velocimetry. optical sensors used underwater. There will be special session on underwater imaging. The keynote paper will be 'Light in the sea and ocean optics' by Dr J.T.O. Kirk. *Contact* Conferences Dept, The Institute of Physics, 76 Portland PLace, London W1N 3DH; Tel +44-(0)171-470-4800; Fax:+44-(0)171-470-4900; Email: congress@ iop.org Web site http//www.iop.org/IOP/Congress

Global Ecosystem Dynamics 17–20 March, Paris. *Contact* Michelle Lloyd, Plymouth Marine Laboratory; Tel. +44-(0)1752-633-100; Fax: +44-(0)1752-633-101; Email: mill@ wpo.nerc.ac.uk Web: http:// www1.npm.ac.uk/globec/

Magmatism and Mineralisation in Arcs and Ocean Basins (Symposium to be held as part of Geoscience 1998). 16–17 April, Keele University, Staffordshire. Magmatic arcs, back-arc basins and ocean ridges are regions of prolific volcanism and hydrothermal activity, and contain many types of globally important metal deposit. The meeting is aimed at industry as well as academics. *To receive further information on Geoscience '98 and registration details, contact:* Conference Department, The Geological Society, Burlington House, London, W1V 0JU, UK Tel: +44-(0)171-434-9944; Fax: +44-(0)171-439-8975; Email: harrison@geolsoc.org.uk; http:/ www.geolsoc.org.uk

Extreme Environments (Joint Challenger Society and the Marine Biological Association of the UK). 20–23 April, University of Plymouth. *Contacts* Peter Herring, Southampton Oceanography Centre, Email: P.Herring@soc.soton.ac.uk *and* Paul Tyler, Southampton University, Email: P.Tyler@soc.soton.ac.uk

Marine Environmental Education 24 April, Royal Museum of Scotland, Edinburgh. Convenors: SAMS, the Scottish Consultaitive Council for the Curriculum, Scottish Natural Heritage and the Scottish Environmental Protection Agency. *Contact* Pat Herd, Conference Officer, Centre for Scottish Public Policy, 20 Forth St, Edinburgh EH1 3LH; Tel. +44-(0)131-477-8219/8220; Fax: +44-(0)131-477-8221.

Sixth European Marine Microbiology Symposium, 17–21 May, Sitges, Catalonia, Spain. Contact Dolors Vaqué – 6th EMMS, Institut de Ciències del Mar – CSIC, P. Joan de Borbo s/n, E-08039 Barcelona, Spain; Tel. 343-221-6416; Fax: 343-221-7340; Email: emms@icm.csic.es Web: http://www.icm.csic.es/bio/emms/welcome.html

WOCE Conference 24–29 May, Halifax, Nova Scotia, Canada. *Contact* WOCE International Project Office; Email: woceipo@ soc.soton.ac.uk

Education and Training in Integrated Coastal Management: The Mediterranean Prospect 25–29 May, Genoa. *Contact* ICCOPS c/o The University of Genoa, Deaprtment Polis, Stradone di S. Agostino, 37-16123 Genoa, Italy; Fax +39-(10)209-5840; Web site: http:// www.polis.unige.it/1998 education

Coastal and Marginal Seas (Joint Challenger Society, Oceanography Society and IOC) 1–4 June, UNESCO Headquarters, Paris. Convenors: Kenneth Brinkand Katherine Richardson. *Contact* Judi Rhodes of The Oceanography Society; Email: jrhodes@ccpo.odu.edu *or* Web site: www.tos.org

Benthic Processes in the Arabian Sea: Biogeochemistry, Biodiversity and Ecology (Royal Society of Edinburgh, Scottish Association for Marine Science and the Challenger Society). 1–3 July, Edinburgh. Keynote lectures will address multidisciplinary studies on the oxygen minimum zone and the complex forcing dynamics of the monsoon cycle in relation to biogeochemistry, biodiversity and ecology of the benthic system, present and past. Convenor: John Gage. *For further details contact:* John Gage, SAMS; Email: J.Gage@ dml.ac.uk *or* Deep Arabian Sea, The Royal Society of Edinburgh, 22–24 George Street, Edinburgh EH2 2PQ; Tel. +44-(0)131-225-6057; Fax +44-(0)131-225-6277; Email: RSE@ rse.org.uk (For regular information see: http://www.nerc-oban.ac.uk/dml/meetings/)

International Conference on Satellites, Oceanography and Society (Expo 98). 17–21 August, Lisbon, Portugal. *Contact* David Halpern, Email: halpern@pacific.jpl.nasa.gov

UK Oceanography 98 7–11 Sept, Southampton. *Contact* Neil Wells, SOC. (*See full-page advert on p.8*).

33rd European Marine Biology Symposium, 1–7 September, Wilhelmshaven, Germany. *Contact* Tel. +49-4421-944-0; Fax +49 4421-944-199; Email: embs@ terramare.fhwilhelmshaven.de http://www.fh-wilhelmshaven.de/terramare/embs33.htm

LOIS RACS (Joint with the British Hydrological Society). 3rd week of September, Institute of Civil Engineers, London. *Contact* Des Walling, Exeter; Graham Leeks, IH; David Huntley, Plymouth.

Remember If you are organizing a conference or meeting on any aspect of oceanography, you can publicize it through *Ocean Challenge*. Details should be sent to the Editor at The Dept of Earth Sciences, The Open University, Milton Keynes, Bucks MK7 6AA, UK. Email: A.M.Colling@open.ac.uk

A MESSAGE FROM THE PRESIDENT OF THE CHALLENGER SOCIETY

21 December this year will mark the 125th anniversary of the departure of HMS *Challenger* from Portsmouth on its epic voyage, so this is an auspicious time for the Challenger Society to be reviewing its position. In this issue of *Ocean Challenge* we hope to stimulate you into reconsidering the role of the Society by presenting two perceptive articles: the first by Henry Maurice, written in 1945, on the prospects for the Challenger Society in the immediate post-war period (reproduced opposite), and the second by James Baker providing a contemporary view of the challenges facing marine scientists, from a US perspective (pp.29–31). How do these ideas project onto the current position of the Challenger Society for Marine Science in the UK and in Europe, and what messages do they have for our future?

Henry Maurice provided some useful pointers. We can identify strongly with his appeals for a committed interdisciplinary approach (with a special mention for marine biology) and for the persuasive and effective communication to the general public of the importance of marine science. Although the Nuclear Armageddon scenario in his final paragraph has mercifully been avoided (thus far), we are instead facing a more insidious and multi-faceted threat from global change and environmental degradation induced by human activity. The implications are nicely summarised by James Baker: 'In this new global context of integrated social, economic, and environmental security, the insights we gain through research will be a key to realizing sustainable development.' This moves marine science to an essential position at the centre of contemporary concerns for the future.

Next year, when the Society is celebrating its 95th birthday, we will be publishing an action plan *Challenger 2000* to be implemented as we move towards the new millenium. What should this strategy contain? How should we influence the many issues raised in James Baker's article (and others of importance, such as the significance and sensitivity of marine biodiversity)? What should our role be and how might we contribute most effectively to the development and application of marine science?

To begin to answer these questions, it is worth considering some quotations from the two articles.

First, from Henry Maurice:

'... if the Society sets itself to be a propoganda society, it should not merely preach the gospel, but should add to itself disciples who would also become preachers.'

'... the true vocation [of the Society is] to supply a link between the many workers in the field of study of "the sea and all that is therein".'

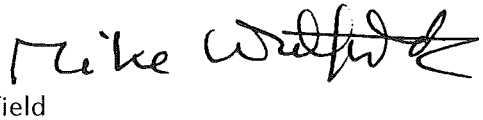
And from James Baker:

'The Challenger Society and similar organizations in Europe and the United States can play a critical role in encouraging their members to become involved in public policy discussions.'

'Organizations like the Challenger Society can help by examining the role of science in meeting the needs of society.'

These observations suggest that we need to function more actively as a professional organisation which pulls together the various strands of marine science in the UK, and in Europe, and expresses the significance of oceanography to a wider audience so that we can contribute more effectively to the debates on vital environmental issues.

How do you think we can best achieve this? Send me your proposals for the definition and implementation of the *Challenger 2000* strategy to ensure that the Society is playing a vital and active role in the promotion of marine science when it celebrates its centenary in 2003.



Mike Whitfield
President, Challenger Society for Marine Science
Email: miw@mba.ac.uk

THE

CHALLENGER SOCIETY

Founded
for the Promotion of the Study of Oceanography

WHERE THE SOCIETY STANDS

An address given to the society on October 24th, 1945

by HENRY G. MAURICE, C.B.

When Dr. Hindle delivered a message inviting me to address the Challenger Society, and to make suggestions, if I understood the message aright, as to the direction of its future activities, I drank deep of the cup of flattery and, pot-valiant, so to speak, I accepted the invitation.

With the morning came sobriety. I asked myself the question, "Who am I that I should advise oceanographers about their business?" I have not found a satisfactory answer to that question. But I can offer some excuses for my presumption.

Let me first recall a few relevant incidents in the history of the last forty-three years from which I hope my excuses may emerge. The Challenger Society was founded in the year 1903 for the promotion of the Science of Oceanography. I wonder what prompted the founders to take that step at that time? In the previous year the International Council for the Exploration of the Sea had been established, with its seat in Copenhagen. His Majesty's Government had become parties to this arrangement and committed to co-operation in international investigation of the sea, with, as was well understood, the emphasis on investigation of facts bearing upon the problems of the Fishing Industry.

One curious result of these new responsibilities of the Government was the transfer of the administration of Fisheries, or, rather, a part of the administration, from the Board of Trade, where it properly belonged, to the recently formed Board of Agriculture and Fisheries. On the face of it, that was an ill-advised move. The explanation of it which I believe to be the correct one is this: there must be a Government Department responsible for the Government's part in the international work. The Board of Trade, to whose Marine Department the Fisheries rightly belonged, was not equipped for scientific research. The new Board of Agriculture, established in 1889, was developing a research staff. Therefore, let Fisheries be transferred to that Board. I am not aware of any assistance given to the Fisheries Division by the scientific staff of the Agricultural side of the Board except, at the outset, in the matter of statistics.

In point of fact, the North Sea Investigations, as they were then called, were entrusted, in the first instance, to the competent hands of the Marine Biological Association.

Personally, I am grateful for the transfer which took place, inasmuch as, if it had not, I should not have strayed—for it amounted almost to that—into a field of work which became the absorbing interest of my life.

Whether there was any connection between the foundation of the Challenger Society and the developments to which I have referred, I do not know. Let us say that Oceanography was in the air and Dr. Fowler and his friends came under the influence of its climate.

I think it is clear, from the early history of the Society, that its founders conceived it as a Society of professional oceanographers - using the term Oceanography, in its widest and most correct connotation, to signify the study of "the sea and all that is therein." The original membership was strictly limited. The meetings were primarily "Scientific Meetings." The proceedings consisted almost entirely of the reading and discussing of scientific papers and the exhibition of apparatus of research. The publications were, I think, clearly intended for persons working in the field of Oceanography and, perhaps, for students, until, in 1912, that admirable work, "The Science of the Sea," was published—a work which seemed to be intended for a much wider public.

At the time, Edward Hindle was Scientific Director of the Zoological Society of London.

The Science of the Sea was 'an elementary handbook of practical oceanography', put together by the Challenger Society and edited by G. Herbert Fowler (a co-founder of the Society).

The Society should aim at bringing together not only the workers in the field of marine science, but the fishermen who ... are concerned with the life that is in the sea

I do not intend to follow the Society's activities throughout its history; but I am impelled to halt egotistically at the date 1912, because in that year I found myself, most unexpectedly, and very fearfully, in charge of the Fisheries Division of the Board of Agriculture and Fisheries, and, shortly after, I received from my old schoolfellow, Lucius Byrne, a copy of "The Science of the Sea" with a reminder of our early association in the Natural History Society of Marlborough College.

It was an anxious time for many reasons, but, perhaps especially because the Fisheries Division, having, before then, taken over the international work from the M.B.A. had, somehow, fallen foul of, as far as I could gather, the general body of workers in Marine Biology. It was, as I have said, an anxious time; but my way was smoothed by the kindly help of a committee of most distinguished men of science, about half of them, as well as I can remember, members of this Society. I became a disciple to the apostles of that part of the whole study of Oceanography which is Marine Biology, and I like to recall the debt of gratitude I owe to so many of them—too many of whom, alas! have passed away—for their patient help.

My next landmark in the history of the Society is 1922. The war was over. The Fisheries Division was, at last—or was in the way of becoming—adequately equipped with scientific staff and a ship; the relations of the Division with the M.B.A., as with the various other marine biological stations in Great Britain and the Isle of Man, were amicably settled; the International Council was in full swing again. E. J. Allen and the Admiralty Hydrographer joined its meetings whenever they could. We were all co-operating and the Challenger Society finally clinched the general co-operation by organising joint meetings of all the marine biologists, so that they got to know one another and one another's work more perfectly and were able to arrange it so that much of the work dovetailed into a comprehensive programme.

The second function, to uphold the claims of biology as an essential part of Oceanography, ought not to be necessary

I think that at that stage the Challenger Society found its true vocation, which was to supply a link between the many workers in the field of study of "the sea and all that is therein." It is hardly necessary to enumerate the stations at which the study of marine biology is pursued, but let us do so. The Marine Biological Association at Plymouth, the Scottish Marine Biological Station at Millport, the stations of the two Fishery Departments at Lowestoft and Aberdeen, devoted especially to economic investigations, and the various stations depending on Universities at Cullercoats, Hull, Aberystwyth, Port Erin and St. Andrews. I hope I have left none out. And, standing as a background to the activities of all these, the Department of the Admiralty Hydrographer and the Admiralty survey ships, and the Tidal Institute at Liverpool. To this long list we have now to add the Discovery Committee devoted to the exploration not only of the southern populations of whales, but of the whole ecology of the South Polar seas.

Where among all these does the Challenger Society stand? Where can it most usefully stand now, when once again we are confronted with the necessity of rebuilding the fabric which war has shattered?

The Challenger Society does not dispose of any considerable fund of money. Such money as it has had at its disposal has been well spent in its publications, in grants in aid of individual researchers and, I think, bursaries for poor students. It has long been recognised that publication of results is the necessary conclusion of research and that the cost of publication is, therefore, a normal part of the cost of research. A fully equipped research institution will normally have its own means of publication and there are, in addition, many reputable journals available for the publication of any worthwhile work. Thus there should seldom be occasion for grants in aid of publication from a private organisation, except, let us say, to assist some young researcher who is working independently along original lines and may have difficulty in securing recognition. For such occasions, and for special publications of its own, the Challenger Society will, no doubt, always keep funds available. But, on the whole, I believe it can most efficiently promote the study of Oceanography by the exercise of other functions.

These functions, as I conceive them, and, with great diffidence, suggest them as the basis of discussion, are three, and I place them in this order.

First, to continue the function it has so usefully exercised in the past, by acting as a liaison between the various existing institutions for the study of Marine Biology and the Fishing Industry.

Second, to uphold the claims of Biology as an essential part of Oceanography.

Third, to preach Oceanography—that is, to keep Oceanography as a Science vital to the existence of this island power firmly before the minds of the general public and the Government of the day.

I need not dwell for long *the first of these functions.* It has been exercised in the past to the great satisfaction of, certainly, the workers concerned. I believe it has been a great help to those workers to take them, or some of them, periodically, out of the comparative isolation of their respective stations, to bring them together and give them an opportunity of exchanging ideas, of arguing, even of quarrelling if they have that temperament. It is terribly easy to become one-idea'd when working continually in the same limited company and

with the same limited scope, and oral exchange of ideas is more stimulating than the most thorough study of current scientific literature.

But there is a second aspect of this function which I wish specially to emphasise. The Society should aim at bringing together not only the workers in the field of marine science, but the fishermen who, most particularly, are concerned with the life that is in the sea. I feel that the more often the joint meetings which I have in mind are held in fishing ports the better, and I suggest that, whenever they are so held, the endeavour should be made to have at least one popular lecture which the fishermen of the port would be invited to atend, a lecture which would explain to them something of the bearing of marine research on their industry, of the chain of life which makes up the marine ecology, of the effect on this chain of physical and chemical conditions, of the necessity, in short, of understanding the whole before you can interpret the part. If their interest can be engaged, the fishermen can help the marine biologist in many ways, and the fisherman, if he understands what it is all about, will accept those controls which are essential to the well-being of the industry, and will help to make them effective.

The same opportunity could be taken to explain to them the necessity of international co-operation in research and of international regulations based upon its conclusions. I think I need hardly argue in this room the importance of maintaining international co-operation such as has been secured through the International Council for the Exploration of the Sea, but it is of the utmost importance that the fisherman, and, perhaps, even more particularly, the owners of fishing vessels should appreciate its value and its necessity.

The second function, to uphold the claims of biology as an essential part of Oceanography, ought not to be necessary. But, in fact, I think it may be. I imagine that all of you are aware of the existence of the National Committee for Geodesy and Geophysics, and of an Oceanographical Sub-Committee appointed by it. You are probably aware, also, that the attention of the Sub-Committee has been largely concentrated on the question of the establishment in this country of an Institute of Oceanography. As there is no country in the world to which Oceanography is more important than it is to this island and to the British Empire and the British Commonwealth of nations, it will surely be generally accepted that we should have an Oceanographic Institute comparable with any in the world—even in the dollarcratic United States of America. And let us not forget that the importance of the subject is enhanced rather than diminished by the advent of the aeroplane and air-transport, which has increased the necessity for accurate meteorological information, to which Oceanography can make so valuable a contribution.

But there is a tendency to speak not of an Institute of Oceanography, but of an Institute of Physical Oceanography. That, surely, would be a one-eyed sort of institution. We are, for one thing, the greatest fishing nation in the world. Are we to leave out of our Institute of Oceanography the living organisms whose life is so largely governed by the physical conditions, and which, if I am not mistaken, themselves play an essential part in, at least, the chemistry of the sea? The physicists and the chemists—for whom, I hasten to say, I have every respect—are apt to forget that, in the matter of the exploration of the sea, the biologists often gave them a lead. I think it is no serious exaggeration to say that, leaving on one side cartography, the mapping of rocks, reefs, shoals, depths and currents, and the recording of the tidal movements of oceans and seas, the biologists were first in the field of physical and chemical Oceanography.

I remember that, shortly after I became responsible for the Fisheries Administration of the Board of Agriculture and Fisheries, we received an indignant communication from the Admiralty Hydrographer. He had learned that we named a member of our then very meagre scientific staff "the Hydrographer." There was, said the Admiralty Hydrographer, but one Hydrographer in the United Kingdom and he was it. It seemed clear that he was using the term hydrography in its narrow cartographical sense. Our man was, in fact, a chemist. I never quarrel if I can help it, so we changed his title, if I remember rightly, to Scientific Superintendent for Hydrography. It would have been much simpler and more apt to have called him Hydrologist, but that word had not at that time entered my vocabulary.

We had a friendly revenge not long after. We were are war with Germany. The Admiralty found themselves in trouble because of their lack of knowledge of the specific gravity of the water in certain areas and the differences of specific gravity were disconcerting to our submarines. They asked us whether we could help. We could and they were grateful. In a different direction the Challenger Society itself was able to help the Navy. From 1915 to the end of the war, according to my recollection, Dr. Fowler, on behalf of the Society, organised and controlled the examination of deep-sea deposits, knowledge of which was also important to the Commanders of submarines, and became, for that period, practically a full-time worker on the Admiralty staff. Let me add that relations between the Fisheries Department and the Admiralty had already become most cordial and have remained so ever since. I recall these incidents merely to point out that many of the studies which are now a recognised part of physical Oceanography were first undertaken or promoted by the biologists as a necessary part of their work because life in the sea, as out of it, is so profoundly influenced by physical environment.

I think that ... the Challenger Society found its true vocation, which was to supply a link between the many workers in the field of study of "the sea and all that is therein"

Every marine biologist will admit that he cannot get on without the help of a physicist ...

Every marine biologist will admit that he cannot get on without the help of a physicist. Whether the physicist can get on without the biologist is a moot point, but I think it will be generally agreed that biological phenomena in the sea may often be indicators of physical conditions and, thereby, put the physicists more quickly on the right track than they could have found it without such aid.

In either case, the bearing of the two studies on one another is so intimate that it would be folly to establish an Oceanographical Institute which took no account of biology. How biology is to be represented and what part it is to play in the work of the Institute must depend largely on the eventual plan of the functions of the Institute as a whole. I will only say here that my conception of an Oceanographical Institute for this country is that, while, on the one hand, it would, by means of its own ships and staff carry out investigations of waters near and far—more especially distant waters—taking all the oceans and seas within its purview, it would, at the same time, become a focus of all the various oceanographical work pursued in the country and provide facilities for workers and students both on land and in its ocean-going ships. And I think the Challenger Society should use its influence to secure that those facilities are extended to marine biologists and that biology should be adequately represented on the staff of the Institute itself, if ever it comes to fruition.

The third function ... is what may perhaps be called popularising Oceanography

The third function I have suggested is what may perhaps be called popularising Oceanography, bringing home to the people and Government of this country how closely their welfare is bound up in the seas which cover so preponderant a part of the surface of the globe, how fertile those seas are and how important it is, therefore, that we should learn more and more about them. I suggest, in short, that this Society might well play in relation to the promotion of Oceanography a part analogous to that played by the Navy League in relation to the maintenance of our strength at sea.

I recognise the difficulties expressed by Mr. F .S. Russell at our last meeting about opening the doors of the Society to all who care to join it, subject, of course, to proposal and election, so as to exclude the undesirable. But I cannot help thinking that this is a likely road to the end we have in view. I think we need propaganda, and that, if the Society sets itself to be a propaganda society, it should not merely preach the gospel, but should add to itself disciples who would also become preachers. There is, I recognise, one danger, namely, that if the Society ceases to be a body of scientific eminence, it may lose some of its influence with the institutions already established. But it would not, I think, be difficult to frame rules by which the business of the Society, and particularly its scientific activities, were controlled by an Executive Committee of recognised scientific status. If that one difficulty were overcome, I think that, without prejudice to the status of the Society, it might be possible to attract to it such a number of members at a comparatively low rate of subscription, that we could afford to pay a Secretary and have an office—conceivably, by arrangement with the Oceanographical Institute, if it comes into being, under its roof—and publish a Journal, and organise lectures on the Science of the Sea for intelligent laymen.

Is this all too ambitious and too fantastic? I do not know. But here we are and we are asking ourselves the question how we can be most useful. The question itself presumes the importance of the subject not simply as a subject of great interest to the curious, but as one of vital importance to the nation.

I have not mentioned the atomic bomb, because, if we are to retain our sanity we must assume that that man-devised curse will, somehow, be controlled. But let me indulge in a flight of hideous fancy. Let us suppose that the criminal lunatics of the world—they are many—get the upper hand. Might it not be that the only chance of survival of the human race would lie with those who take to the sea in ships which, madly zigzagging, avoid destruction and maintain life by what food they can carry with them or capture from the sea until the lunatics have destroyed the rest of the race, themselves included, and the ocean-borne remnant return to build up a new civilisation in which the study of biology takes its proper place, and the physicists, in firm alliance with the biologists, proclaim and enforce the outlawry of destructive agencies, and devote themselves to measures of construction and conservation.

... if the Society sets itself to be a propaganda society, it should not merely preach the gospel, but should add to itself disciples who would also become preachers

Henry Gascoigne Maurice, 1874–1950

Maurice was educated at Marlborough College, where his father was the school doctor, and then read classics at Oxford. He was called to the bar in 1904 and subsequently joined the staff of the Board (later Ministry) of Education. There he became private secretary to the president, Walter Runciman, and accompanied him when he was moved to the Board of Agriculture and Fisheries. In 1912, Runciman appointed Maurice Assistant Secretary in charge of fisheries. He remained at the head of that division as Fisheries Secretary until he retired in 1938.

Though not a scientist, Maurice had a lifelong interest in natural history. He was a keen angler, and active in measures for nature conservation. In retirement, he became Secretary of the Society for the Preservation of the Fauna of the Empire, and he served as President of the Zoological Society from 1942 to 1948. These interests dated back to early youth, when he was a member of the Natural History Society at Marlborough. As he mentioned in his 1945 talk, a fellow member of that society was Lucius Byrne. Their paths converged again at Lincoln's Inn. Byrne was an amateur marine zoologist; he had joined the Marine Biological Association in 1897, and was one of the founder members of the Challenger Society in 1903. He sent Maurice a copy of *The Science of the Sea*, the handbook which the society had recently published, under the editorship of its secretary G. Herbert Fowler. Maurice himself became a member of the Challenger Society in 1916.

Reading *Science of the Sea* encouraged Maurice to take a broader approach towards fisheries science than had been usual up till then. He took steps to repair the damaging rift between the Board and the Marine Biological Association, on whose council he served. He backed the Development Commission in its inter-war policy of expanding the work of the marine and freshwater laboratories, which had hitherto been starved of funds. This made possible, for example, the collaboration between Marshall and Orr at Millport, and the important work on marine productivity at the Plymouth Laboratory in the 1920s and '30s.

Maurice was an enlightened and respected administrator, whose talents were internationally recognized. He was President of the International Council for the Exploration of the Sea from 1920 to 1938. During these years he sought to address the problems of overfishing, by international co-operation and control, resulting in the London Conference of 1937 on overfishing and the Whaling Conferences of 1937 and 1938 which established a basis for future progress. He was made Président d'Honneur of ICES on retirement. He died in 1950.

Margaret Deacon
Southampton Oceanography Centre

More information can be found in the following:

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Hindle, E. (1950) Obituaries: Mr Henry G. Maurice, C. B., *Nature*, **165**, 997–8.

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Mills, E.L. (1989) *Biological oceanography: an early history, 1870–1960* Cornell University Press.

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Forthcoming Events

Events in 1997

Ocean Exploitation Tomorrow – will it be sustainable? (Joint meeting of the Deutsche Gesellschaft für Meeresforschung and the Challenger Society). 10–11 October, Geomatikum, Bundesstrasse 55, 20146 Hamburg, Germany. In the spirit of improved collaboration between European oceanographic societies, the DGM and the Challenger Society have organised this common symposium on the future perspectives of marine research. The symposium will deal with potentials and hopes, but also concerns, such as research funding and research vessel development. *Contact urgently by* Fax 0049-40-4123-5235 *or by* Email: dgm@dkrz.de

Coastal Environmental Management and Conservation (Bordomer 97) 27–29 October, Bordeaux. *Contact* M. De Loof, Ifremer, 155 rue J.-J.-Rousseau. 92138 Issy-les-Moulineaux Cedex, France

Carbon Dioxide in the Ocean–Atmosphere System: 200 years of Progress (Joint Meeting of the Challenger Society and the Royal Meteorological Society's History Group). 8 November, John Houghton Lecture Theatre, Meteorological Office, Bracknell. Talks include: Peter Cox: An overview of the developments of understanding of the global carbon cycle since the 18th century; D. Thorburn Burns: Progress in techniques for measuring the concentration of CO_2 in the contemporary and past atmospheres; Patrick Holligan: Sources and sinks: understanding the role of the ocean; Andrew Friend: Disentangling the distribution and magnitude of terrestrial sources and sinks; F.B. Mudge: Understanding the role of CO_2 in global climate; Simon Shackley: Convincing politicians that CO_2 is important for more than tonic water! *Contact* Maurice Crewe, National Meteorological Library, Met. Office, London Rd, Bracknell, Berks, RG2 2SZ.

The Role of Iron in the Marine Environment (Challenger Society Meeting). 5 December, London. *Contact* Prof. Andrew J. Watson, Tel. +44-(0)1603-593761 (direct) or +44-(0)1603-456161 (switchboard); Fax: +44-(0)1603-507719; Email: a.watson@uea.ac.uk *or* a.j.watson@uea.ac.uk; *or* http://www.uea.ac.uk/~ajw/ajw.htm

American Geophysical Union Fall Meeting 8–12 Dec., San Francisco, CA. Email: meetinginfo@kosmos.agu.org

Events in 1998

North-East Atlantic Liaison Group, followed by **Marine Forum Meeting** (on topical issues including hormone mimics and small cetaceans). 16 January, Council Room, The Linnean Society, Burlington House. Piccadilly, London. *Contact* The Marine Forum, University College of Scarborough, YO11 3AZ; Tel. +44-(0)1723-362392; Fax: +44-(0)1723-370815; Email: marforum@ucscarb.ac.uk

WOCE (Joint Challenger Society and Royal Meteorological Society). 21 January, Imperial College, London. *Contact* Trevor Guymer at Southampton Oceanography Centre. Email: T.Guymer@soc.soton.ac.uk

The History of Marine Meteorology (to commemorate the International Year of the Ocean 1998) (Joint Meeting of the Challenger Society and the History Group of the Royal Meteorological Society). 14 March, Bristol. *Contact* Malcolm Walker, Dept of Maritime Studies, University of Wales, Cardiff, PO Box 907, Cardiff, CF1 3YP; Tel. 01222-874271; Email walkerjm@ cardiff.ac.uk

Extreme Environments (Joint Challenger Society and the Marine Biological Association of the UK). 20–23 April, University of Plymouth. *Contacts* Peter Herring, Southampton Oceanography Centre, Email: P.Herring@soc.soton.ac.uk *and* Paul Tyler, Southampton University, Email: P.Tyler@soc.soton.ac.uk

WOCE Conference 24–29 May, Halifax, Nova Scotia, Canada. *Contact* WOCE International Project Office; Email: woceipo@soc.soton.ac.uk

International Conference on Satellites, Oceanography and Society (Expo 98). 17–21 August, Lisbon, Portugal. *Contact* David Halpern, Email: halpern@pacific.jpl.nasa.gov

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Remember If you are organizing a conference or meeting on any aspect of oceanography, you can publicize it through *Ocean Challenge.* Details should be sent to the Editor at The Dept of Earth Sciences, The Open University, Milton Keynes, Bucks MK7 6AA, UK Email: A.M.Colling@open.ac.uk

A New Initiative: Project Darwin 2000

The primary aim of this ambitious project is to build and equip a 70-foot Sailing Research Vessel that will provide a facility for global environmental research, as a cost-effective alternative to expensive conventional research vessels powered by fossil fuel.

The vessel will be available to small teams of researchers to make extended ocean cruises at relatively low cost, as well as to educational institutions to expand their shore-based curricula with hands-on experience at sea.

The Project will be based in the South West of Britain, but the opportunity to use the vessel for research and educational purposes will be available to students from colleges and universities throughout the world.

Funding for Project Darwin 2000 is being sought both from grant-awarding bodies and from private sector sponsorship. It is intended that the Project have a charitable status, and be managed by a Board of Trustees.

For more information, and expressions of interest, please contact:

Ray Staines, Director
Project Darwin 2000
Carrick Business Centre
Beacon House
Commercial Rd
Penryn
Cornwall
TR10 8AR

Tel. +44-(0)1326-378737
Fax: +44-(0)1326-378643

Further details will also be included in the next issue of *Ocean Challenge.*

News and Views

UK ratifies UNCLOS

At the end of July, Britain's new Labour Government announced that it had decided to ratify the United Nations Convention on the Law of the Sea (UNCLOS). As recently as April, the previous Conservative Government had issued licences to oil companies to prospect for oil and gas in the Rockall Trough and nearby shelf areas (the so-called Atlantic Frontier). Greenpeace landed a small party on Rockall in June, as a protest against the issue of those licences, but the UNCLOS ratification must have taken most of the wind out of their sails – indeed, their occupation ended in late July.

Under UNCLOS rules, much of the area in which the licences were granted became 'high seas', i.e. international waters over which Britain is not entitled to claim jurisdiction – and hence cannot issue licences for anything. Negotiations by interested parties to explore for hydrocarbons must now shift to the international arena.

Britain annexed Rockall in 1955 and used this to justify setting up a 200 nautical mile (n.m.) exclusive fishing zone and subsequently allowing exploration for oil and gas. None of this was strictly legal in international law, however, because Rockall is an uninhabited islet with no economic life of its own. Britain could legally claim only a 12 n.m. territorial sea around it, but managed to get away with the larger claim despite counterclaims by Ireland, Iceland and even Denmark.

Now, having ratified UNCLOS Britain can legally claim an EEZ that extends 200 nautical miles from the Outer Hebrides, which does actually include Rockall and part of the northern Rockall Trough – but some 60 000 square miles of ocean have effectively become high seas, open to all. That includes international fishing fleets, which can now move into water previously available only to fishermen from EC countries (as a member state, Britain could hardly keep them out). It is an interesting development: Greenpeace was protesting against what it called the 'industrialization of the north-east Atlantic', and is reported to have welcomed the Government's decision. But if there is oil in the Rockall Trough, the oil companies will get it, probably sooner rather than later; and there could also be a damaging international free-for-all among the fish stocks.

Men who helped to change the course of Science

Jacques Cousteau and H.H. Lamb

These two great men both died in June. Though each in his own way made enormous contributions to marine and atmospheric science, only Cousteau was a household name; appreciation of Lamb's achievement was largely confined to the circle of fellow workers in the field of meteorology and climatology. Both men were pioneers. Cousteau invented and developed much of the technology that permitted the astonishing range and variety and clarity of underwater filming which has excited millions of TV viewers worldwide since the 1950s. How many oceanographers owe their careers to an early conversion experienced upon watching one of his productions? Lamb was a pioneer of climatic (as distinct from simply meteorological) research, and he built up UEA's Climate Research Unit into a world-class scientific institution, from what was by all accounts a somewhat moribund base. It is probably no coincidence that when the issue of anthropogenic influences on global climate hits the headlines, as often as not it is a member of the Unit from UEA we see on our TV screens.

In their different ways, both men had their bruising encounters with politicians and bureaucrats. Cousteau, for all the public and official plaudits he received, was savage in his denunciation of the military–industrial complex for its obsessive secrecy about developments in underwater technology, and he campaigned tirelessly against nuclear testing and other forms of despoliation of the global (and especially marine) environment. Lamb experienced the kinds of obstructionism that many innovative scientists encounter, especially in his earlier days when climatology and the science of climate change were still relatively new. Lamb's attempts to secure funding for his research were, it is said, 'repeatedly and shamefullly ignored', in spite of the fact that his work was considered of prime importance by other scientists in the field – he was simply ahead of his time and suffered for it.

The contributions of both men are firmly embedded in the corpus of modern scientific and technological knowledge. Unfortunately, the obsessive secrecy and bureaucracy that plagued each of them in different ways has not been noticeably dented by their efforts.

'Drum' Matthews

Dr Drummond (Drum) Matthews FRS, marine geologist of distinction, died on 19 July of a heart attack. After early work with the Falkland Islands Dependencies Survey (now the British Antarctic Survey), he gained a PhD at Cambridge under Maurice Hill, working on an enormous haul of basalt from Swallow Bank in the deep eastern Atlantic. He became closely involved with the problems of understanding mid-ocean ridges, and is especially remembered for his contribution to the interpretation of magnetic anomalies as the 'tape recorder' of sea-floor spreading, set out in the seminal Vine and Matthews paper of 1963.

Nearly as important, though less well remembered, was his work with Jenny Lort that showed that the seismic layering of the ocean crust was a function of the cracking of the rocks, rather than of mineralogy or petrology. He organized numerous successful deep ocean marine geophysical and geological cruises, and supervised many who have become leaders in the field. Later he became identified with the BIRPS deep reflection profiling project, and with the new insights it generated into the structure of the deep continental crust and upper mantle.

The name BIRPS illustrates his quirky and often whimsical sense of humour – there have been many other instances, such as the naming of a companion to the Peake Deep as – what else – the Freen Deep. He was a fascinating and stimulating individual.

Editors' Note We at the Open University have warm memories of Drum as one of the external examiners during the early years of the OU Oceanography course. Modestly claiming that he hadn't earned his examiner's fee, he donated it as a prize for the best student of the year, and so initiated the annual award since renamed as the Challenger Society Prize.

Our thanks go to Joe Cann for the above appreciation.

Irish Sea Safe(r) from Nuclear Attack?

It was almot bound to happen, wasn't it? In March, the then Environment Secretary (John Gummer, in case you'd forgotten) rejected plans by Nirex to store nuclear waste in a rock repository beneath Sellafield. Nirex had spent about £300 million trying to demonstrate that the ultimately (almost self-evidently) impossible was in fact feasible.

There is a sandstone aquifer below Sellafield, itself underlain by older and highly fractured (and therefore permeable) crystalline rocks that are in direct hydraulic connection both with the aquifer above and with the Lake District to the east (indeed they are part of the so-called Borrowdale Volcanics, which form much of the Lake District). The regional pattern of groundwater flow is westwards, towards the Irish Sea, rising towards the surface near the coast, as it 'floats' over the denser salt-water wedge that characterises all coast-lines. Rain falling in the Lake District percolates through the Borrowdale Volcanics, and some of it must find its way towards the surface, via the sandstone aquifer, if only because of the effect of the denser saline intru-sion at the coast.

The nuclear repository was to be built in the Borrowdale Volanics, below the aquifer just east of Sellafield itself. It is hard to see how anyone could guarantee that groundwater would never (or at least not for several thousands of years) get into the repository, corrode the containers and carry radioactive elements in solution into the Irish Sea, in part via the aquifer itself.

As long ago as 1994, a Royal Society report expressed reservations about the project, not least because the scientists and engineers considered the geological setting unsuitable. In fact, the geology was to some extent irrelevant. Sellafield was the only *politically* acceptable location, because for decades Britain's princi-pal nuclear reprocessing facility has been there.

So now what? This repository was to be only for intermediate to low-level wastes, which still have no final resting place. The question of what to do with the much more lethal (though mercifully less voluminous) high-level wastes likewise remains unanswered. And each year there is more and more of all these wastes. Meanwhile, in the USA they propose to go back to underground storage of intermediate and low-level nuclear wastes in abandoned salt mines, a scheme they abandoned some twenty years ago. Geologically, it is not a bad idea, but when proposed in Britain a few years ago, vociferous public opposition soon put a stop to it.

At all events, it seems that for the present the Irish Sea is not likely to accumulate any more radioactivity than it presently receives. This may not mean much in light of recent press reports that levels of radioac-tivity in shellfish near Sellafield have increased by an order of magnitude or more since 1993. The principal culprit seems to be the artificial isotope technetium-99, with a half-life of some 10^5 years, and it is alleged that the contamination is spreading throughout the Irish Sea.

Of additional interest to Irish Sea watchers are recent revelations that a quantity of low-level radioactive waste had also found its way into the Beaufort Dyke, along with those war-surplus munitions and chemi-cals (*Ocean Challenge*, Vol. 6, No.2, p.14). No detectable radiation has so far been recorded from these wastes, which is not altogether surprising: most people would not expect any radiation to be detected from dumps of brazil nuts or coffee beans either, yet if these substances were produced in nuclear plants, they would be classified as low-level radioactive wastes.

Readers may recall the article by David Assinder in Vol.1 of *Ocean Challenge* (No. 3, Autumn/Winter 1990), reporting that the Irish Sea is 'not the most radioactive sea in the world'. We hope to have a follow-up article in a forthcoming issue, to set these recent events in a proper context.

Meanwhile, there has been some concern about radiation levels in coastal waters off north-west France, where the Cap La Hague reprocess-ing plant is situated. So far, there has been no evidence enabling us to judge if such concerns are justified, let alone whether levels are compa-rable with those in the Irish Sea.

Postscript

The Irish Sea may have had a reprieve, but the problem of nuclear waste disposal will continue to grow daily. For how long? There is a chance that within a few decades nuclear waste will have become a non-issue. All you need to do is package your nuclear waste to make a reactor core, at which you then fire protons from a cyclotron. The radionuclides in the core are literally broken down into (relatively) harmless elements, generating heat to raise steam (via a heat exchanger) which drives turbines. This is much safer than conventional nuclear power, since system failure means only that the proton beam is cut off and the plant simply cools down. All this is the brainchild of Carol Rubbia, the boss of CERN in Geneva. It is brilliant in principle, but there may be a catch or two.

First, how much of the power output from the turbines will be needed to power the proton-firing cyclotron? Second, temperatures will be rather high, and molten lead will be circulat-ing in the system, which could pose technical difficulties, even though it has been used in the reactors of Russian submarines. Third, it is not clear whether this technique disposes only of high-level wastes, notably the plutonium produced in conventional reactors, or whether it can handle other radioactive by-products too. These include radioactive isotopes of elements like caesium, strontium, iodine and zirconium, as well as of gases like krypton. Finally, how easy would it be to round up and package nuclear waste from all over the world? Development of even a prototype could be some years away, not least because somebody will have to fund it. If this is such a great idea, why has it not been more widely reported?

While on this subject, it does seem a pity that research into deep-sea disposal of nuclear wastes into the turbidite sequences of continental rises and abyssal plains was termi-nated so abruptly a decade ago (some readers may remember the work by scientists at IOS (as it then was) on the Madeira Abyssal Plain). Given the low permeability of the sediments and the abundance of redox fronts in them, radionuclides should not be able to travel very far – should they? And even if they were heated by radioactive decay processes, setting up mini-hydrothermal circulation systems, how radioactive would the resulting 'vent solutions' really be? In any case, in the deep oceans, natural communication systems between surface and sea-bed are very efficient going down, but much less so going up. It could take hundreds of years for radio-isotopes to get back to near-surface food chains, by which time concentrations would be significantly reduced both by radioactive decay and by dilution.

'White' Submarine Update

In *Ocean Challenge* a few years ago (Vol.5, No.1, p.15), we mentioned proposals to use decommissioned nuclear submarines as research vessels, proposals driven by US scientists using US Navy nuclear submarines. The detailed case for converting at least one such vessel for civilian research use has been published by the University–National Oceanographic Laboratory System (UNOLS) in a glossy 90-page report (see end for full details).

Using submarines for oceanographic research is not new, of course. The gravity surveys by Vening Meinesz aboard Dutch submarines in the 1920s are perhaps the best known, and Hess and Ewing did similar work using US submarines in the 1930s. In the same decade, Sverdrup participated in an Arctic expedition aboard a decommissioned and converted US Navy submarine.

The Cold War period following the Second World War was a time of very restricted access of academic scientists to US fleet submarines for basic research. But with the advent of *glasnost* in the late 1980s, and the subsequent break-up of the Soviet Union, there was renewed interest in acquiring a US Navy fast-attack nuclear submarine dedicated to basic unclassified civilian academic research.

The first cruise of a US Navy nuclear submarine dedicated to such research commenced in August 1993 when USS *Pargo* departed for a 38-day cruise, including 17 days under the Arctic ice, with a civilian scientific party of five. Although *Pargo* retained her military capability (which put constraints on the installation of civilian instruments) as a 'proof-of-concept' this cruise was highly successful. Scientists wanted more.

A 'Submarine Arctic Science Program' was established and in September 1994 a meeting was held at the American Geophysical Union headquarters, Washington DC, to develop the 'white' submarine concept: a non-combatant ship adapted for unclassified research in earth, ocean and atmospheric sciences. Sponsoring agencies included the National Science Foundation, the US Geological Survey, the National Oceanographic and Atmospheric Administration, and UNOLS.

The report summarizes the results of that meeting and recommends a strategy for acquiring and outfitting a nuclear submarine for research.

Between the time of the meeting and publication of the report, there was another very successful Arctic expedition, by USS *Cavalla*, in 1995.

Similar cruises of several weeks' duration each year are part of a multi-agency US programme which will end in the year 2000, and three years later the last of the Sturgeon class submarines will be decommissioned (this class is especially configured for prolonged under-ice operations). Thus, there is only a narrow and closing window of opportunity for acquiring and converting one of these submarines for scientific research before they are gone. Of the several Sturgeon class ships that still have useful life remaining, one could be operated as a non-combatant support vessel.

Why a nuclear submarine as a research vessel?

Nuclear submarines have capabilities that are superior to those of conventional surface research vessels. When submerged, they operate at about twice the speed of surface ships (up to 25 kt), they have an endurance of up to 90 days, they are unaffected by surface conditions such as ice-cover or high sea-state, they can maintain depth (to as great as 240 m) more precisely than surface-deployed instruments, and they are acoustically extremely quiet.

Two recent scientific cruises of US Navy submarines under the Arctic pack-ice have demonstrated the suitability of such a vessel as a research tool. For example, on an expedition in 1993 the speed and endurance of USS *Pargo* were used to make a near-synoptic map of the subsurface temperature distribution in the Arctic across a wide area. It was found that warm Atlantic waters have recently intruded into the Amerasian Basin, significantly warming that region (although the reason for this is not known).

Two types of problems justify using a nuclear submarine as a research vessel:

- Working under polar ice, where a submarine can move more quickly and (if the water is deep enough) more easily than a surface research ship on the open ocean.
- Working in very bad weather, where a surface ship cannot operate efficiently, or cannot operate at all.

Why now? There is considerable historical precedence for scientific use of surplus military hardware. Just as the end of Second World War made available a number of surplus naval vessels and aircraft that were useful research platforms for many years, so the end of the Cold War provides a single opportunity to acquire a 'surplus' nuclear submarine for basic research. Nuclear submarines have a 30-year useful life and many are being decommissioned early. As more Sturgeon class submarines face early retirement, many American oceanographers want to take advantage of this once-in-a-lifetime opportunity.

The cost of converting a nuclear submarine for civilian use is estimated to be in the order of between $50 million and $200 million, depending on the nature and extent of the modifications. It is envisaged that a large proportion of the costs of running and maintaining the 'white' submarine would be borne by the US Navy, who would also provide a crew to operate the vessel. In short, the submarine would be a fully fledged US Navy vessel entirely removed from combat duties and dedicated solely to civilian scientific research – plainly a good use of taxpayers' money – and at the same time the Navy could gain some kudos by publicising such a venture and demonstrating its environmental credentials.

As suggested above, the most obvious use of a nuclear submarine is in the Arctic Ocean. For the first time since the development of nuclear submarines in the 1950s there is an international political climate that suggests a systematic research and survey programme in the Arctic might find widespread support from nations bordering that ocean. The report suggests that 'perhaps one way of ensuring widespread government support for using nuclear submarines as research platforms would be to mount an international programme where other nations, as well as the US, might contribute. Both the UK and Russia have nuclear submarines that might become part of a cooperative venture, and making the programme international should make it easier to gain access to the entire Arctic Ocean.

Should the UK join the US and enlist Russian support and cooperation to set up a truly international Submarine Arctic Science Programme? Or should UK oceanographers lobby for a British nuclear submarine to be converted to research use? It does not have to be deployed only in Arctic waters, as such vessels can be used at

any latitude, and they have the unique capability to escape storms by simply submerging.

Lack of funds for maintenance and repair means that the Russian nuclear submarine fleet (or rather the rusting remains of that fleet) has been abandoned at various locations along Russian's Arctic shores. Little help in such a research venture can be expected from that quarter. Our own situation is more promising. Britain has more than ten nuclear submarines in various stages of decommissioning (including four Polaris class) at Rosyth in Scotland and Devonport, Plymouth. The chances of converting to anything but scrap are remote. However, there are two Tridents out there patrolling the oceans, another is scheduled to join them in 1998, and a fourth by the turn of the century. Does the Navy really need all those submarines? Might it be more cost-effective to convert one of them for oceanographic research?

The UNLOLS Report contains the revealing sentence: 'With the bold program of investigations proposed here, *the US could for the first time* [our italics] become the world leader in Arctic research.' Britain is already an acknowledged leader in this field. Is this a promising way to maintain that lead?

The report referred to is: *A nuclear-powered submarine dedicated ro earth, ocean and atmospheric research: a report from workshop participants on using a nuclear submarine as a research vessel* (1996) Report published by the US University–National Oceanographic Laboratory System. 90pp. *For more about UNOLS see the end of the next item.*

Revamp for *Alvin* and *Atlantis*

The deep submergence vessel *Alvin* has completed a major overhaul and upgrade and is now operational again. The design improvements are a result of consultations between the DEep Submergence Science Committee (DESSC) and *Alvin*'s operator, Woods Hole Oceanographic Institution (WHOI). The work on *Alvin* was undertaken in conjunction with that on a new RV *Atlantis*, which had a design change in mid-construction to allow it to be *Alvin*'s support ship (so replacing the old *Atlantis II*).

WHOI arranged for *Alvin* and *Atlantis* to call at Washington *en route* to *Alvin*'s recertification dives, and it is thought that the visit had a marked positive impact on US policy-makers. After successful recertification off Bermuda, *Atlantis* and *Alvin* headed for the Mid-Atlantic Ridge, where two successful dives were completed, with about five hours of bottom time. One was in cooperation with UK BRIDGE scientists, and focussed on sampling the biota from all known Mid-Atlantic Ridge sites for genetic studies.The other involved filming of a new BBC series (due out in Easter 1998).

Atlantis and *Alvin* will be very busy. They headed first for the eastern Pacific to work off the coast of California and the Juan de Fuca Ridge. Many scientist have been waiting anxiously for more than a year to use *Atlantis* and *Alvin* (and the remotely operated vehicle *Jason*), on programmes that have been funded over the past two years. In the US, there is so much funded marine science that arranging a schedule has been difficult.

This information comes by courtesy of the current issue (Summer 1997) of *UNOLS News*: Vol. 14, No. 2. The UNOLS WorldWideWeb home page site is: http://www.gso.uri.edu/unols/unols.html

Ancient Wreck at Bagouche

The remnants of cargo from a wrecked ship apparently dating back to Greco-Roman times lie at the bottom of a small bay at Bagouche, 260 km west of Alexandria. In Roman times, there were grainfields and vineyards along this coast, water for irrigation being provided by rainwater stored in cisterns dug into the rock.

The bay, which served as a small port for the region, is about 1 km long, 150–200 m wide and 4–6 m deep, and is protected by two rows of rocks extending seawards between the two headlands. It seems that the ship may have capsized trying to enter the port in rough weather. Several intact and broken amphorae are scattered on the bottom, others are deeply buried, and others are cemented to rock, heavily encrusted with calcareous algae and/or overgrown with seaweeds.

The wreck was originally found in 1968 by Professor Anwar Abdel Aleem of the University of Alexandria, Egypt. Professor Aleem has visited the site several times since, and found that coastal processes expose more amphorae at some times than at others. So far, no wooden parts, anchors or other artefacts have been found. Either they are more deeply buried or they have simply deteriorated – a more extensive investigation has not been possible because of lack of equipment. Professor Aleem would like to draw the attention of underwater archaeologists to this and to other potential sites along the coast west of Alexandria.

Titanic Obsession

What is it about the *Titanic* that makes it such big business? It even featured on the BBC's Antiques Show a month or two ago. Large sums of money change hands for memorabilia, telegrams, postcards, posters and so on, as well as for the rare items rescued from the sinking ship by surviving passengers and crew. Perhaps predictably, not all the items for sale are genuine, and there is a thriving counterfeit industry.

Objects recovered from the sunken vessel herself are not for sale – at least not yet – they are on display, all 8000 of them, at Memphis, Tennessee, courtesy of RMS *Titanic* Inc., the company which provided the funds that enabled Bob Ballard to locate the wreck in 1985. The only genuine 'relic' you can buy so far is a piece of coal ($25), allegedly retrieved from the ship's bunkers.

Discovery of the wreck undoubtedly gave new impetus to public interest in the *Titanic* story, but it never really died. At the last count, there have been 130 books and 18 films, including the most recent one, about to hit the screens at a cost reputed to be greater than that of the original ship!

Opening of a lavish Broadway musical was delayed by serious technical problems with the sets, which are truly amazing. They allow the audience to see different levels of the 'ship' at the same time, and there is a tilting stage, devised to add verisimilitude to the final scenes. The show finally opened to somewhat muted critical acclaim, but the show appeared to be 'excellent on Edwardian hubris and class distinctions and on the courage of those who went down with the ship'.

If musicals are not to your taste, then for galley-slaves there's a handsome new cookery book to enable you to recreate dishes that featured on the ship's menu, including the Last Dinner.

Why do so many people want to spend good money to revisit this tragic story? There are plenty of other maritime tales of heroism, cowardice, self-sacrifice, mendacity, and miraculous survival. Perhaps it is the *schadenfreude* that so many of us feel when ambition over-reaches itself, as it did so spectacularly (titanically, indeed) on the night of 15 April, 1912.

Hubris followed by Nemesis indeed!

Stuff the Quotas, Sell the Fish

A small hooray. Fish quotas are being exceeded and the surplus illegally sold all over the UK – perhaps elsewhere in Europe too. If press reports are to be believed, it seems that some of the British officials charged with policing quotas are turning a collective blind eye to the practice. Far be it from this column to condone law-breaking, but perhaps we can rejoice that for the time being at least some over-quota ('black') fish are not being dumped.

It beggars belief that a system could be not only devised but actually enforced, that requires trawler captains to be fined for not throwing away (dumping) tens of thousands of pounds worth of prime fish, because they have exceeded their quotas. Small wonder that skippers refuse to comply and officials pretend not to notice.

Enforcing quotas might stand a better chance if excess tonnages were simply confiscated and then sold separately, the proceeds being put to some sensible use, such as maintenance of port facilities. This would ensure that transgressors did not benefit but would also mean that they would not otherwise be penalised. 'Quite unworkable!' I hear you cry. Surely no less workable than the present daft system, and a lot less wasteful.

Overfishing may still be hurrying stocks to extinction, but at least selling the surplus means we are eating our way through what is left instead of seeing huge quantities simply thrown away to rot. Hence the hooray at the front of this piece. It is only a small hooray, however, because there does seem to be strong (some would say overwhelming) evidence that commerical fish populations are indeed at historic low levels (e.g. *Nature*, **385**, 6 Feb. 1997, pp.521–22), despite claims by some fishermen that the seas still 'teem with fish'.

The much-publicised issue of quota-hopping becomes less important under circumstances where people are not observing quota limits anyway. Quota-hopping is a consequence of the principal flaw in the Common Fisheries Policy (CFP), which allows (even encourages) boats from different countries to fish in each others' waters. It is argued that quotas dedicated to the UK should be consumed in the UK, not exported, and following recent high-level EU negotiations in Amsterdam, it was agreed that foreign vessels using British quotas must henceforth land 50 per cent of their catches in the UK. But as a perceptive (cynical?) observer pointed out, there is nothing to prevent the fish being loaded straight into freezer trucks and taken 'home'. Quota-hopping has become such a big issue in Britain because the UK fishing fleet is shrinking, so there are fish to spare in our waters – which are then taken by boats from other countries where the trawler fleets are expanding.

But I digress. This whole quota system is a distortion of the ancient Roman concept of *res communis*, which originally meant something held for the common good, to be preserved/conserved for the community as a whole. The distortion occurs because all concerned are exploiting a *limited* resource for competitive profit. There is no incentive for cooperation to conserve supplies, and a free-for-all ensues. Nobody will be mug enough to hold back on their own fishing effort, because if they don't take the fish, someone else will.

The Norwegians are more successful. They don't belong to the EU, so they miss out on some advantages, but at least they are outside the CFP. They can operate an approximation of the old *res nullius*, which being loosely interpreted means that their bit of the sea belongs to nobody but them, because under the Law of the Sea they can claim it as a truly Exclusive Economic Zone.

We may not like the way Norwegians behave towards whales, but they can at least persuade (or coerce) their fishermen to behave sensibly – like not depriving cod and other bigger fish (not to mention birds) of their food by hoovering up great tonnages of smaller fish (e.g. sand eels) at lower trophic levels. They could probably teach us a thing or two about fisheries conservation. We can perhaps take comfort from the fact that when our own cod stocks are extinct, we should be able to get supplies from Norway – no doubt at a price.

Perhaps the new Labour Government will realise that fish are a mobile resource less easily amenable to rules based on territorial boundaries than commodities such as timber or coffee or beans or butter. They might even persuade other EU members of this, not to mention the bureaucrats in Brussels and Strasbourg.

These may be troubled times for fisherfolk, but their behaviour seems at times to make things worse. Only last April, French fishermen blockaded ports and roads to protest against being told to increase the mesh-size of their nets, so that young fish can escape, to grow bigger and be caught another day.

The foregoing may sound glib, but if virtual disappearance of commercial fish stocks from European waters is as imminent as people keep telling us, there have to be drastic reductions in fishing effort, which means the continued decline of fishing industries all over Europe.

Finally, if fish stocks are declining, how can the seas still 'teem with fish', as some fishermen claim? Is it because scientists sample systematically, while fishermen sample selectively, i.e. they go where the fish are? Either way, my fishmonger tells me quite a lot of his cod comes from Norway already!

Meanwhile, down on the fish farm ...

Norwegians have been in the news again recently, accused of dumping farmed salmon on the market and undercutting the Scottish and Irish salmon farmers. What an irony: (alleged) scarcity in the seas, glut at the farms. Is there not a way of balancing the books?

Experiments have been made with farming commercial sea fish and releasing them while still young enough to grow naturally and thus replenish wild stocks. It sounds fine in principle, but tens of thousands of tonnes of farmed fish would be needed and the practical difficulties must be enormous.

But perhaps it isn't as far-fetched as it might sound. The total worldwide fish catch last year was 113 million tonnes, of which 21 million tonnes was farmed – and 10 million tonnes of that was carp from fish farms in various parts of Asia. Salmon farmers produce 400 000 tonnes of fish per year, an order of magnitude more than the annual amount of wild salmon taken (10 000 tonnes). Maybe it *is* possible to farm-rear tens of thousands of tonnes of marine fish for release into the oceans.

But wouldn't that be just another techno-fix, enabling us humans to continue our over-exploitation of the oceans?

John Wright

Oil and the Sea

All oil spills are bad, but it seems that big spills from tankers and oil rigs are less damaging than their reputation suggests. It is probably not generally known that such spills account for *only about 2–3 per cent* of the oil that enters the marine environment, or that around 10 per cent comes from natural hydrocarbon seeps. Virtually all the rest of the oil that gets into the sea (i.e. some 85 per cent) comes from various forms of industry. Most enters coastal waters, though the open oceans do not escape contamination, from atmospheric fall-out and from ships (illegally) cleaning tanks at sea. The mass of publicity that surrounds a major oil spill has only partly to do with pictures of oiled seabirds; it is mainly about the thick oil layers on rocks and beaches that will attract large insurance claims and wreck the next summer holiday season, damaging local economies.

The last big oil spill to affect UK waters was the *Sea Empress* accident early last year, which was followed by recriminations and allegations of incompetence, mismanagement, poor communications, complacency, 'an accident waiting to happen' and so on. The *Sea Empress* was negotiating an entrance to harbour in the dark and allegedly at low tide, when the channel was narrowest and water depths (and hence clearances) were minimal. The adage has it that 'Time and Tide Wait for No Man' but where big bucks are involved the reality is that 'Time is Money and Man cannot afford to Wait for the Tide'.

Actually, it takes only a few years – ten at most – for the environmental effects of a major oil spill to clear, so we should not be too surprised that these apparently major disasters soon become distant memories. Pembrokeshire beaches that were inundated with oil little more than a year ago are reported to be fit for bathing this summer. The saying 'a week is a short time' holds true not only for politics but for human affairs in general. If we can forget what happened last week, how much harder must it be to recall what happened last year? Many *Ocean Challenge* readers were not even born when the *Torrey Canyon* hit the Cornish coast (1967), and would have been toddlers when the *Amoco Cadiz* ran into Brittany (1978). Those disasters are now part of history.

Within the last few months there have been two large and well publicised spills off Japan. One was a *Sea Empress*-type event in the well-charted waters of Tokyo Bay; the other was off Japan's north coast, where it threatened the cooling intakes for nuclear power stations. Both spills must have been contained and/or dispersed, or we would have heard by now. Perhaps most telling of all, it is barely five years since the Iraquis deliberately spilled huge volumes of oil into the Persian Gulf (and ignited many oil wells at the same time), during the Gulf War. There were dire prophecies of environmental catastrophe on a scale hitherto unimagined, the effects of which would be felt for generations to come. Did they turn out to be right?

But the 80–90 per cent of oil pollution that goes on all the time is *chronic pollution* which receives little or no publicity; and where it is localised the environment stands no chance of recovery. Look at the Caspian Sea and the Niger Delta, to name but two examples.

And it can hardly fail to increase with time, since humanity's apparently insatiable thirst for petroleum and its by-products is unlikely to be assuaged in the foreseeable future. To meet rising demands, the oil industry pumps more and more oil out of the ground. Increasing amounts must come from the sea-bed, because most oil happens to be in the big sediment accumulations of the continental shelf–slope–rise region. Correspondingly larger quantities of oil will get into the marine environment.

Interestingly, the time-scale of *natural* recovery from one-off spills is comparable to that following *natural* disasters like volcanic eruptions, earthquakes, floods, forest fires (caused by lightning, not matches), and so on. We might suppose that were the chronic pollution to cease, recovery from it would also be rapid. But what does recovery mean in this context? Even after a one-off oil spill, nobody knows whether the *status quo ante* has been restored, because typically there is not enough information about what conditions were like before the event. In an initially pristine environment, the effects on habitat and biodiversity of several decades of continuous chronic contamination by oil must be both more drastic and less well-documented.

Efforts by Greenpeace notwithstanding, so long as our obsession with the internal combusion and the jet engine continue, so long will the seas be subjected to oil pollution. There is little prospect of global agreements to make serious reductions in the use of fossil fuels and thus ameliorate global warming – let alone oil pollution. Indeed, there is not the slightest sign that anyone is even thinking about the admittedly massive economic restructuring that is necessary to make such agreements workable. Even protestations by major oil companies (Shell and BP especially) that they are moving into renewable energy (wind, biomass, solar) in a big way seem a bit hollow when you examine the small print. It turns out that they expect these energy sources to 'grow to five per cent of the global market by the year 2020.' Wow!

In fact, though cynics might scoff, if even that were achieved it would be no mean feat. Several major banks and insurance companies are actually backing this move because they are fed up with paying out on claims arising from climate-related disasters. Their stated objective is more grandiose than that of the oil companies: 'To make fossil fuels obsolescent (*sic*)'.

All the same, continuing improvements in technology are enabling (not to say encouraging) the oil companies both to improve recovery from existing wells, and to look further and further afield for new ones. We have the Atlantic Frontier over here (which evidently includes several parts of the Irish and Celtic Seas as well as the Rockall area), while in other parts of the world there are new finds in the Arctic wildernesses of Alaska, in the forests of Peru and in the already environmentally stressed Caspian – to cite a few recently publicised examples. Given all that, it's a fairly safe bet that by 2020 at least 90% of the global energy market will *still* be dominated by conventional energy sources, mainly fossil fuels at that (though recent developments on the nuclear power front could shift the balance a bit (see p.10).

Disposal of increasing numbers of obsolete drilling and production platforms will become a growing problem. Surely they don't *all* need to be bodily removed, do they? Couldn't many of them simply be amputated at some suitably safe depth and left as artificial reefs (see p.22)? In NewSpeak we could describe this as a win–win scenario. Who knows, it might even get some support from Greenpeace ...

John Wright

New Studies of Effects of Oil Industry

A £2.2 million research programme to seek ways of minimizing the adverse effects of oil exploration and exploitation in deep waters was launched in June. MIME (which stands for Managing Impacts on the Marine Environment) is funded collaboratively by the Natural Environment Research Council (NERC) and the Engineering and Physical Sciences Research Coucil (EPSRC), and by a consortium of oil companies and the Department of Trade and Industry.

Five projects have been approved:

- Study of the distribution and ecology of cold-water corals, which grow in deep waters off the continental shelf. A team led by Professor John Gage (SMBA) will be investigating their susceptibility to damage and pollution.
- Dr George Wolff (Unversity of Liverpool) is leading a study of the interaction between the chemistry and biology of the sea-bed and that of the overlying water.
- A team led by Dr Graham Shimmield (Dunstaffnage Marine Laboratory) will be trying to establish whether it is better to clear away material deposited after drilling, or to leave it to be covered over by natural processes. This material (known as 'drill cuttings') can contaminate surrounding water and sediments.
- Dr Steve Grigson (Heriot-Watt University) is leading a project to develop more sensitive techniques for monitoring possiblec ontamination by specific chemicals used by the offshore oil industry.
- Five teams (led by Professor Steve Rowlands, University of Plymouth) will cooperate in developing computer models for predicting concentrations and environmental impacts of discharged substances.

It is hoped that MIME will contribute to the scientific basis for sound environmental decisions by oil companies and regulatory authorities. Deep waters are much less well known than continental shelf seas, and the work will be particularly relevant to the 'Atlantic Frontier' areas off the continental shelf, which are currently the focus of oil exploration. MIME will involve open collaboration between government bodies, industry and independent research organizations, and all the results will be freely available for publication.

- Professor Steve Thorpe, of the University of Southampton, has received the 1997 Walter Munk Award for Distinguished Research in Oceanography Related to Sound and the Sea. The award is presented by the US Navy and The Oceanography Society.

Steve Thorpe was honoured for his outstanding work and many contributions to the understanding of ocean processes, including his pioneering measurements of bubbles from breaking waves, made using high frequency acoustics; also for his seminal work on Langmuir circulation, and his investigations of the structure of turbulence based on side-scan sonar measurements of the surface of the ocean. He has also made significant contributions to our understanding of the role of bubbles in air–sea gas fluxes.

He is recognized as an outstanding fluid dynamicist and physical oceanographer who has effectively utilized acoustics to understand fundamental processes in the ocean. The Selection Committee were impressed that important insights into small-scale physical oceanographic processes were obtained through the use of a relatively simple back-scatter sonar.

Professor Thorpe has just annouced his early retirement, but he will continue his research work.

- Dr Alan Longhurst, who has just retired from the Bedford Institute of Oceanography, is to be congratulated on being awarded ASLO's Lifetime Achievement Award for 1997. Alan worked for the British Colonial Research Service in Nigeria and Sierra Leone from 1954 until 1963. He then moved to Scripps where he was Director of the NOAA–NMFS Fisheries Oceanography Center, and where he developed the Longhurst–Hardy Plankton Recorder. His next appointment was as Deputy Director of IMER where he was responsible for the development of GEMBASE, the simulation model of the Severn Estuary. He then moved to become Director of Marine Ecology at Bedford where he was highly influential in developing it into a major centre of excellence, a fact unrecognized by the Canadian Government (who 'spoiled it for a hap'orth of tar'). Alan has just just completed a book entitled *Ecological Geography of the Ocean*, which is likely to become a classic interpretation of ocean biogeography.
- Martin Angel hung up his boots on 13 April after working at NIO, IOS, IOSDL and SOC without ever changing his job. He has long been associated with the Challenger Society. He succeeded Mary Swallow as 'Convenor of the Scientific Meetings' in 1974, and then produced 25 issues of the Society's Newsletter, before *Ocean Challenge* came into existence. He still serves on the editorial board of the magazine. Having failed to find the time to attend one of NERC's pre-retirement courses, he finds that he is not properly trained to respond to the challenges of his new status, and so still regularly appears on the doorstep at SOC!
- Colin Summerhayes left Southampton Oceanography Centre on 1 May to take up an appointment in Paris with IOC, running the GOOS International Programme. Colin has recently received the President's Award from the Society for Underwater Technology for his major contributions to marine geology, ocean science and technology, particularly in fostering the developments of *TOBI* and *Autosub*. In the wider field of ocean-ography, he was the catalyst in organising a Dahlem Conference on Upwelling in 1994, which resulted in a landmark publication. His most recent major contribution was in lobbying and eventually chairing the Government's Marine Technology Foresight Panel.
- As a result of Colin's departure from SOC, Phil Weaver is taking over the Challenger Division for Sea-Floor Processes, and Howard Roe is taking over the responsibility of looking after NERC staff at SOC.
- Dr S.A.S. (Steve) Jones is now Technical Leader for Physical Oceanography at DERA (Defence Evaluation and Research Agency) in Winfrith, replacing Dr A.D. (Tony) Heathershaw, who is on secondment to SOC.
- Professor John Simpson has taken over as Head of School at Menai Bridge, in succession to Professor Ernest Naylor.

We thank Alan Weinstein (of ONR) and Martin Angel for their contributions to the above news items.

NOW There's a FUNNY THING...

Sunburn cream – from corals?

Reef-building corals can be exposed to intense tropical sunlight in shallow water for several hours each day, during low tide, and have in consequence evolved some protection from damaging ultraviolet radiation, especially the shorter uvB wavelengths. The organic compounds that provide this protection, called mycosporins, are produced by the symbiotic zooxanthellae; and it appears that the shallower the water in which the corals live, the more mycosporins they contain. Mycosporins were already known to occur in fungal spores (hence the name), and they are found in sponges too – but corals are more abundant, so that's where most mycosporins are found.

However, mycosporins are unstable outside of their hosts, so it is not cost-effective to extract them from natural sources. It is difficult to synthesise a compound with similar properties in the laboratory, and in fact the product which gave the best results has a molecular structure quite different from that of mycosporins. But it is odourless, colourless, non-staining and water-resistant, and is claimed to be 'three times better at blocking uvB radiation than existing preparations'. However it is not yet on the market.

It is indeed fortunate for the global coral population that the threat of increased ultraviolet radiation damage resulting from stratospheric ozone depletion has not caused a rush by the pharmaceutical industry to 'mine' coral reefs for mycosporins. It is fortunate because, according to reports from several sources, corals are dying all over the world. As much as 70 per cent of the present global coral population could have died out by half way through the next century. This is not a trivial issue, since coral reef communities are a cornerstone of coastal ecosystems throughout tropical latitudes.

The key problem seems to be bleaching of the corals, which results when the photosynthesizing zooxanthellae leave the coral polyps. However, there is still no consensus about the cause of the bleaching. Some authorities hold that it is elevated temperatures, others that it is reduced temperatures (is this plausible we ask, in a world that is experiencing global warming?). It could also result from changes in salinity, or from pollution of various kinds, including sediments from coastal construction projects.

Another obvious cause of coral mortality is eutrophication and smothering of reefs by algal 'jungles' produced by excess nutrients in coastal run-off. Recent research provides an interesting twist in this context. Phosphate appears to be more lethal to corals than nitrate, because it inhibits growth of the coral skeleton (whereas nitrate apparently does not).

Anthropogenic factors may also be responsible for the intermittent devastations caused by population explosions of the coral-eating Crown of Thorns starfish (*Acanthaster planci*). These have been most publicised in relation to Australia's Great Barrier Reef, but affect reefs elsewhere too, notably in the Indian Ocean and other parts of the Pacific Ocean.

Whatever the reason for such widespread coral mortality turns out to be – and as usual we shall doubtless find that not one but a multiplicity of causal factors are involved – we can fairly confidently conclude that it is not attributable to depletion of the ozone layer. Otherwise, all that research into mycosporins would be a waste of time, would it not?

Longitude – the book

What was it about Dava Sobel's biography of John Harrison, maker of the first reliable marine chronometer back in the 18th century, that made it a best seller? Was it the skulduggery, people with big and perhaps not wholly justified reputations – most notably the Rev. Maskelyne, who became Astronomer Royal – either plagiarising (i.e. stealing) or ridiculing the inventions of one they perceived to be a lesser mortal? While such obstructionism may have contributed to the long production period, it seems mainly to have been the inventor's equivalent of writer's block that made Harrison take over 30 years in all to produce his final masterpiece (there were several prototypes) and win the 'bounty' of £20000, originally set by the Admiralty in 1714.

The brouhaha over the book is all very surprising, not least to the author. She has herself also suffered some vilification from persons who believe themselves superior to her in knowledge and who allege that she distorted the truth for a fast buck. Cynical readers might wonder if it is only because she had the idea and can write and they didn't and can't!

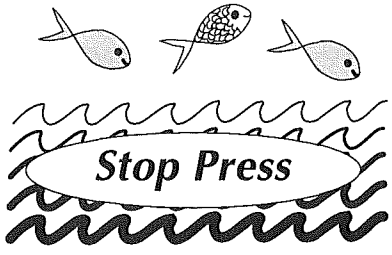
The Chrismas edition of the TV show 'Only Fools and Horses' apparently featured a missing Harrison clock. He made six, it is believed,of which four are in the Greenwich Museum, one is in London's Guildhall. If there really is a sixth, where is it? Does David Jason know something ...?

Earth and Moon in a spin

Finally, I was puzzled recently by seeing two conflicting periods for the passage of the Moon around the Earth, *viz* ~ 27.3 days and ~ 29.5 days, the latter also being the period of a full monthly tidal cycle, i.e. the time taken for the Moon, Earth and Sun to come back to the same relative orbital positions. I asked a number of experts but got no answers that I could understand. I suspect it was because my question was so naïve that these experts could not bring their intellects down to such an elementary level.

In case anyone out there is wondering, I managed to discover the answer, which was indeed blindingly simple, once I recalled that the Earth + Moon 'couple' also orbits the Sun! The time taken for the Moon to go once round the Earth (strictly the centre of mass of the Earth–Moon system) is close to 27.3 days, and that's called the sidereal period. But in those 27.3 days, the Earth–Moon 'couple' has also moved along its solar orbit. And because the orbital motions are both in the same direction (anticlockwise seen from above the North Pole), the Moon has to go a bit further along *its* orbit round the Earth to return to the same position relative to both Earth *and* Sun. The time for that to happen is close to 29.5 days and is called the synodical period, the one which controls the tides – and strictly speaking should not be referred to as the orbital period of anything!

John Wright

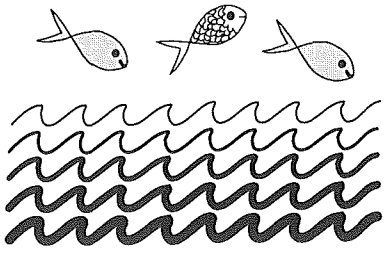


New Curbs on Pollution: A Step in the Right Direction

As a signatory of OSPARCOM (the Oslo and Paris Conventions on Marine Pollution), the British Government announced in early September that it proposes to apply much stricter regulations to the disposal of wastes at sea. Radioactive waste discharges are to be reduced as far as practicable with immediate effect, while discharges of other toxic effluents are to be phased out over a 20-year period; and (no doubt with *Brent Spar* in mind) redundant oil and gas platforms will be disposed of on land rather than at sea.

The proposals have been welcomed by some, but others say they do not go far enough. Irish environmentalists will not be satisfied until Sellafield is closed down, while the oil industry has pointed out the value of platforms as artificial reefs, and insists that disposal on land is not the safest option for all such structures.

In any case, much of the pollution reaching the open oceans far from land is airborne (e.g. hydrocarbons and metals such as lead and cadmium from motor vehicles, power stations, cement plants and incinerators; PCBs from waste dumps). Nevertheless, modest though the Government's proposals may appear to some, they are clearly a step in the right direction.



GNVQs in Marine Environmental Science

The system of National Vocational Qualifications (NVQs, SVQs in Scotland) was outlined in *Ocean Challenge* a few years ago (Vol. 4, No.3, pp.20–21). To quote loosely from the article by Linda Hodgkinson, as a reminder:

'Now firmly established in the United Kingdom and becoming better known among our fellow member states in the European Community, these qualifications are aimed at people in work. They enable more people to gain qualifications that are relevant to the work they are currently doing, and that meet nationally specified occupational standards.

'N/SVQs are based on nationally recognised standards. They are qualifications about work, based on measurable standards of performance determined through extensive consultation. For the first time, these set out what is expected of people in work at different levels of competence. The outcomes of education and training are expressed in terms of what individuals can do and to what standard.

'GNVQs (General National Vocational Qualifications), and their Scottish equivalents, are different from N/SVQs in that they are assessed *within an educational setting,* that is, school, FE college or HE institution, and are specified in terms not of one particular occupation, but of a broad occupational area and the skills, knowledge and understanding which underpin it.'

Recently, the Education Committee of the Challenger Society cooperated with the City and Guilds Institute of London to develop a GNVQ Unit for science students wishing to develop their interest/experience/understanding of the marine environment. The GNVQ Unit became available in September of 1996, i.e. for the school year just ended.

It is formally designated as Unit 20 of the Advanced GNVQ in Science, and is one of a range of additional units, selections from which, together with a core of mandatory units, make up the GNVQ.

Entitled 'Marine and Environmental Science', the Unit has four elements (20.1 to 20.4) whose syllabuses are summarised below:

1. Basic physical oceanography (including temperature and salinity and vertical structure; ocean circulation; the oceans and climate).

2. The coastal zone with especial reference to impacts of human activities (including comparison of seawater and river water; mixing and flushing in estuaries and shallow seas; sediment transport and deposition; sources and effects of different pollutants).

3. Resources from the sea (including wave and tidal power as well as hydrocarbons; mineral deposits; methods of exploration and extraction; economic and environmental considerations).

4. Marine fisheries (including food webs; natural variability of stocks; overfishing; strategies and tactics of stock management).

Some parts of the detailed syllabus are quite difficult to follow, which may be partly a result of the overtly geological context in which this Unit is placed, described thus:

'This Unit builds upon the geological optional units at advanced level: Unit 12, *Using the Earth's resources,* and Unit 14, *Evaluating environmental activity,* but provides more specific underpinning knowledge of the marine geological structure. The Unit explores the structure of the ocean and the resources found there and the impact of human activity on the coast and the shallow sea zone, as well as the role of marine fisheries.'

That was not written by a marine scientist! Another reason why parts of the syllabus are difficult to follow is that suggested improvements to the first draft were not incorporated, because contact between the Challenger Society and the City and Guilds Institute was lost as a result of staff changes there. However, the Challenger Society Education Committee is seeking information from educational institutions on student uptake of the Unit in 1996–97, and has offered assistance when revision is due.

Satisfaction, yes – riches, no!

After UK Oceanography at Bangor last year, Martin Preston distributed a questionnaire to younger participants. He got back 54 of them, completed or partially completed. Several of the questions were relevant to activities of the Challenger Society and the replies should interest our readers.

The tone of the replies will to some extent have been conditioned by the nature of the questions and their wording; and 54 returns amounts to less than 15 per cent of the participants, so we should be wary of regarding the results as coming from a truly representative sample. All the same, they are most interesting. Here is a summary of Martin's findings:

1. Most responses were from PhD students or post-docs on 'soft money' short contracts. Only a few respondents had permanent jobs. It seems that a lot of young people coming onto the oceanography job market are unsure about what is going to happen to them next, though many wish to stay within marine or environmental sciences.

2. The distribution of subjects studied during first degrees was interesting. Nearly three-quarters of the respondents had studied marine or environmental science as a significant part of their degrees. The other dominant subjects were (commonest first) physics, maths, chemistry, geology, and biology. Many had obtained a significant multidisciplinary element in their training. It is therefore evident that a good many of the potential job-seekers will have less training in a single discipline than would a single-subject graduate.

This could have implications for the stated policies of those institutions that indicate that they prefer to recruit graduates with backgrounds in specific science disciplines and turn them into oceanographers. There may be a mismatch between student expectations and recruitment policies.

More specifically, such policies are also difficult for university oceanography departments that need undergraduates in order to survive but have problems answering the question: 'What job opportunities are available to me if I study this degree course?' In practice, Martin Preston's own experience at Liverpool has been that the multidisciplinary route leads to as many relevant job opportunities as the single-science route. The main parameter is the quality of the graduate.

3. Perhaps one of the most interesting outcomes is that 'intellectual interest and satisfaction' came top of the list for most peoples' employment requirements, with 'security' second, closely followed by 'location'. 'Financial reward' came fourth. Perhaps this helps to explain why the scientific community is low in the pay stakes? (But see also pp.19–21.)

4. Only a small minority of respondents appear to be interested in making their careers in education, either at secondary or tertiary level. This is interesting in the light of comments from some to the effect that on the one hand there is a need for more widespread teaching in the marine sciences, and on the other that there is an excess of both graduates and people with PhDs.

It is (or should be) a matter of considerable general concern that neither marine science nor meteorology appear in the National Curriculum. The Challenger Society Education Committee is presently trying to develop ways in which at least marine science can feature in some of the prescribed material.

5. Perceived priorities in the marine sciences for the next decade were dominated by climate change, pollution, and coastal and shelf processes. Only one person explicitly mentioned research into deep-sea processes. It is to be hoped that the caveat above about non-representative sampling does apply in this case! It may be that messages about the latest initiatives in deep sea studies are not percolating down to the younger workers in the field?

6. The question: 'What should the Challenger Society be doing to advance marine science in the UK?' drew many varied responses. Perhaps the most important was that the Society should organise and run training courses (this would also meet NERC requirements for the provision of post-graduate training), and that it should sponsor short summer schools. These are laudable objectives, but require to be fleshed out and made more specific. The nature and subject matter of the training courses and summer schools need to be determined.

It was also suggested that the Society should:

- Lobby for the marine sciences more than it does – which includes keeping the research fleet afloat.
- Be more proactive in encouraging young scientists and helping to improve their career structure. (For information about progress being made here, see pp.19–21.)
- Encourage more cross-disciplinary study (which is interesting in light of comments on post-graduate requirements in 2 above).

The Society can do something to help with all of these points, but the suggestion from one respondent doesn't really fall within the Society's remit. That suggestion was that we should work to 'abolish the Monarchy'!

Contract Research in Oceanography

Alison Weeks

Over the last ten years, an increasing amount of oceanographic research has been carried out by researchers on fixed-term appointments. This trend is of course evident in other areas of scientific research both in the UK and abroad. In the USA, for example, contract research is well established, but there has always been a wide diversity of funding opportunities there. It is also more common for university lecturers in the US to be partially funded by contract research, thus making contract research an integral part of academic life.

The problem of developing a career by means of a series of fixed-term appointments has now spread from those working in the university sector to workers in institutes funded by the Natural Environment Research Council (NERC). There is an important difference, however: in Higher Education Institutions (HEIs) contract research is carried out on an individual basis, but in NERC institutes it is part of the overall strategy for management of funds.

In this review of the current position of oceanographic researchers, the university experience will be considered first, then that in the NERC institutes.

Higher Education Institutions

In UK universities, research is largely carried out by researchers working on fixed-term appointments (FTAs), working for, and alongside, lecturers. Contract researchers currently make up 43% of academic staff in the 'old' universities. The length of the FTA is exactly matched to the funds available. The university retains the overhead costs included in the proposal. When the funds run out, the research ceases, perhaps to be continued (by someone else) at a later date when funds become available. This situation may suit people who have just completed their PhDs, but it becomes increasingly difficult to build a career in such a temporary culture.

Continuity between contracts occurs mostly by luck, because research funding – whether from the EU, NERC, other government agencies or the commercial sector – cannot be guaranteed to be available from a specific date. Often, great hardship is suffered by researchers who are deeply committed to their work, and who await funds. Bridging funds are sometimes provided to cover gaps in funding, but these funds are usually expected to be repaid from the new contract.

After one or two post-doctoral (or post-graduate) positions the researcher becomes more expensive, and his or her participation in the project needs to be strongly justified to the funding body if the financial support to keep them on the project is to be maintained.

It is difficult for the post-doctoral research assistant to develop a team of research students and other research assistants. NERC, for example, does not allow non-permanent university staff to apply for research grants, presumably because of the perceived difficulty of ensuring completion of the work. Many university departments do not encourage non-permanent staff to apply for research funds, or even to include their names on research proposals as collaborators in the research on an equal footing. On the other hand, EU funding arrangements have now been modified to allow non-permanent staff to apply for research funding.

Towards the final year or six months of a contract the researcher will begin to turn his or her attention to finding another position; if one happens to come up before the end of the contract, research time will be lost. Of course, this final part of the contract is usually the most productive phase, when papers are likely to be written.

So, in university departments the ambitious oceanographic researcher must move from a temporary contract to a permanent position as rapidly as possible. However, the possible options – a post as lecturer, or in a commercial company or a government-funded institute – are all oversubscribed and therefore scarce. The alternative is to leave the country or to pursue an alternative career, both of which could be viewed as a waste of valuable national resources.

NERC Institutes

In NERC institutes, individuals bid for research funds, and the overheads in the proposal go to the institute. The funding must be used as stated in the proposal; however, there is flexibility within the contract to recruit a team of researchers, some of whom may already be employed within the institute, with the advantage of using experienced scientists to carry out the work. Usually, contract funds are used for FTAs, and core-funding is used for open-ended agreements (OEAs), but the latter may be made up to full-time posts with contract funds.

Researchers on FTAs make up about 32% of staff in NERC institutes, and currently more than 90% of new positions are of fixed term. Interestingly, within the key Senior Officer/Higher Senior Officer grades, 50% of staff are employed on fixed-term contracts, and the majority of staff under 40 are employed on such contracts. Typically these fixed-term contracts are of nine months to two years in duration. Many of the problems of working on fixed-term contracts in NERC institutes are the same as those experienced in universities. Indeed, NERC found that between 1995 and 1996, 50% of researchers on FTAs left before the end of the contract.

A working party under the chairmanship of Professor D. Ritchie has been re-examining NERC's use of FTAs, with the aim of ensuring that current policy not only provides NERC with an effective means of managing resources but also makes appropriate career opportunities available to the best staff.

One of the main reasons for convening the working party was to try to find ways of providing a better career structure for people employed on FTAs. While researchers employed on OEAs in HEIs usually have tenure, NERC appointments can be terminated on the grounds of redundancy. Also, all NERC appointments have a probationary period of between six months and a year, at the end of which an individual can be dismissed if it is not thought that he or she will make the grade.

The working party proposed that all initial recruitment to scientific posts should be on the basis of fixed-term appointments. After five years on a fixed-term contract, the performance of the researcher should automatically be assessed and they should either be offered an open-ended appointment or be released. The Director of the Centre would make this decision. Initial appointments should be either for five years or for three years extendable for a further two years.

The researcher's point of view

Many researchers on FTAs in both NERC institutes and HEIs are of the opinion that tenured oceanographers favour a mobile community of 'young' researchers. This belief, and current funding difficulties, are causing many young oceanographers to turn to other careers or to leave the UK. In fact, the age profile of workers on FTAs is shifting upwards, so that 57% of university researchers on fixed contracts are now over 30.

The idea of FTAs is not in itself bad – if funding is plentiful then it provides a great deal of freedom for a researcher who wishes to focus his/her time in five-year blocks, unfettered by administrative duties. However, when funding sources are restricted, the pressures of working on the cutting edge of research may become intolerable. With the added pressures of family and home, the career of the oceanographer in the UK has become considerably less appealing than it was ten or 15 years ago. There are high levels of job dissatisfaction: insecurity and a sense of low status lead to poor morale, while long hours and heavy responsibilities may result in feelings of exploitation. In the case of universities, there is evidence of a shortfall in levels of good practice promoted by the 'Good Employer Agreement' (developed between universities and the AUT).

General problems in NERC units and HEIs are that many funding bodies do not allow principal investigators to apply for their own salaries, so they must have funding from other sources (e.g. lectureships in the case of HEIs, and core-funding in the case of NERC units). Moreover, there are often age-limits on fellowships. This has a particularly strong impact on the careers of women who wish to pursue research and have a family.

There are, in addition, other problems peculiar to oceanographic research. For example, in NERC units sea-time allowances are provided for researchers on FTAs, but in HEIs these are rarely built into research proposals as it would make them uncompetitive for funding. This means that HEI and NERC researchers work side-by-side on research at sea with considerable differences in pay.

Furthermore, because oceanography is an interdisciplinary science, it takes longer to attain the necessary experience and knowledge than for other sciences. Experience is also needed to interpret oceanographic data, and career continuity is necessary to allow the expertise of the researcher to mature.

What can be done?

The 'Concordat on Contract Research Staff Career Management' was formulated in the mid-nineties to set out a framework of standards for career management, and for conditions of employment, for researchers working for universities and colleges on FTAs. The signatories include the Royal Society, the British Academy, the Committee of Vice-Chancellors and Principals, and the research councils.

The aims of the Concordat are to create a more effective framework for career management for contract researchers. To implement the framework, a review procedure was set up and took effect from September 1996. This procedure requires that, at the beginning of the contract, a statement be written by the HEI to the funding body concerning the provisions for career development, and that some information on training and development benefits be included in the grant/fellowship reports prepared during the contract period. In addition, information must be provided to the funding body about the intended career of the researcher after the contract has been completed.

The main principles of the Concordat are to ensure that plans are made for training and continuing development for researchers, which may be pursued in academia, industry, commerce or the wider public sector. The development of the career of the researcher should be planned with a view to future prospects. During the contract period, the training and development element should be continually monitored. Care should also be taken to ensure that the conditions of service and rewards for the researcher are in line with those provided for established staff (e.g. sick leave, pensions, access to facilities and maternity leave and pay). In-service training and career guidance and development should also be provided.

The Concordat shows an appreciation of the problems for researchers in HEIs and if implemented will go a long way to bridge the gap between working conditions in HEIs and in NERC units. However, the management of researchers depends on a number of other issues such as funding levels, links with the commercial sector and the nature of academic appointments.

The role of the Challenger Society

At the request of the Challenger Society, I have recently undertaken a review of the problems of oceanographic contract researchers in HEIs and NERC units. Here are some of the ideas that have been suggested for improving the situation.

1. Fellowship schemes

More five-year fellowship schemes could be made available (Royal Society, NERC, EC, Marine Biological Association, SMBA etc.), and these could be extended to a further five (or more) years to allow fellows to build their own research teams. NERC institutes can (and do) create their own schemes. Funding could be directed to increasing the number and duration of fellowships. NERC fellowships and fellowships based in HEIs should parallel each other as far as management structure and working conditions are concerned, and researchers on FTAs should be able to move freely from one to another.

2. Appraisal, counselling and acquisition of transferable skills

Researchers on FTAs require annual appraisal, and if the post is not to be renewed then counselling is vital. In most NERC institutes, annual appraisal, counselling and clear guidelines are well established, but the same is not true in most HEIs. To work effectively, appraisal schemes need a good structure, and commitment from the management.

A training element should be part of the research project, including the development of transferable skills with appropriate accreditation. Of course, these can only be set in the context of the project for which the researcher is originally employed. In NERC institutes the new rules for conversion of a contract from FTA to OEA will successively reduce the opportunities for FTA appointments for older workers.

The appraisal/counselling process should be transparent so that the contract researcher knows exactly what is needed for their post to be converted to an OEA. In NERC institutes, appraisal for researchers on FTAs and the criteria for transfer to an OEA are currently dealt with separately; it would be better if these evaluations were done together.

Until recently, management of researchers on FTAs in HEIs has been undertaken on an *ad hoc* basis. However, the Concordat referred to above should soon begin to bring

about a better management environment in these institutions.

3. Permanent part-time lectureships

Permanent part-time lectureships (3 months +) would allow some stability for researchers who enjoy teaching and wish to build a research team via PhD students, or researchers employed on fixed contracts (if they took up this option, they would need to top up their salaries from research funding). This path could be attractive to long-established lecturers with considerable research commitments, and would release HEI funds for junior lectureships (part-time or full-time).

Teaching fellowships (which are actually junior lectureships without tenure) should be restricted to a maximum of two years to reduce exploitation of recently graduated PhDs who are desperate for jobs. Teaching hours are often very long, and continuation of personal research usually has to be done outside office hours. Teaching fellows know they must continue with research if they are ever to obtain a lectureship or a research position.

4. Independence for workers on FTAs

To improve their career structure, researchers on fixed contracts could be encouraged to work more independently. However, this is a difficult issue and one that may have different solutions in HEIs and NERC institutes. As mentioned earlier, UK funding agencies do not provide salaries for principal investigators, with the result that FTAs funded by NERC are effectively working for a principal investigator in a more permanent position. Most fixed-term funding is tied to a contract which is clearly prescribed, leaving little room for independent working. Fellowship schemes are the only option permitting independent working. All in all, there is little room for the mature researcher on a fixed contract to build a research programme or team of researchers (PhD students or research assistants).

In HEIs, there are a number of independent researchers working on contract (usually on funds from the EC and other funding agencies) who do have opportunities to build small research teams. Clearly, a good appraisal/career development structure would help researchers in this category.

5. Research assistants and technicians

For these workers, one model would be to use the NERC 3+2 or 5 year FTA and convert to an OEA, particularly in the case of technical posts where continuity is paramount. Unfortunately, many research assistants (graduates) and technicians work on FTAs for many years, which proves unsatisfactory for all concerned. The only way to retain these workers on contract is by good management practice, allowing a clear career development via promotion to higher grades.

6. Links between NERC institutes, HEIs and industry

A national scheme to allow researchers on fixed contracts to work in different NERC institutes, HEIs and in industrial placements could be effective in managing scarce resources. It could also be valuable in the development of new ideas and projects.

The skills obtained at undergraduate, Masters and PhD level in HEIs provide highly desirable transferable skills such as data-handling, fieldwork and laboratory training, statistical analysis, computing, writing, teamwork, and the ability to work independently. At the moment, these skills are not fully appreciated by the commercial sector. A marketing strategy is needed to highlight the quality of researchers who might wish to move from academic research into industry.

7. Government action

Representations should be made to government about the crisis in career structure in oceanographic research, with a view to increasing funding levels. To achieve more impact, approaches could be coordinated with those from other science disciplines.

It is to be hoped that, if implemented, some of the ideas presented here might help to reverse the decline in the quality of employment currently being experienced by oceanographic reseachers.

This article reflects my own personal views. However, the proposals listed above, and readers' responses to them, will help the Challenger Society Council to formulate its recommendations.

Alison Weeks is a Senior Lecturer at the Southampton Institute, and a member of the Council of the Challenger Society for Marine Science. If you would like to comment on the points raised in this article, please contact her by Email on Alison.Weeks@solent.ac.uk

DGM Snippets

A recent issue of the *DGM Mitteilungen* (No. 4 for 1996), carried some items that might interest *Ocean Challenge* readers. These include an article on the spread of persistent organic compounds through atmosphere, oceans, and the marine biosphere, matched by a short piece on anthropogenic contamination of deep ocean ecosystems. There's a rather longer review (with some recommendations) of Article 17 of the Rio Agenda 21, and correspondence relating to increased cooperation among marine science communities of member states in the EU.

A short discussion of the merits of the terms 'Benthos' and 'Benthon' has the makings of a controversy which would be unlikely to endanger efforts to increase cooperation between our societies, but could generate a bit of semantic heat among language purists. 'Benthon' would of course match plankton and nekton, and the adjective would be benthonic, to match planktonic and nektonic. Do *Ocean Challenge* readers have any preferences? The editors remains neutral in this matter, though we shall continue to regard benthos and benthic as standard usage until persuaded otherwise!

Bursaries for Meetings

It has been proposed that a modest bursary be made available to people wishing to attend marine science meetings (including those of the Challenger Society). Applications should be made to Dr M.J. Howarth, Meetings Secretary, who is at the Proudman Oceanographic Laboratory, Bidston Observatory, Birkenhead, Merseyside L43 7RA, Tel./Fax: 0151-653-8633/6269; Email: j.howarth@pol.ac.uk

But beware: Successful applicants will be required to provide an account of the meeting for readers of *Ocean Challenge*. They will get part of their bursary before the meeting, the balance to be paid when the Editors have received your copy. You have been warned!

Toxic Seas and Taxes

Deep-water containment of pollutants

Martin Angel

A meeting of the Society for Underwater Technology, intriguingly entitled 'Tax Pounds and Toxic Seas', was held in London in March, under the chairmanship of the SUT's President, Sir Anthony Laughton.

Moya Crawford of Deep Sea Recovery Ltd gave the keynote address and began by emphasizing Government's strange lack of interest in 'inner space', despite its growing importance to industry and its role as a source of intellectual curiosity. Marine technology is expanding rapidly and within the next two years Deep Sea Recovery Ltd will extend its working capability from the present depth limit of 1 500 m to 6 000 m. So the deep ocean will soon cease to be 'out-of-sight and out-of-mind'. Even as she was speaking, the wreck of the *Derbyshire*, lying in over 4 000 m of water, was being examined. Dr Crawford now has convincing evidence that wrecks and oil installations function as artificial reefs at depths of >55 m, enhancing local fish populations. If the removal of large installations from the sea-bed is no longer regarded as environmentally necessary, it could save a billion pounds in the North Sea alone, two-thirds of which would have had to be paid for by the UK tax-payer.

Environmental impacts in the ocean tend to be exaggerated. For example, a study into the possibility of removing the nuclear torpedoes from the sunken Soviet submarine *Konsomolets,* which is lying at a depth of 1 700 m in the Barents Sea, showed that it is technically feasible, but expensive and a bureaucratic nightmare. Imagine the problems of a British company working in Norwegian waters to recover a Russian submarine – each country having its own version of maritime law and none wishing to take on the large financial penalties which would be incurred if anything went wrong. Similar problems are associated with the oceanic dumps of nerve gases and other chemical warfare agents that are a legacy of the last World War. The general concensus is that if such debris poses no *direct* threat either to the environment or to humanity, the dumps should be left where the are, but continually monitored to ensure that they are not an active threat to the environment.

Professor Harry Elderfield (Cambridge University) then discussed the chemical impact of pollutants in the sea. He emphasized that oceanic processes are intimately linked with atmospheric and terrestrial processes, so oceanic environments cannot be regarded as being in any way pristine – unaffected by human activities. The oceans are an integral part of the global ecosystem and its chemical cycles, and the eventual fate of most environmental contaminants entering the sea is to become sequestered in the deep ocean. Contaminants enter the oceans by a variety of routes, some rather unexpected. For example, on the basis of its isotopic signature much of the lead incorporated into corals off Bermuda has been traced to automobile emissions in the USA.

Residence times of some trace metals are shorter than the turnover times of ocean waters (1000 years), and these metals are strongly influenced by biological activity. Particles generated by primary production in the upper layers of the ocean scavenge many substances from the water column. These materials are either rapidly deposited on to the sea-bed, or remobilised in midwater. Reactions within the sediments are of considerable importance, redox conditions having a significant effect on the mobility of many metals.

The BRIDGE programme has given us new insights into the way metals are dispersed within the ocean. Maps of iron concentrations in Pacific sediments display 'halo' effects around vent-fields, reminiscent of the spread of caesium-137 from Sellafield. The role of particles generated by black smokers is now better understood; for example, they scavenge dissolved uranium from the seawater and deposit it in sediments in the immediate vicinity of the vents.

David Dixon of the Plymouth Marine Laboratory then discussed the 'genotoxic' effects of pollutants which by damaging DNA can result in mutations, the development of cancers and reduction in resistance to disease, thereby reducing biological competitiveness. At present, about 50% of contaminant inputs come from run-off, 30% are airborne, 10% are produced as a result of accidents and only 10% as a result of dumping *per se*. Dr Dixon argued that individual cells of simple organisms are just as susceptible to genetic damage as the cells of more complex organisms. Moreover, deep-sea organisms which inhabit relatively constant environments can be expected to be less resilient to the effects of contaminants than shallow-living species. However, the ability of individual organisms to resist disease and contamination varies considerably.

Dr Dixon has developed a number of techniques for detecting signs of stress caused by pollutants. For example, DNA extracts from impacted species run through gel electrophoresis show clear tails of DNA debris (he noted that vitamin E protects DNA from damage). The incidence of malformed larvae is much higher in polluted than in clean waters. Using specific DNA probes, initially in experimental animals exposed to pollutants, he was able to demonstrate that considerable rearrangement was occurring in their DNA molecules, and was then able to detect the same effects in animals taken from polluted environments. If deep-ocean disposal does become more widespread then test systems will be needed to detect such impacts in appropriate organisms. Just as important will be the need to establish the impacts at community and ecosystem levels, since these are likely to influence ecological processes.

Martin Angel (Southampton Oceanography Centre) then discussed the carbon dioxide problem. World population is on course to reach 10–12 billion by 2100, and all known reserves of fossil fuels are likely to have been burnt within 150–200 years. Models suggest that this combustion will generate a transient increase in atmospheric carbon dioxide reaching four times pre-industrial levels and that it will take two millenia for atmosphere and ocean to reach equilibrium again, with atmospheric concentrations at double pre-industrial levels. Even if there are no global warming effects(!), such increases will have major impacts on plant communities both on land and in the upper ocean. The pH of surface seawater will fall to 7.5, enough to have a major ecological impact. Under these circum-

stances, adopting the 'business as usual' option seems extremely unwise, despite the severe socio-economic impact any remedial action would have on present global economies. Familiar arguments heard from industrialists – that it is in our economic and social interests to have cheap energy – are unsustainable in the longer term.

Britain is one of only two countries to have met the objective of pegging carbon emissions to 1990 levels, but this has only been achieved through fuel-switching (especially from coal to gas) not through reduction of energy consumption. Nor has it taken into account industrial activities outside the UK – for example, flaring of gas from the Nigerian oil field managed by Shell is more than enough to discount our apparent achievements. Even if we can improve energy efficiency, exploit more renewable sources and switch more to nuclear generation, it seems unlikely that emissions can be held to 1990 levels, let alone reduced, without considerable social and economic pain.

It is already technically feasible to capture carbon dioxide from flue gases for disposal, albeit horrendously expensive (it would mean a 30% cost surcharge and a similar loss in fuel efficiency). And where could such vast quantities of carbon dioxide (2–3 Gtonnes each year, where G = giga- = 10^9) be sequestered? Britain is fortunate in having access to an offshore geological deposit that is suitable: a consortium including the British Geological Survey has shown that brines in the Utsira Sandstones beneath the North Sea have a potential storage capacity of 800 Gt of carbon dioxide. The Norwegians have already begun to pump carbon dioxide stripped from natural gas back down oil-wells into this geological structure.

However, not all major emitters have such convenient geological repositories. For some countries the best repository will undoubtedly be the deep ocean – a scientifically elegant solution which short-circuits the natural pathway from atmosphere to ocean. The eventual capacity of the oceans to sequester carbon dioxide has been estimated to be 20 000 Gt [but see also *Ocean Challenge,* Vol. 6, No. 3, p.10]. However, the essential resolution of existing major uncertainties will require a long-term concerted effort. The likely banning of ocean disposal of carbon dioxide under the London Dumping Convention will undoubtedly inhibit the willingness of any Government to sponsor such research. But can we afford to ignore this and other solutions to this real and growing threat to our very existence?

After lunch, a video was shown about the lifting of the *Irving Whale,* an oil barge that had sunk in the St Lawrence seaway. To the non-expert, the video gave a powerful impression of the technical challenges involved in the safe recovery of such a wreck.

The formal meeting then continued with Dr David Young of the Stennis Space Laboratory reporting on a comprehensive desk-top study on the possible use of the deep ocean for the disposal of dredge spoils and sewage sludge in the USA. This waste-management option is seen as an alternative to be adopted only after all other avenues have been tried, namely reduction of the amount of waste being produced, maximizing recycling, and actually using waste materials beneficially. Ocean disposal would have to involve containment and isolation, to limit deleterious effects on ocean environments. The demonstration study in question began in 1993 as a result of 'Congressional tasking' following the report of a scientific workshop held at Woods Hole in 1991. Sites considered were at abyssal depths (greater than 3 000 m), as a major criterion for acceptability was that no detectable concentrations of pathogens or toxins from the wastes should reach depths less than1000 m. The main point source of waste was envisaged to be the New York area. It was noted that sewage disposal at site 106, just beyond the continental shelf off New York, has had no adverse effects on biota either on the sea-bed or in the water column.

Abyssal depths are low-energy environments from which there are no significant direct links with the photic zone. Using a wide range of criteria, an optimal site has been identified on the Hatteras Abyssal Plain. The proposed technique for disposal is to fill 'geotubes' (reinforced polyethylene bags) with some 500 m^3 of spoil, and allow them to free-fall to the sea-floor. Leaching of dissolved contents will, it is thought, take 400–1000 years, and the maximum spread around the drop site would be over an area of 20 km^2. As recovery of sea-bed communities from major perturbations takes about a millenium, it is proposed that disposal be limited to a single site. In this way the impact could be kept well within limits of acceptability.

The next paper was delivered by Dr John Cooper of the National Radiological Protection Board, who reviewed the status of radioactive waste disposal in the deep ocean. Little has happened since the moratorium was introduced ten years ago. Dr Cooper began by defining some key terms: A becquerel is one nuclear transformation per second: 3.7×10^6 becquerels (Bq) are equivalent to 1 curie. Doses are measured in sieverts (Sv), typically microseiverts (μSv); a dose of 1 sievert in a day is lethal. A typical natural dose is 2 200 μSv yr^{-1}, and a short flight to Europe can result in additional dose of 5 μSv as a result of cosmic radiation. At present, the average lifetime dose from radioactive waste is 50 μSv. The problem arises when trying to establish a safety threshold, since one's chances of developing cancer are proportional to dose received and there appears to be no threshold.

Radioactive waste is generated mostly by the nuclear industry, but significant amounts are also produced by the phosphate industry (amongst others). About 8 000 m^3 of radioactive waste are produced in Europe each year, of which only 50 m^3 are high-level waste. The aim of waste-disposal is to isolate waste for sufficiently long to keep doses to people to acceptable limits. Disposal in the ocean started in 1946 when some waste was dumped near the Fallaron Islands off San Francisco. Since then, 0.55 PBq (PBq = petabequerel = 10^{15} Bq) have been dumped at 16 sites in the North Pacific, 0.02 PBq at five sites in the western.Pacific, 2.94 PBq at 11 sites in the north-west Atlantic, and 42.31 PBq at 15 sites in the north-east Atlantic (most of the last by the UK). Note that each year about 1 PBq of C^{14} is produced world-wide by cosmic ray bombardment.

In 1967, the Nuclear Energy Authority began to coordinate disposal of radioactive waste under the auspices of the OECD. The London Dumping Convention, which was drawn up in 1972 and eventually ratified in 1975, became the vehicle whereby raw disposal in the ocean was eventually banned. In 1977, a multilateral consultation exercise, known as CRESP, was set up to coordinate studies and to evaluate the impacts of the north-east Atlantic disposal site. The last dumping operation at the

north-east Atlantic site was by the UK in 1982, and a voluntary moratorium was introduced in 1983. A detailed and exhaustive review of the impact of the dump site was conducted by CRESP in 1985. Even though this evaluation concluded that there is no evidence for any significant pathways back to humans, a total ban was introduced in 1993.

Recently, the Russian government admitted that between 1961 and 1990 the Soviets had used the high Arctic (mostly around Novaya Zemlya) for the disposal of seven reactors containing high-level waste (generating 47 PBq), 6508 containers of intermediate-level waste (0.58 PBq) and a further 179 vessels and other large objects containing low-level waste (0.02 PBq). Assessments are now being made as to whether any remedial action should be undertaken and, if so, what it should be.

Malcolm Craig of SubSea Offshore Ltd then gave a fascinating account of two major salvage operations: one to recover three containers, each loaded with 108 25-gallon drums of arsenic trioxide, which had been washed overboard from a freighter; the other to recover eight tonnes of metallic mercury from the hold of a Second World War wreck.

For the arsenic recovery, a 'basketball catcher' capable of recovering 20 drums in one lift was specially built. ROVs were used to pick up the drums individually and drop them into the catcher. Mounted beneath each basket on the catcher frame was a large 'overpack drum' with centralisers to ensure that it could be dropped into its overpack drum in the right position. Once in the overpack drums, the arsenic drums were completely encased in cement. When the cement had set, the rack was recovered and the overpack drums were transferred into containers for transport onshore to a land-fill site. A fourth container located on the sea-bed was marked as containing sodium cyanide, but when cut open it was found to be empty. The whole recovery operation took just over a month.

The second recovery was from the wreck of a Liberty ship *Empire Knight* which had struck a reef known as Boone Island Ledge in February 1944 while on a voyage from New Brunswick to New York. The vessel broke in two and the aft section drifted away before sinking in water 250 ft deep. In 1988, a salvage company acquired the rights to recover cargo from the wreck, but when the manifests were examined it was revealed that one of the aft holds had been loaded with flasks containing an estimated eight tonnes of metallic mercury. Because of the highly toxic nature of metallic mercury, the wreck and the appropriate hold were surveyed. The cargo was still in the hold but because the aft section was lying on its side, the flasks were scattered around, broken open and corroded. Much of the mercury was still in evidence, and could be seen lying about in the hold. First, much of the cargo in the hold had to be removed by saturation divers who had to take additional precautions because of the high toxicity of mercury vapour at such pressures – getting the damaged flasks out was particularly difficult and any mercury still in them had first to be extracted. Eventually, 169 damaged and corroded flasks were recovered out of an original total of 221. The amount of mercury recovered totalled 1221 lbs, but assuming that each flask originally held 75 lbs, another 15 354 lbs must still be in the hold of the wreck. The cost of this difficult, dangerous, and only partially successful task was 4.5 million dollars.

The final lecture was by Mike Allen (a partner in Herbert Smith) who discussed future liabilities for dormant wrecks. I hesitate to give a detailed summary of his contribution as the details of the law are so complex. The definitions of terms such as 'lagan', 'derelicts', 'flotsam' and 'jetsam' are precise and yet full of ambiguities. Defining a wreck is one thing, but ascertaining who owns it or who has responsibility for any liabilities associated with it is far less straightforward. Everyone wants to own a valuable cargo that might be salvageable, but no-one wants to meet the costs that might be incurred by the recovery of a dangerous cargo. In salvage, there is often a 'no cure, no pay' principle, which is now leading to major problems in deciding who meets the cost of any environmental damage caused. And intervention by environmental protesters trying to stop the recovery of the *Irving Whale* delayed the salvage by a year and cost an additional 12–15 million dollars!

When there is no immediate threat posed by a wreck, why recover it? One reason might be that many wrecks leak oil. The *Royal Oak* is such a wreck but it is a war grave. The Norwegian Government paid for the removal of fuel from the bunkers of a German freighter sunk during the war. Sun Oil may incur the cost of removing oil from the wreck of a vessel sunk by a Japanese submarine during the last World War.

Fuel remaining in bunkers is usually considered to belong to the ship owners, if they are still in business. Cargo belongs to the insurers. The difficulties of sorting out the law were well illustrated by the complex liabilities associated with any recovery of the Russian submarine *Konsomolets*, mentioned earlier. Under which country's maritime law would such a salvage be conducted? And who would carry the liability for any accident? Similar questions had arisen during an earlier discussion meeting at the Institute of Civil Engineers, about the decommissioning of hydrocarbon installations. I sometimes wonder why I became a scientist – the future would seem more secure and lucrative if I had become a lawyer instead!

Martin Angel
Southampton Oceanography Centre

1997: Year of the Reef

This year has been designated the International Year of the Reef. We hope to have a review of events in the next issue.

Meanwhile, if you are interested in the survival of coral reef ecosystems, you could do worse than get in touch with Coral Cay Conservation, an organization that over the last eleven years or so has had an increasingly important role in the protection of reefs. From small beginnings in Belize, it has expanded greatly and now has projects worldwide, notably in the Phillippines, Madagascar, Vanuatu, the Red Sea and the Maldives.

Coral Cay Conservation can be contacted at 'The Ivy Works', 154 Clapham Park Road, London SW4 7DE; Tel.+44 (0)171-498-6248; Fax: +44 (0)171-498-8447; Email:ccc@coralcay.demon.co.uk Web site: http://www.demon.co.uk/coralcay/home.html

Challenger Society for Marine Science

ANNUAL REPORT 1996-97

Message from the President, Professor Mike Whitfield:

I was delighted to take on the rôle of President of the Challenger Society for Marine Science during the *Oceanography'96* meeting in Bangor. This meeting epitomised to me the new sense of the Challenger Society as a professional organization, expressing the excitement of marine science and encouraging its grass-roots development (or, should I say, its primary production) by students and young research workers. Membership is currently in excess of 600, with one-third student members and two-thirds full members. In my brief two-year spell as President, I will aim to strengthen the Society and to ensure that its growing influence is well-focused. In organizational terms, my aims are three-fold: (i) to make best use of our hard-earned resources through financial planning, budgeting and forecasting; (ii) to ensure good communication between the various activities championed by the Society and with the membership at large; (iii) to put in place strategy that will ensure that the case for marine science in the UK, the vigour of its development and its growing links with Europe are widely expressed. In scientific terms, I intend to work for a strong programme of scientific meetings (planning for *Oceanography 1998* and *Oceanography 2000* is now under way) and to ensure that the work of the affiliated groups is more closely interwoven with the other activities of the Society. The Council will also be exploring further the rôle of the Society as a lobbying organization, making the case for marine science whenever the opportunity arises.

Above all, the Challenger Society is a professional body representing, and being responsive to, its members. I am open to suggestions from any quarter as to how the Society can act more effectively for marine science in the UK and how we should nurture the related scientific culture. There will be a major turnover of Council members at the 1997 AGM and I shall need all the help I can get to encourage the process of any change and development while maintaining the continuity of the organization.

Highlights of the year

The seventh of the Society's *UK Oceanography* conferences took place from 2 to 6 September 1996. Held at the University of Wales, Bangor, the meeting attracted 375 delegates, which made it the largest ever of these biennial conferences. Some 129 talks were given, including ten keynote addresses, and some 150 poster presentations were also made. The conference was a great success, both scientifically and socially, and those who made the necessary arrangements are congratulated, especially Dr A E Hill, who chaired the national and local organizing committees.

A new scheme to encourage conference delegates to join the Society was very successful, bringing a total of 173 new members. On 12 March 1997, the total membership was 605, made up of 386 Full Members, 216 Student Members and three Honorary Members, these being Sir Cyril Lucas, Rear Admiral G S Ritchie and Mr R G Williams. Membership numbered 25 in 1903, the year the Society was founded. It reached 100 in 1931, 200 in 1953, 300 in 1961 and 400 in 1966. It had never reached 500 before 1996, let alone 600.

Efforts to forge links with the other European societies that are interested in marine science have continued. Indeed, colleagues from outside the United Kingdom were, for the first time, invited to participate in a *UK Oceanography* conference. This was another successful initiative. The meeting attracted a strong delegation from Germany and representatives of other countries, too, notably Sweden. The overseas delegates were clearly impressed, judging by the complimentary reports of the conference published in the newsletter of the Deutsche Gesellschaft für Meereskunde (*Mitteilungen* Nr.3/96) and the favourable comments received from representatives of other countries.

Council membership and responsibilities:

Since the last Annual General Meeting, which took place on 3 September 1996, the Council of the Society has met three times, on 18 October 1996, 22 January 1997 and 4 April 1997. The Council members and their responsibilities were as follows in the session 1996-97:

Professor M Whitfield	President
Professor J H Simpson	Immediate Past-President
Mr C P Quartley	Honorary Treasurer
Mr J M Walker	Honorary Secretary
Professor A Clarke	Policy
Mr T H Guymer	Affiliated Groups
Dr R B Heywood	Publicity
Mr M J Howarth	Meetings
Mr A J Phillips	Secretary of the Education Committee
Dr C Robinson	Honorary Secretary-designate
Dr G B Shimmield	Policy
Dr A R Weeks	Merchandise
Dr J A Williams	Membership

The following served as ex-officio or co-opted members of Council:

Mrs J Jones	Executive Secretary
Ms A M Colling	Editor, *Ocean Challenge*
Mr J B Wright	Associate Editor, *Ocean Challenge*
Dr E J W Jones	Meetings Coordinator
Dr M R Preston	Chairman of the Education Committee

Dr A D Heathershaw held responsibility for publicity and marketing until January 1997 and was then succeeded by Dr J O'Mahoney, who took his place on Council as a co-opted member.

Mr R L Prior-Jones chaired the Editorial Board of *Ocean Challenge* until April 1997 and was then succeeded by Dr R A Mills, who took his place on Council as an ex-officio member.

The following retire from Council at the 1997 Annual General Meeting: Professor A Clarke, Dr R B Heywood, Dr E J W Jones, Mr A J Phillips, Professor J H Simpson, Mr J M Walker and Dr J A Williams. Along with Dr Heathershaw and Mr Prior-Jones, they are warmly thanked for their service and contribution to Council and the Society.

The Society is very grateful for the support which it has continued to receive from the staff of the Southampton Oceanography Centre, especially the Director, Professor John Shepherd. We are also very grateful to Jenny Jones, the Society's Executive Secretary, for serving the Society so ably and enthusiastically during the year.

Policy

The Policy Committee has not met during the year, but Andrew Clarke has written a discussion document for Council on how the Society should promote itself as a learned society. A draft of the document was discussed by Council and then passed to members of the Policy Committee, as a result of which the document was changed relatively little from the draft. The next phase of work for the Policy Committee depends critically on decisions taken by Council concerning the future rôle of the Society.

Education

The Education Committee has completed the initial stages of the introduction of a GNVQ in Marine Science and is now investigating the possibility of devising a form of in-service training (INSET) for Secondary School teachers which would enable them to use marine science as examples within the teaching of the National Curriculum. Preliminary links have been made with the relevant part of the Natural Environment Research Council with a view to coordinating outreach initiatives.

The Education Committee is also investigating the use of commercial or 'home-made' computer-aided learning packages in the teaching of marine science. A compilation of useful Web pages is also under development. The Committee would welcome information/advice from anyone presently involved in teaching marine science at Secondary School level, as well as within the Higher Education Sector.

The Committee is represented on the IACMST working group on Marine Science Education and Training. A report will be issued on these subjects within the next year and the Education Committee would be glad to hear of any issues of concern to Challenger Society members.

Ocean Challenge

The publication date on the three issues of Volume 7 will be 1997, and these issues will be distinguished by the redesigned cover (which members will in fact have seen already on Volume 7, No.1). There is now a steady flow of articles, but the Editors will always welcome contributions, from whatever source. Members are urged either to submit articles for publication or to commission them from others (or both!). Meeting reports and items for the *News and Views* section are especially needed, and it would be really wonderful to have some *Letters to the Editor*.

The magazine is to be produced to a regular schedule, not only for the benefit of members but also to make it more attractive to advertisers. *Ocean Challenge* aims to widen the impact of marine science and is an important element in the Society's drive to attract new members. To this end, the Editors are increasingly seeking contributions from marine scientists in Continental Europe, as well as North America. A welcome development in this connection has been the recruitment of Professor Hjalmar Thiel (Hamburg University) to the Editorial Board.

Bill Prior-Jones has resigned as Chairman of the Editorial Board after several years of sterling service and unflagging encouragement and support for the Editors. His period of office culminated in the initiation of a plan to put *Ocean Challenge* on a more financially secure footing. Bill is succeeded by Rachel Mills of the Southampton Oceanography Centre. Her appointment has been warmly welcomed by all concerned, and the Editors are confident that she will continue to support and encourage measures to increase the circulation and readership of the magazine and thus make it known throughout Europe and beyond.

European developments

During the year, the Society has made good progress towards the goal of establishing closer working relations with other European Marine Science Societies. In particular, we have strengthened our links with the Deutsche Gesellschaft für Meereskunde (DGM) through participation of DGM members in the *UK Oceanography* conference in Bangor. For the first time, invitations to the conference were extended to colleagues in the rest of Europe, and we enjoyed a good response from the DGM and other fraternal groups, notably the Swedish Society of Oceanographers, represented by their President, Dr Johan Rodhe.

Professor Thomas Höpner, President of the DGM, also brought fraternal greetings to the conference; and his extended stay in the United Kingdom on sabbatical leave has allowed the development of common policies on a number of issues, including a possible Federation of European Oceanographic Societies. This key issue of future relations between the Societies will be discussed at a meeting being organized by L'Union des Océanographes de France at Wimereux in France early in 1998.

We are also maintaining close coordination with the DGM in relation to our respective publications. The exchange of news items and articles is being facilitated by the inclusion of Hjalmar Thiel of the DGM on the Editorial Board of *Ocean Challenge*.

Publicity and marketing

The stock of merchandise was moved to the Southampton Oceanography Centre in the early part of 1996, following the appointment of Jenny Jones as the Society's Executive Secretary. The new small stand was taken to *Oceanology International* at Brighton in March 1996 and the stand was manned for the week, mostly by Jenny but with support from other members of Council, Society members and students. The stand was very successful, attracting a number of new members and selling merchandise. The total amount taken during the week was £677. During the late spring/early summer of 1996, merchandise was restocked. The next meeting attended was *UK Oceanography'96* in Bangor in September. The new large stand was taken to this meeting, along with the smaller stand. The large stand was placed in the foyer, while the small stand and the merchandise were in the main hall with the posters and commercial exhibits. About £560 was taken during the week and the Society recruited a number of new members, in addition to those who took up the offer of membership with the conference registration.

Jacqueline O'Mahony helped with the stand at Bangor and her enthusiasm made the stand a focal point. She has now joined Council to help Alison Weeks and Jenny Jones with publicity and marketing.

The presence at meetings benefits the income of the Society but is also a powerful tool for promotion. To give further consideration to publicity and marketing as a means of increasing membership and income, as well as improving awareness of the Society among oceanographers, professionals in associated fields and students, a Publicity and Marketing Group has been formed and its first meeting was held in early 1997.

Meetings

In addition to *Oceanography'96*, members of the Society have organized meetings on a wide range of topics that amply reflect the current vigour of oceanographic research. These include: *Scientific priorities in Irish Sea research* (Drs H Davies and M Preston, Liverpool, July 1996); *Ocean assessment and indicators of ocean change* (Professors S Thorpe and J Woods, London, September 1996); *The exploration and exploitation of deep-water minerals* (Drs T Minshull and L Parson, London, October 1996); *The life and oceanographic times of John Young Buchanan, 1844-1925* (Dr N Wells and Professor H Charnock, Southampton, November 1996); *Littoral investigations of sedimentary properties* (Dr A Cramp, London, February 1997); *Shelf-edge oceanography* (Dr J Huthnance, Southampton, April 1997); *Modern ocean-floor processes and the geological record* (Drs K Harrison and R Mills, London, May 1997); *Ocean colour* (Dr J Aiken, London, July 1997). The Society co-sponsored a meeting entitled *Electronic Engineering in Oceanography* at Southampton in June 1997. During the past year, we are pleased to report, two books based on Challenger Society meetings have appeared: Black, K.D. (Editor), 1996, *Aquaculture and Sea Lochs*, Scottish Association for Marine Science, Oban, 93 pp; MacLeod, C.J., Tyler, P.A. and Walker, C.L. (Editors), 1996, *Tectonic, Magmatic, Hydrothermal and Biological Segmentation of Mid-Ocean Ridges*, Special Publication 118, Geological Society of London, 266 pp.

Affiliated Groups

British Group of Altimeter Specialists (BGAS) - contact: Trevor Guymer

The group continues to be active and meets twice a year, once in the UK, the other time in Europe as part of the European Group of Altimeter Specialists (EGAS). The latter was formed in 1993 after a successful bid to the CEC for funds to organize a series of euroconferences on satellite altimetry. Challenger Society funds are used exclusively for students attending the UK meeting; CEC funds have been used exclusively to help young scientists participate in EGAS. Both groups have email lists to which anyone can subscribe and which provide an effective means of keeping up-to-date on relevant space missions, data-analysis techniques, etc. The original hard-copy newsletter, GASBAG, has been replaced by an electronic version on the WWW (*http://www.soc.soton.ac.uk/Gasbag*) which contains information on how to subscribe to the two email lists, details of forthcoming meetings, abstracts of papers produced by members (prior to publication), short articles, vacancies, and links to home pages of various other altimetry users.

The 1996 BGAS meeting was held at Southampton Oceanography Centre on 4/5 June. About 30 attended, representing nine research organizations, and the papers covered waves, currents, sea ice and calibration and validation of ERS-2. Porto was the venue for the EGAS meeting held on 2-4 October 1996. European countries represented were: Portugal, France, Italy, Netherlands, Germany, Greece, UK. We were also pleased to welcome guests from Canada and the USA, as well as members of the European Space Agency, giving a total attendance of approximately 50. Financial support from the CEC enabled about 20 younger scientists to participate. 32 oral presentations were given and a special poster session attracted 14 displays, one of which advertised the Challenger Society. The talks were grouped into several themes: precise orbit determination, land and ice applications, data processing and validation, geodetic applications, waves, oceanic features. Abstracts are available on the Web (see above address).

Ocean Modelling Group - contact: Steve Maskell

The group continues to flourish and its meetings attract 50 or more. The last meeting was held during *UK Oceanography* at Bangor. The next is planned for September 1997 at the University of Liverpool.

History Group

A successful meeting on the life and work of J Y Buchanan was held at Southampton on 23 November 1996. The attendance was about 40. At the end of the meeting, the formation of a Challenger Society History Group was discussed. Though there was much support for the idea, no further progress towards the formation of such a group has yet been made. Margaret Deacon continues to represent the Challenger Society on the committee of the Royal Meteorological Society's Specialist Group for the History of Meteorology and Physical Oceanography.

Finance

Income and expenditure in the calendar year 1996 were, respectively, £24,754 and £23,316, giving an operating profit of £1,438. Depreciation on computer equipment and exhibition display stands was calculated as £2,379, giving a net loss of £941 for the year. Financial support from the Southampton Oceanography Centre and the Centre for Coastal and Marine Science is gratefully acknowledged.

Sedimentary Processes in the Intertidal Zone

Kevin Black, David Paterson and Adrian Cramp

Intertidal science in now clearly recognised as an interdisciplinary subject. The most fruitful approach is to utilize expertise in the fields of biology, chemistry, sediment-ology and physics to shed light on intertidal processes. The aim of this two-day meeting, jointly organized by the Challenger Society for Marine Science and the Geological Society of London, in association with the LISP-UK Steering Committee, was to bring together geoscientists, chemists and biologists working on the intertidal zones of European estuaries and coasts.

The meeting, held at the end of February at Burlington House, London, was well attended, with over 90 participants from the UK and the rest of Europe (Denmark, France, Germany, the Netherlands) as well as a number from North America. The programme was an eclectic one, combining reports from many branches of scientific research, united by the theme of sediment dynamics. A total of thirty talks and twenty-two posters were presented, and the topics included work completed under the umbrella of the NERC LOIS initiative (LISP-UK) and contributions from the European programmes under the MAST (INTRMUD) and Environment programmes (PRO-MAT).

Although a wide range of interesting single- and cross-discipline topics were presented, the meeting was organized around four major sub-themes: physical sediment processes, biota–sediment interactions, remote sensing of intertidal environments, and geochemical properties of sediments.

Physical processes

Physical process acting on sediments – erosion, transport and flocculation, and deposition and consolidation – were the dominant theme of the meeting. About half of the talks, and several poster presentations, focussed on this area.

The opening invited address by Professor Ashish Mehta (University of Florida) introduced the primary physical mechanisms whereby coastal muds are recirculated between the bed and the overlying water, with a special emphasis on the role of fluid mud. Dr Mehta concentrated on field sites from Louisiana and Surinam/Guyana, unfamiliar to many members of the audience, and discussed the interaction of coastline geomorphology with annual monsoon events.

The second invited address by Carl Amos (Bedford Institute of Oceanography, Nova Scotia, Canada) focussed on the tidal mudflats of the Humber estuary, in the UK. These are the site of the highly successful LISP-UK project (1994–97); LISP stands for Littoral Investigation of Sediment Properties. Dr Amos, who participated in LISP-UK, described mesoscale variability in the erosion resistance of a number of sites along a shore-normal transect. He showed that the mean erosion rate of comparatively firm muds was an exponential function of current speed, and he outlined cause–effect relationships in the pattern of erosion resistance down the shore: upper mudflat areas were dominated by atmospheric desiccation, lower mudflat areas were dominated by weakening by wave scour, and central mudflat areas were strengthened by biological binding by microscopic plants. This scenario is consistent with the biological stabilization of the mid-shore zone in the Dollard estuary (on the Dutch–German border) reported by Bart Kornmann (Netherlands).

A study by John Widdows and co-workers (Plymouth Marine Laboratory) in the Humber estuary broadly supported Dr Amos' findings. However this group also found significant correlations between indices of sediment stability and numbers of macro-infauna, as well as demonstrating quite dramatically the powerful ability of these fauna to clear near-bed turbidity by biodeposition.

A number of European researchers (Morten Pejrup and Ole Mikkleson, from Denmark; Willem van der Lee and Bart Kornmann, from the Netherlands) have been studying flocculation and floc formation in tidal waters above mudflats, particularly in the Dollard estuary. Dr Pejrup reported an inverse relationship between floc diameter (determined using *in situ* Owen-type settling tubes) and suspended sediment concentration (SSC). Such a relationship implies that the maximum size to which flocs can grow depends on the current shear in the water column. From transformations of measured floc diameter to settling speed, Dr Pejrup had also calculated the amount of sediment that would be deposited on the sea-bed and thus also the amount of sediment that would remain in suspension for a given tide. This information is of critical importance in assessing the mass-balance of sediment within a particular region and provides an indication of possible changes in bed level.

Willem van der Lee has conducted similar studies using an underwater video camera to photograph suspended flocs. Specialized underwater photography is now being widely used as a tool to visualize suspended flocs, because it avoids disturbing these fragile entities. The study involved the camera drifting with the flocs, first shorewards along a tidal channel and then across the tidal flat, so in principle sampling the same body of water all the time. In the tidal channel, floc size was found to be dependant on the SSC field, with the largest flocs forming at times of maximum SSC. However, over the tidal flat the converse was apparent, and maximum floc sizes were found around high slack water (low current velocity and low SSC). Dr Van der Lee proposed that reduced turbulence allows flocs to grow. Doug Law (Plymouth Marine Laboratory) also described how changes in floc size (measured using an *in situ* laser particle-sizing instrument) related to ambient current shear, in this case over the LISP mudflat site on the north shore of the Humber estuary.

Other studies of sediment transport were reported by Richard Whitehouse and Helen Mitchener (Hydraulics Research Ltd) and Malcolm Christie and Keith Dyer (Plymouth). Both groups had used instrumented field rigs to measure important dynamical processes. The first report concerned measurements from the Severn estuary, and emphasized the link between tidal flooding and drying out, and geomorphic changes in sediment level. The Plymouth

workers have clearly demonstrated the link between tidal phase and times of maximum bottom sediment entrainment for sites in the Humber estuary, where much of the sediment transport occurs during the passage of a shallow, turbulent, bore-like flood front and, to a lesser extent, during mudflat emergence on the ebbing tide.

Throughout the meeting, question and discussion periods ensured active participation from all audience members. A problem affecting the studies just referred to, highlighted by Carl Amos, was the difficulty of separating advected suspended sediment from that eroded locally.

The presentation by Colin Jago (University of Wales, Bangor) differed from most talks in that it was a regional study of sedimentation in a sandy estuary. Dr Jago utilised two different approaches to assess the long-term (30-year) accumulation rate of sand in the Taff estuary, South Wales. Measurements of suspended sediment flux across the estuary mouth (from profiling transmissometers) were compared with direct measurements of bed level obtained by conventional surveying techniques. Estimates of annual accumulation rate by the two methods (of the order of 0.02 m yr^{-1}) differed by only ~10%, which is remarkable given how difficult it is to obtain such measurements, and the problems inherent in computation of net, sectionally-averaged fluxes from relatively few discrete measurements. However, Dr Jago presented a thoroughly scientific and convincing argument based on his very extensive data.

Biota–sediment interactions

Over the last two or three decades, there has been a steadily increasing body of research specifically concerned with biota–sediment interactions. However, researchers have only comparatively recently considered the implications of these interactions for sediment transport. A number of interesting talks and posters highlighted mechanisms whereby benthic flora and fauna can either increase or decrease sediment erosion.

John Widdows (Plymouth Marine Laboratory) described the influence of the deposit-feeding clam *Macoma balthica* on the stability of sediments in the Humber estuary. These creatures live some centimetres below the sediment surface and forage for food at the surface using a tube-like siphon. Dr Widdows found a significant correlation between sediment erodibility and the spatial density of *Macoma*, showing that, in spite of their sub-sediment dwelling, they are able to mediate sediment transport at the sea-bed. If this information is combined with the three-dimensional distribution according to frequency, size and maturity of macrofauna derived for the area by John Davey and Valerie Partridge (Plymouth Marine Laboratory and Acadia Centre for Estuarine Research, Nova Scotia), it seems that the potential for biological destabilization across the mudflat may be enormous.

Using a portable field flume, John Widdows and co-workers have also investigated the magnitude of biodeposition by the suspension-feeding cockle *Cerastoderma edule*. Conventionally, scientists concerned with sedimentation on tidal flats have examined only the physical processes of deposition. However, this study showed quite dramatically that the biodepositional flux can exceed that due to physical sedimentation alone by an order of magnitude or even more. Studies of this nature show clearly that we ignore the presence of benthic organisms, and the interaction of biological and physical processes, at our peril.

At the close of the first day, Professor John Murray (Southampton Oceanography Centre) provided the audience with a welcome respite from the talks with an extremely novel and often humorous video presentation of biota–particle interactions. The ploughing, dislodging and butting of a variety of nematodes, turbellarians, ostracods and gastropods from a silty mud and medium sand were viewed with wonder. This proved quite conclusively – even to hardened physical sedimentologists – that these almost invisible meiofauna can and do exert a substantial influence on grain–grain interactions!

In contrast to bioturbation and biodeposition, the parallel phenomenon of biogenic stabilization (first described in 1977 for laboratory mud slurries containing various species of benthic diatoms) was discussed by an unexpectedly large number of researchers. Altogether, the meeting contained seven presentations citing evidence of marine sediment biostabilization from a number of different geographical locations. In most cases, the prime agents were benthic diatoms, but biostabilization by chemoautotrophic bacteria was also reported (Susanne Heise, Germany). It seems that biostabilization may be a ubiquitous phenomenon in meso- and macro-tidal muddy estuaries, particularly during the summer months. The 'extracellular products' of benthic diatoms are now known to be the active biomolecules responsible for the increase in grain–grain bond strength. Work by Graham Underwood and David Smith (Essex University) indicates that there is a complex natural cycling of these products, with pronounced variability both temporally (on diel, tidal and fortnightly time-scales) and spatially (on scales of microns, mm, cm and m).

In spite of the wealth of information contributed by speakers, a thought-provoking discussion revealed a dearth of understanding of the myriad biostabilization phenomena. It is clear that continued research is necessary if we are to develop a full understanding of this important aspect of sediment ecology and dynamics.

Remote sensing of intertidal zones

A number of papers addressed the study of intertidal zones via remote sensing. Remote sensing is a technique particularly well suited to such environments because it has a wide spatial coverage and can be used frequently to assess estuary-wide temporal changes.

Mick Yates (Institute of Terrestrial Ecology) described the use of remote sensing to map the distribution of sediment type and certain morphological and physical characteristics in 25 UK estuaries. Dr Yates also described complementary work aimed at using sediment type as a proxy for the number of shorebirds supported per unit area of tidal flat. Useful relationships have thus far been established between sediment distribution and the number of shorebirds in the Wash, eastern England.

Rolf Riethmüller (Germany) reported on the use of aerial remote sensing to measure sediment distribution in the Wadden Sea. He was able to discern the percentage of grains <63 μm in diameter (mud fraction) in surficial sediments. In addition, during the summer months, extensive mats of benthic diatoms (which would significantly affect sediment stability) could be detected. Further processing of the remotely sensed data (to obtain spectral reflectance) enabled discrimination of the chlorophyll concentration in the uppermost layer of sediment and Dr Riethmüller was thus able to map both sediment type and phytobenthic coverage across

broad areas. Using empirical relationships between sediment stability and benthic chlorophyll-*a*, he extended his interpretative maps to provide an indication of sediment stability. This work represents a considerable advance in our ability to both view and map the stability of large areas of coastline. Continued validation of the remote data should provide a firm basis for monitoring and managing these environments.

David Paterson (St Andrews) also examined the relationship between sediment spectral reflectance and biological processes occurring within the upper layers of cohesive sediments. However, his presentation was concerned more with the detailed ecological processes associated with motile benthic diatoms throughout tidal cycles, and showed how the microspatial positioning of these small cells can radically alter the spectral reflectance signal. The juxtaposition of this talk with that of Dr Riethmüller focussed the discussion on the issue of remote sensing and the potential for future applications.

Rob Nunny (AMBIOS Coastal), one of many non-academic participants at the meeting, described remote sensing of various types of sea-floor – different rock types, sediments and benthic organisms (algal beds etc.) – in the Dornoch Firth, Scotland, using an acoustic method known as the RoxAnn system. RoxAnn is a ship-based echo-sounder system which processes the second and third echoes to provide information on sea-bed roughness and hardness. This system, which has been used extensively in the oil industry but which was probably unknown to many of the academic delegates, demonstrated the relative ease with which large areas of sea-bed could be accurately characterized; in contrast, comparable techniques using aerial photography or ground sampling, would be extremely time-consuming.

These three talks demonstrated the general usefulness of remote sensing, in whichever form, to intertidal science. Although some degree of 'ground truthing' is always necessary, potential applications for future studies using this technology are wide and varied, and very numerous.

Geochemical properties of sediment

A number of talks and poster presentations were concerned with the geochemical properties of mudflat and saltmarsh sediments. Several authors (Jim Lewis, Southampton Oceanography Centre; Simon Turner, Brunel University) showed how depth profiles of natural and anthropogenic chemical species may be used to assess the record of deposition through time. Bob Clifton (Plymouth Marine Laboratory) had measured the levels of the radionuclides ^{137}Cs and ^{210}Pb at each of the four LISP stations in order to determine the net accretion rate and the degree of sediment mixing. These investigations, in association with similar measurements made concurrently by Graham Shimmield (Dunstaffnage Marine Laboratory), indicate that the surface 50–100 cm are relatively well mixed, and that a sedimentation rate of the order of 1 cm per year may be appropriate.

A number of studies were concerned with pore-water chemistry. José Soares and Peter Statham (Southampton Oceanography Centre) reported on a new technique for measuring mm-scale variations in metal content in intertidal muds. In contrast to the results from conventional (cm-scale) sampling, they found a highly detailed micro-variation in metal content with depth for saltmarsh sediments in Southampton Water. Trish Frickers and Peter Watson (Plymouth Marine Laboratory) measured the gradients and fluxes of ammonia, nitrate, nitrite, phosphorus and silica in the surface sediments at locations along the LISP transect. They reported a cross-shore variability influenced in the main by the activities of benthic macrofauna. Different populations and differing densities at each of the stations yielded substantially different fluxes (positive and negative) according to the species.

Summary

The two-day meeting was a great success. It was the largest Challenger Society meeting ever hosted at Burlington House, and included those who have worked in the field for many years, as well as post-graduate students presenting their work for the first time. The meeting was also timely: intertidal science has a long history but there has been little in the way of a comprehensive overview of the fundamental physical, chemical and biological processes for some years. The talks and poster presentations encompassed these and much more.

Whilst the overall theme of the meeting was sediment dynamics, the large number and wide variety of presentations clearly illustrated how complex sedimentary environments are, and how important it is to have an integrated view of all the processes involved. Most of them affect or, in some cases, mediate the transport of fine, inorganic sediments.

The occasion also provided a lively forum for debate. It is often only through discussions that we are able to identify gaps in our knowledge and see the way ahead for future research. The meeting also granted an opportunity to view or hear about new or developing technologies. These included several field devices for measuring erosion, a new microscale sediment sampling technique (DGT), a novel application of remote sensing technology, and an *in situ* motorized penetrometer. Such technology underpins much of the field-based research, and it is precisely this research that increases our knowledge and understanding of natural environmental processes along muddy coastlines.

The proceedings of the meeting will be published in a peer-reviewed Special Issue of the Geological Society of London, due out in May, 1998. There are many areas which, due to space constraints, have not been described here, but which were nonetheless an important and integral part of the conference and will appear in the final volume. These include: benthic spatial heterogeneity, modelling (of ecological and physical processes), sedimentation on saltmarshes, pigment fingerprinting, river–estuary sediment transport, mudflat typology, and geophysical assessment of muds.

The meeting Abstract Volume is currently on the WorldWideWeb at http://www.st-and.ac.uk/~ksb2/conference/booklet.html

The meeting was sponsored financially by the UK Joint Nature Conservation Committee and the Challenger Society for Marine Science, with additional funding from an EC MAST Program (PROMAT) and support in kind by the Society for Underwater Technology. The respective organizing committees are grateful for the assistance provided by these organizations.

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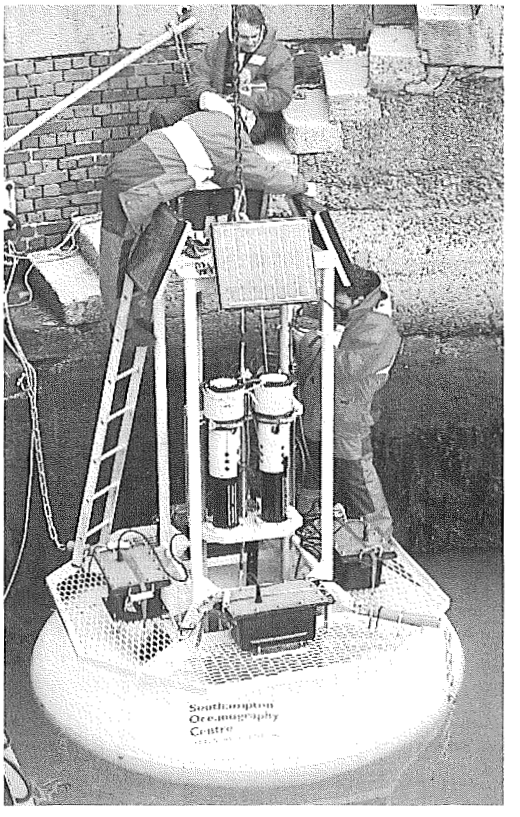

Sonus 3 buoy launched at SOC March 1997

Marine Monitor provides control, data gathering and real-time telemetry aboard the Southampton Oceanography Centre SONUS buoy. Parameters include salinity, temperature, turbidity, fluorescence, nitrate, phosphate, PAR irradiance, and dissolved oxygen. Data are telemetered to base in real-time. Other users include CEFAS (MAFF) and SEPA.

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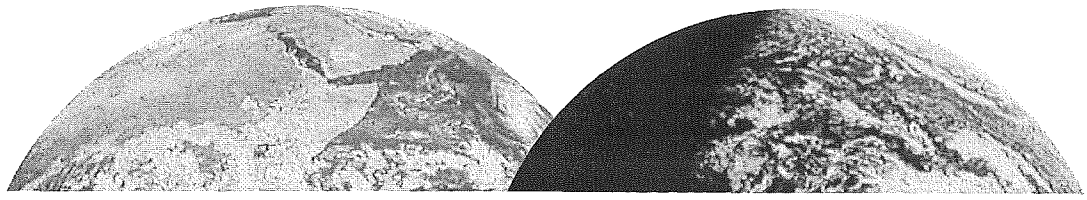
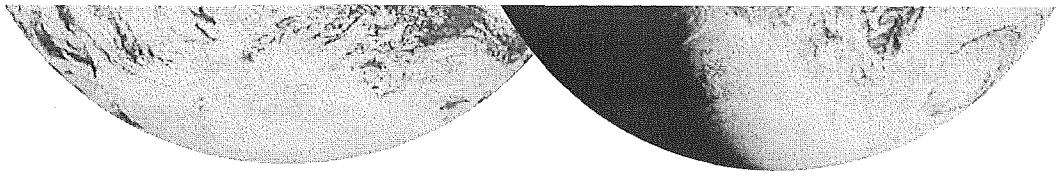


Our world and the sea:
Global Change and Global Security

D. James Baker



For much of this century and past centuries, national security has revolved around military strength. Yet as we approach the 21st century, nations are finding that security – in its widest sense – is increasingly dependent on more than national defence; it also depends on economic growth, the conservation of natural resources, and the protection of the environment. At Rio de Janeiro in 1992, the nations of the world called for the recognition that environmental protection and stewardship of natural resources go hand-in-hand with global economic growth. This is the definition of sustainable development.

The Changing Global Context

As we face the challenges of sustainable development, it will be important to use the best available scientific knowledge to address real and pressing problems of society. The world's growing population will continue to make increasing demands on the environment and on natural resources, and international scientific research will be essential if we are to understand the potential environmental impacts of human activities and respond appropriately to changes in the global environment. We must link scientific information with management decisions and incorporate scientific advances into the ongoing, day-to-day activities of environmental agencies.

The issues we face are truly global, and international collaboration will be a key to ensuring that the knowledge we gain contributes to the common good; the principles of thinking globally are more important than ever. Oceanographers are used to dealing with global systems. Since the original *Challenger* Expedition in the latter half of the 19th century, oceanographers have greatly improved our knowledge about fisheries, weather and climate, marine water quality, coastal ocean processes, and geological history. Advances in ocean science and technology have contributed to the use and conservation of marine resources – from fisheries to minerals. Economic development of coastal areas requires knowledge of the ocean's role in weather and climate and of the ocean as a sink for pollution. We have seen increasing conflicts over the use of oceanic and coastal resources, and we must use the scientific knowledge and experience we have gained to manage these conflicts in the most productive ways.

We all agree that we need to learn more, but we must also do a better job of applying what we do know to addressing societal problems. Research and applications go hand in hand. Scientists need to work in partnership with the full range of ocean and coastal users and managers so that our management of resources is both science-based and responsive to practical needs. In this article I will give some examples of how the US National Oceanic and Atmospheric Administration (NOAA) has begun to make the transition from research to operations, both in its own US activities and within international organizations, and how it has used partnerships to improve the management of natural resources.

From Research to Operations

Through the World Weather Watch, managed by the World Meteorological Organization, meteorologists have successfully made the transition from scientific research to operational predictions and from local weather observations to a global weather-observing system. As a consequence, in many regions of the world today the public expects to be provided with accurate weather forecasts in

This article is largely based on a talk given to The Oceanography Society in Amsterdam in July 1996.

the same way that it expects to be provided with traditional infrastructure such as roads, bridges, sanitation services, and telecommunications. The services provided by the meteorological community are utilized on a daily basis by agriculture, recreation, transportation, and construction sectors, as well as by the general public. Plans are underway to expand the World Weather Watch into a Global Climate Observing System (GCOS) to provide an even broader range of services.

How well is the oceanographic community making the transition from scientific research and technological advances to improved operational systems? Oceanographers are now planning a Global Ocean Observing System (GOOS) which will contribute its climatic aspects to the Global Climate Observing System. One example of the contributions of GOOS is the improvement of forecasts of the El Niño–Southern Oscillation (ENSO) phenomenon. For the United States, the variations in climate associated with ENSO have had dramatic impacts on agricultural productivity, water resource management, hydro-electric power generation, and commodity markets. In the south-eastern United States alone, the annual benefits to the agricultural sector from improved ENSO forecasts are estimated to be more than $100 million annually.

To get those forecasts, we need oceanographic data. NOAA has been the key supporter of the Tropical Atmosphere Ocean (TAO) Array in the Pacific Ocean. The array has been providing those oceanographic data, which have been essential for the prediction of seasonal and interannual variations in temperature and precipitation. The TAO Array comprises 68 moored buoys and provides real-time monitoring of sea-surface temperatures, surface winds, and upper ocean thermal structure across the Pacific. TAO has been supported by the United States and other countries in the region, and the international contributions of ship-time and observational moorings have been important to maintaining the program. In the United States, NOAA is taking the lead to ensure long-term operational support of the TAO Array, as recommended by the planners of GOOS and GCOS. This will be the first step towards making the transition from research to operations for this important observing system.

NOAA has also made real advances in converting oceanographic instruments from research to real-time operational systems with the development of the Physical Oceanographic Real-Time System (PORTS). PORTS is a multi-sensor system that provides real-time data on currents and water levels. The data provided by PORTS make it possible for vessels to operate safely during a wider range of tide levels, without increasing the risk of grounding, and the system could potentially reduce the need for dredging. A good example is the PORTS system in San Francisco Bay. The water beneath the Golden Gate Bridge can be as deep as 380 ft (~115 m) but it quickly becomes shallow inside the headlands. Accurate real-time information about currents and water levels is essential for safe navigation of the Bay. The San Francisco PORTS is part of a large multi-faceted San Francisco Bay Demonstration Project, which is being conducted by NOAA in partnership with a range of Bay Area groups.

The Importance of Partnerships

The incorporation of new scientific knowledge and new technologies is essential to continued improvements in operational systems. At the same time, in designing systems and management approaches that best meet societal needs we must engage with scientists from other disciplines, as well as with policy makers and the public. Partnerships are a key to maximizing the return on our investments, to facilitating the exchange of scientific information, and to designing effective resource and environmental management solutions. For NOAA, partnerships have been essential in addressing fisheries and coastal zone management issues.

Fisheries

In the United States, NOAA has responsibility for ensuring the sustainability of marine fisheries. NOAA's ability to fulfill this responsibility is dependent on applying scientific information and adopting a precautionary approach to fisheries management questions. In that context, we have found that it is essential to involve a broad array of interested parties in addressing resource management or facilities issues.

For fisheries management, NOAA depends on input from Regional Fishery Management Councils. Under the Magnuson Fishery Conservation and Management Act, eight regional councils were established – for the Caribbean, Gulf, South Atlantic, Mid-Atlantic, New England, Western Pacific, Pacific, and North Pacific. These councils include representatives of federal and state governments, the private sector, environmental organizations, recreational interests and the academic community. They develop fishery management plans based on science and economic needs, but always in the context of sustainable fisheries. The councils have been instrumental in addressing problems such as uncontrolled access to fisheries, the overcapitalization of the commercial fishing industry, overfishing, and the bycatch of non-target species.

A good example of how the Regional Fishery Management Councils have worked is the management of the Alaska halibut and sablefish fisheries. Prior to 1991, these fisheries operated under an open-access system, which became increasingly dangerous and overcapitalized. In both fisheries, vessel operators were in strong competition with one another and often endured rough weather and life-threatening conditions in order to harvest as many fish as possible before the catch limit was reached and the fishery closed. Too many boats were chasing too few fish. In addition to being dangerous and inefficient, these derby-

style fisheries were disruptive to local economies. The rapid harvest in such a short period of time meant that fresh fish were available for only a few weeks each year; most of the fish that were caught had to be frozen for future purchase and consumption.

In 1991, the North Pacific Fishery Management Council recommended a limited-access management system of Individual Fishing Quotas (IFQ) for the sablefish and halibut fixed-gear fisheries in and off Alaska. Under this system, an individual's quota share is determined by their fishing history in specified base years, and only fishermen who are granted IFQs are authorized to harvest halibut or sablefish. Fishermen are able to harvest their individual quotas in ways that are most beneficial to their own operations; their quota allocation is guaranteed and they no longer have to engage in a race to catch the fish. The IFQ system has made the fishery safer and more efficient and has provided fresh rather than frozen halibut and sablefish for consumers.

Coastal Zone Management

Another example of the success of involving affected stakeholders in decision-making is the Coastal Zone Management Program. In the United States, coastal populations are expected to grow by 15 per cent during the next 20 years. Coastal waters are being stressed by polluted runoff and increasing demands for recreational services; and the number of lives and properties vulnerable to coastal storms is growing. Coastal recreation and tourism generate $8 to $12 billion annually in the United States, but this economic activity depends on continued productivity of coastal habitats, clean coastal waters, well-planned coastal communities, and safe and navigable harbours. Science-based management approaches are essential to ensuring the future environmental health and economic prosperity of coastal regions.

The Coastal Zone Management Program was established in 1972 to address problems such as inadequate public access to the coasts, degraded coastal resources, derelict urban waterfront areas, and unplanned coastal development. The Program gives balanced consideration to the need for coastal economic development and resource protection. Under the Program, the Federal Government sets broad guidelines and works with states as they develop their own coastal zone management programs. Since 1972, 29 of the 35 US coastal states and territories have developed approved state coastal programs, and five additional states are in the process of developing coastal management programs.

The Program has had many successes: for example, thirteen states have developed coastal hazard management programs to keep development out of high hazard areas and to reduce storm damage losses. And nearly 3400 acres (~1350 hectares) of ecologically or recreationally important coastal areas have been purchased with coastal management funds. In Philadelphia and Erie, Pennsylvania, $5 million in coastal management planning funds has helped leverage nearly $1 billion in waterfront redevelopment projects. The Program is a clear example of how the Federal Government can work in partnership with states and communities to promote sustainable development.

Scientists as Advocates

Organizations like the Challenger Society can help by examining the role of science in meeting the needs of society. The full benefits of scientific research and development will only be realized if our results are incorporated into improved operational systems and resource management approaches. Continued scientific research is essential to improving our understanding of the Earth system, to protecting the environment, and to managing the Earth's resources for current and future generations.

As members of the scientific community, we have an important role to play in fostering international collaboration and working together to address environmental and natural resource problems. In this new global context of integrated social, economic, and environmental security, the insights we gain through research will be a key to realizing sustainable development. And we as scientists have a responsibility to inform the public about what we do. Knowledge is power, and the scientific community can provide the information that the public needs to address critical environmental and scientific issues.

As scientists with a global view, we have an obligation to provide the world with the strongest possible scientific and technological foundation for the 21st century. But this will only be possible if those of us who have devoted our lives to science actively participate in public policy debates and communicate the importance and relevance of our work. The Challenger Society and similar organizations in Europe and the United States can play a critical role in encouraging their members to become involved in public policy discussions.

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Dr Baker was previously President of Joint Oceanographic Institutions Incorporated, Dean of the College of Ocean and Fishery Sciences at the University of Washington, and on the faculties of Harvard University and the University of Rhode Island. He was the first President of The Oceanography Society.

Post Script

Of course, these ideas needed to be tested with appropriate field measurements. The traditional notion of formation and spreading of LSW needs to be re-examined. Is LSW indeed formed outside the gyre during harsh winters? Does it take months, not a decade or more, for this water to reach the subtropical North Atlantic? If so, then the idea of a sluggishly responding deep ocean is not always correct – which raises new questions regarding atmosphere–ocean coupling in the region.

This past winter we again visited the Labrador Sea during the severest months, as part of a larger experiment sponsored by the US Office of Naval Research studying convection in the Labrador Sea. Unfortunately, as of a couple of years ago the NAO began dropping again, so the conditions were not favourable for convection outside the gyre. Hence we concentrated our work within the gyre, where we were sure to observe deep convection (which in fact we did). Complete confirmation of the ideas presented here will thus have to wait until the NAO undergoes its next large oscillation.

Editor's Note: *Closely related articles on LSW formation and spreading can be found on pp.649–50 and 675–79 of* Nature, ***386,*** *17 April 1997.*

Further Reading

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Talley, L. D., and M. S. McCartney (1982) Distribution and circulation of Labrador Sea Water. *Journal of Physical Oceanography,* **12**, 1189–205.

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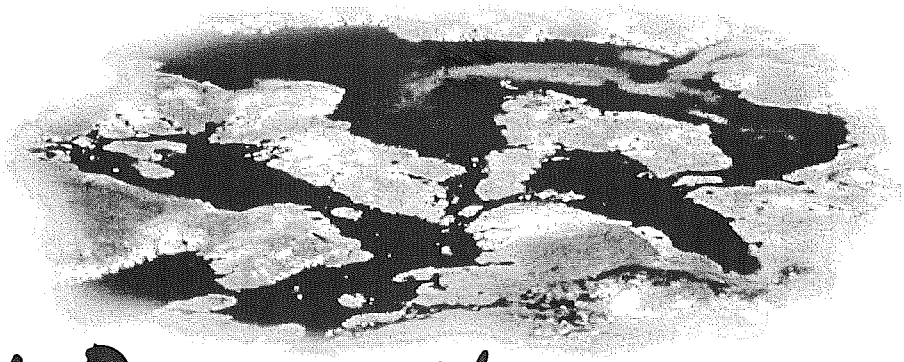
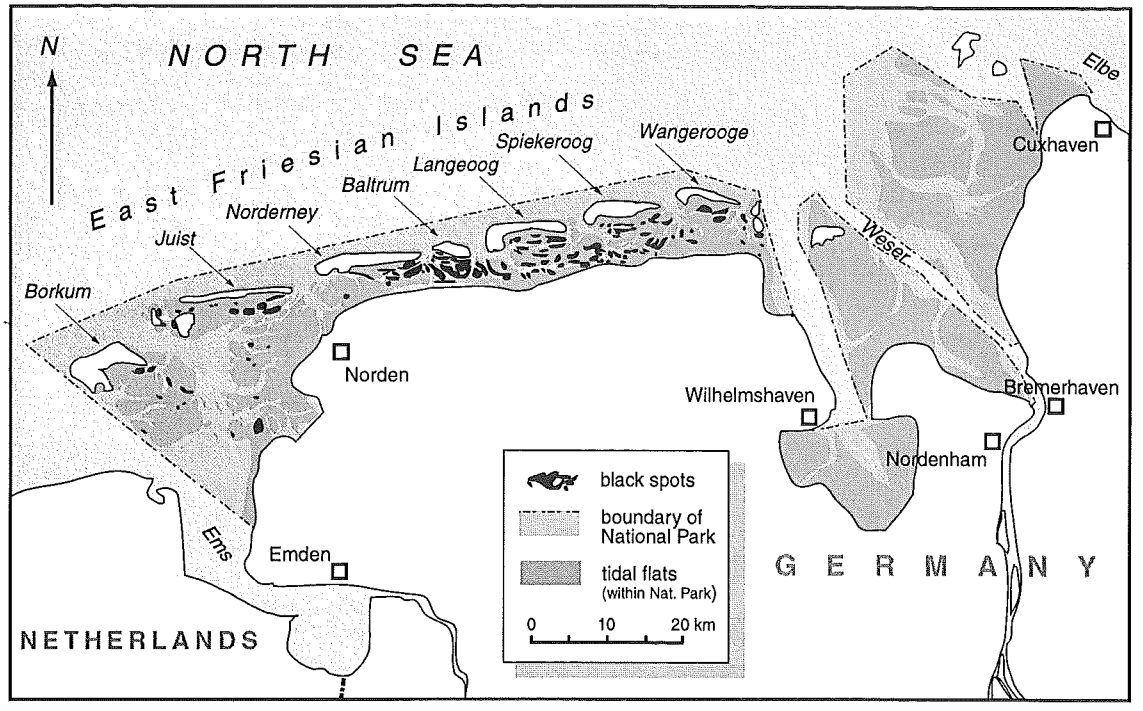
Robert Pickart is an Associate Scientist at the Woods Hole Oceanographic Institution. After two winter cruises to the Labrador Sea, the idea of studying equatorial oceanography has suddenly become quite appealing.



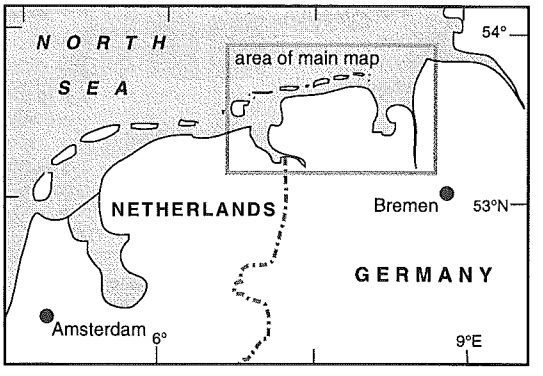
Black Days in the German Wadden Sea

Thomas Höpner

After flying over the East Friesian Islands of the Wadden Sea on 28 and 30 May 1996, the responsible authorities reported a dramatic growth in areas affected by 'black spots', a phenomenon which scientists had so far considered to be 'only' a warning signal. Experts had warned of such extreme consequences of over-fertilization and over-exploitation but this eventuality had not been considered very likely. However, it had happened and, furthermore, black spots (a term coined by researchers in a project entitled 'Ecosystem Research in the Lower Saxonian Wadden Sea') had turned into black areas. During previous years, the total area covered by these spots had amounted to 0.1% of the tidal flats, but by 12 June 1996 they covered up to 20%. Creeks were filled with black water, hydrogen sulphide accumulated in pore water, and even in tidal pools sulphide reached concentrations toxic for all bottom organisms. Everywhere on the tidal flats there was a deficit of oxygen.



Places where black spots were observed during the aerial surveys of 18/30 May and 12 June 1996



What are the black spots?

One of the functions of the Wadden Sea sediments as far as coastal waters are concerned is facilitating the decomposition of organic material. This material accumulates through the growth of bacteria, algae and bottom organisms, either on the spot where the organisms died (i.e. is autochthonous), or after the organic remains have been brought from offshore by tides, currents and wind (i.e. is allochthonous). Through physical transport and through burrowing by bottom organisms (bioturbation), organic material is carried down into the sediment. Near the surface, decomposition takes place by oxygen consumption; in deeper layers it takes place mainly by reduction of sulphate, which is one of the main constituents of seawater.

As long as the decomposition capacity is not overstrained, a balance can be attained at a redox horizon a few centimetres down in the sediment, in mud sometimes only a few millimetres down. The horizon separates black, oxygen-free (anaerobic) and sulphide-containing sediment at depth from the upper light-coloured oxic sediment layer. Its position is essentially determined by bioturbation because this is the most important way in which oxygen is transported down into the sediment. Sulphide, which forms in the anaerobic sediment from sulphate, is reoxidized to sulphate in the oxic layer so that the benthic organisms depending on oxygen at the sediment surface are protected from the poisonous sulphide. The black areas are nothing more than the absence of the oxic sediment layer and the appearance of the black anaerobic sediment at the surface. This situation can only arise when the decomposition capacity is overstrained, with the result that bioturbation ceases.

The Ecosystem Research group regarded the appearance of black areas as a warning signal and have studied the phenomenon since 1989. The group also undertook experimental simulations. This was far-sighted and – from the scientists' point of view – fortunate, since the black spots increased in their main areas of investigation, so they could observe how they developed naturally.

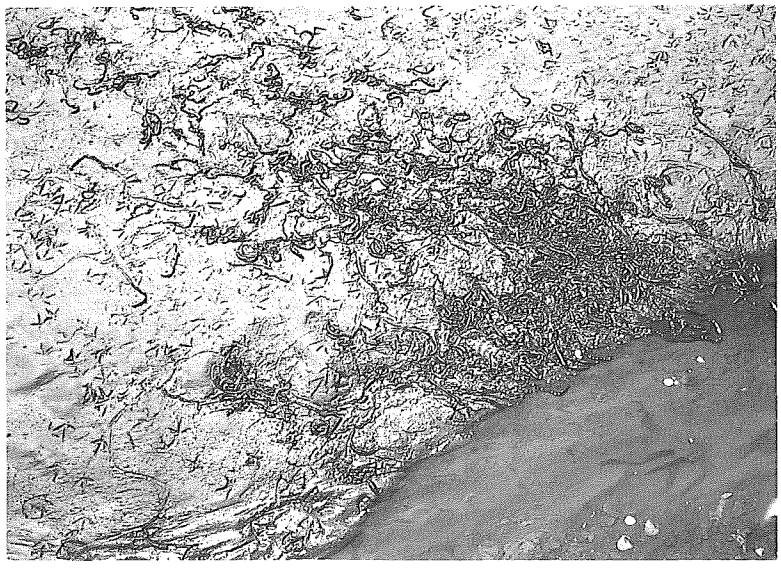
There was excessive growth of macroalgae (also a eutrophication phenomenon), which became aggregated into clumps and then buried in the sediment. An additional factor was the accumulation of dead sand-gapers (*Mya arenaria*). Biological decomposition of these organisms consumed the oxygen so fast that it could not be replenished from the surface. However, it was replaced by sulphate from seawater, which was reduced to sulphide. Together with iron ions, this produced the black stain; when black stains appeared at the surface, they indicated the lack of oxygen and the existence of sulphide. The warning signal indicated a local overstrain of the decomposition capacity of the sediment: when it was observed, the surface had become hostile to life.

Pools on the mud-flats became anoxic and sulphide-rich (the area shown is about 2 m by 1 m)

The fact that the black areas were easy to observe made them a very good warning signal for toxic conditions. They formed the basis of a useful research project because they lasted for several weeks or months. They were a reliable indicator of toxic conditions because they represented the biological damage itself (though only in a very small area and surrounded by sediment that was still biologically and chemically sound).

There was not yet a crisis, but a drastic increase would lead to one. The black spots enabled us to investigate the crisis before it actually occurred. After the end of the freezing weather (end of March 1996) there had been indications of a larger overstrain but this was not sufficient for a definite warning. However, when the crisis occurred we were already well aware of the contributory factors.

In June 1996, large numbers of dead* Arenicola marina *(lugworms) could be seen lying on the surface of the mud



A multi-causal cascade

On 12 and 13 June, the administrative authorities of the National Park and the German–Danish–Dutch Common Wadden Sea Secretariat (CWSS) called together an international group of experts who, after a visit to the tidal flats and an evaluation of the research results of a number of years, came to the conclusion that the appearance of black areas was a multicausal phenomenon. As a result, we developed a cascade-like scheme of development which has been widely approved (see the table opposite). There are still some aspects that are hypothetical but they are at the very least plausible.

It was assumed that the initial strain was the accumulation of dead organisms. Additionally, there was a dramatic decrease in numbers of the common mussel (*Mytilus edulis*) which meant a decrease in the active biological filter function.

Once black spots had occurred in a particular location, they could be expected to develop again. The reason is that the first overstrain binds the iron by the development of sulphide. Each further overstrain and production of sulphide leads to an increase in sulphide concentration in the pore water because there is no longer a binding capacity of the iron. The mathematical model which satisfies the black spot scenario is confirmed by the latest observations.

As the freezing weather of January–March 1996 occurred during the course of the Ecosystem Research project, there was the opportunity to study the effects of ice-formation. On the tidal flats, bottom animals sensitive to cold, especially cockles (*Cerastoderma edule*) and sand-mason (*Lanice conchilega*), were almost completely destroyed. As a consequence of the low temperatures, their organic remains stayed partly preserved in the sediment until the end of May.

A further deterioration

At the end of May, there was a further additional strain by an extraordinary bloom of the planktonic cold-water diatoms *Coscinodiscus concinnus* and *C. walesii*. After the breakdown of the bloom, large amounts of biogenic lipids were released into the coastal sea and an unknown proportion was washed into the Wadden Sea. This increased the amount of oxygen-consuming material, and it is probable that the lipids temporarily hindered the input of oxygen into the sediment and hampered gill-breathing by bottom animals. The variable lipid load was probably the reason why the extent of the damage was different in different regions. By this time, even lugworms (*Arenicola marina*) were dying in vast numbers.

Black spots: a cascade effect resulting from overcharging a predamaged ecosystem?

Pre-damage by high stock of organisms, organic material, nutrients, and toxic matter (?)
severe loss of (filtering) mussels

Exhaustion of sulphide buffer by previous black spots

Damage in the freezing winter (1996)
by additional losses of filtering and burrowing bottom animals

Further accumulation and preservation
of dead organic material

Loading in mid-May
with an extraordinary diatom bloom and diatom-borne lipids.

Temperature trigger in early June
by a sudden warming

Peak of damage 10 June
hydrogen sulphide toxicity
lack of oxygen
additional increase in dead organic material

Further decline in filter-feeding and burrowing animals

Self-perpetuating/positive feedback effects
formation of hydrogen sulphide
oxygen consumption
nutrient release
release of heavy metals (?)

After a consistently cool period (with only one warm day on 31 May) temperatures rose on 5 June from an average of 15 °C to 30 °C and did not fall until 12 June. There was either no wind or only a light wind. With the sudden rise in temperature, the abrupt oxygen-consuming decomposition of accumulated organic material started abruptly, and this was too much for the physical and biological mechanisms of oxygen supply.

Tragically, the conditions were self-perpetuating or even self-reinforcing. As a result of the inadequate bioturbation there was no input of oxygen. The decomposition of sulphide was too slow. Sulphate reduction continued to dominate and excessively high sulphide production was maintained. The sulphide concentrations in the pore water rose 2000-fold and correspondingly, the sulphate concentrations fell to half their natural value in seawater. This hampered or prevented the new colonization by bottom organisms. The nutrients contained in the organic material were released and increased the eutrophic conditions.

The event reached its climax on 10 June. From 12 June onwards, a strong wind and lower temperatures improved the superficial appearance of the tidal flats, but there was no basic improvement.

None of the events in the 'cascade' was individually responsible for the catastrophe. The primary cause was the high nutrient input with the resulting eutrophication (defined as an increase in the amount of accumulated organic material). The later steps of the 'cascade' are additional or triggering components.

The beginning of recovery

From the end of July, the sulphide concentrations started to decrease slowly and by the end of September were back to normal in most places. At the same time, there was an unusually high spat-fall of the dominant benthic organisms. It was fascinating to see how the young animals began to ventilate the sediment by burrowing. At first, only a few millimetres were affected, then, with growth of their bodies, this was extended to centimetres. The geobiochemical regeneration was a biological process rather than a physico-dynamic one.

Post Script

In August 1997, even after one month of extraordinarily hot, calm and sunny weather, the ecological state of the area affected one year before was satisfactory. There was an extremely high stock of young benthic faunal organisms and of benthic micro- and macroalgae, but almost no black spots.

The regenerative power of the Wadden Sea was able to overcome the crisis, but tests are still being carried out to show whether there are any long-term consequences. Unfortunately, it seems that the Wadden Sea has become more vulnerable to impacts.

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Book Reviews

The Ocean Circulation Inverse Problem by Carl Wunsch (1997). Cambridge University Press, 442pp. £35.00 (hard cover, ISBN 0-521-48090-6).

'Have you seen that new book on ocean inverse techniques?' I asked a meteorological colleague of mine. 'What, Wunsch?, Yes – *excellent*!' which is, I guess, the general verdict.

As Carl Wunsch says in the introduction, 'What I mean by the title of this book ... is the problem of inferring the state of the ocean circulation, understanding it dynamically, and even perhaps forecasting it, through a quantitative combination of theory and observations.' Reassuringly hardback, with 400 pages of text and figures, 20 pages of references and enough equations to sink a small battleship, the book takes the reader through the jungle of maths and methods which are the backbone of inverse modelling today.

The first chapter I recommend to *everybody*, however fleeting their interest in the inverse problem. The tone is inspiring and enlightening yet down-to-Earth, and dispels many of the myths of oceanography that newer converts consider written in stone. However, if you baulk at matrices or are looking for a noddy review of the field, then you can probably stop there. It is *not* a book for the casual reader, the coffee table or the mathematically faint-hearted. It is designed as a 'graduate level text for the student of oceanography', and it is true to that aim.

After a brief workout on oceanography and then statistics – Chapters 2 and 3 (which will either boost or depress you depending on your previous knowledge) – it is in at the deep end. Though at times heavy going, it remains readable thanks to the amusing footnotes, asides and wry comments. The author obviously possesses great insight into the workings of the methods, and this insight turns otherwise dry detail into understandable techniques. It's not just the 'how', but also the 'why'. Only towards the end (when perhaps only the hard core are still reading just for fun) are the explanations rather thinner on the ground.

From least-squares to Gauss–Markov estimation, sequential estimators and the adjoint/Pontryagin principle, including both time-independent and time-dependent problems, the reader is shown what it *means* to work out the 'singular value decompositions and null spaces', etc. of a problem. The emphasis is on methods, their errors and their limitations. Specific examples, from 2×2 matrices to examples using real data, are worked through in all their numerical glory, not just as asides or as 'exercises for the student' but as main illustrations in the text. Even if you will never program one of these methods in your life, you will gain an insight into the pitfalls and the errors to expect from other people's data. If it falls to you to use such methods in cold blood, then the numerically worked examples are doubtless a godsend.

Whinges really are minor – the pictures in the first chapter are inexplicably reproduced both in black/white and in colour, and confusingly numbered and positioned, but this is a niggle rather than a problem. The flow is sometimes a little disjointed, and one can feel a bit lost, especially at the end, where the book really lacks a unifying conclusion. That said, each section contains the guidelines and summaries only an expert in the field can give, and who reads a textbook cover to cover anyhow?

It is *not* a stand-alone text. Prior knowledge is essential. The mathematics are non-trivial, and before using any of the methods a first timer will most likely need to refer to other material. There are however ample 'foothold' references into the relevant parts of the literature. I have not worked through the examples with the author, nor derived all the equations, but I now know where to look when the need arises!

If you do nothing more than just flick through the introduction, get hold of the book at least once. The crusading style of the first Chapter and the book's obsession with determination of error estimates of the numerical fits are lessons to us all. The approach is refreshingly honest, readable, even entertaining. The underlying message lies in his quotation from Huxley: 'as the grandest mill in the world will not extract wheat-flour from [peapods], so pages of formulae will not get a definite result out of loose data.' Although at times that conclusion appears depressing, this book will start you on the road to do the best you can.

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Atmosphere–Ocean Interaction (2nd Edition) by Eric. B. Kraus and Joost A. Businger (1994). Oxford University Press, 325pp. £65 (hard cover, ISBN 506618-9).

This book largely succeeds in its stated aim '... to present a coherent, up-to-date account of processes that involve the transfer of energy, matter and momentum between the atmosphere and the ocean'. There is a strong emphasis on processes and one particularly commendable strength of the text is in its treatment of sub-mesoscale processes (from the marine microlayer, bubbles and spray to Langmuir circulation and mixed-layer development). The book appears to have been written principally for postgraduate physical oceanographers and meteorologists, but as it is well written it should be reasonably accessible to many others. The inclusion of gas and particle transfer would reward the study of interested marine geochemists.

This 'second edition' is a heavily revised version of a monograph written by Eric Kraus alone some twenty-five years ago. In the intervening years the volume of research in this field – if not the penetration – has increased enormously. I am highly impressed that two scientists can cover such a large area of research at such an advanced level. It is not surprising that this coverage is sometimes patchy; whilst the treatment is always at least competent, some sections betray a relatively superficial knowledge of the sub-discipline concerned.

The first three chapters are relatively standard text-book affairs. Chapter 1, 'Basic concepts' introduces some relevant fluid mechanics. This is dealt with well enough but may be an unfortunate (and unnecessary) discouragement to the less mathematically inclined. Chapter 2, 'The state of matter near the interface', deals (predictably enough) with temperature, salinity, moisture and heat, but also encompasses dissolved gases, bubbles, spray and sea-ice. Chapter 3 deals concisely with 'Radiation' at the sea surface. Chapter 4, 'Surface wind waves', covers both the kinematics and dynamics of these waves; the kinematics is all firmly established, but in the sources and sinks of wave

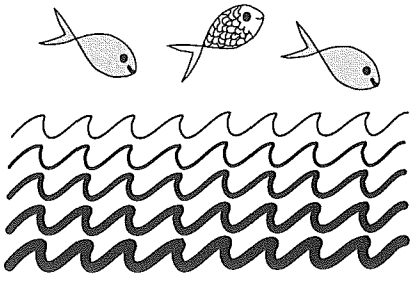
energy there is currently much controversy. This is a fair and coherent account of current knowledge, but further reading is recommended.

Chapters 5 and 6 form the heart of the book and deal with highly active areas of research to which the authors have contributed most significantly. 'Turbulent transfer near the interface' is an excellent account benefitting particularly from Joost Businger's active interest in micro-meteorological methods. The description of exchange across the marine microlayer (the critical process for the transfer of most gases) is relatively sparse but is an adequate introduction. 'The planetary boundary layer' covers both the atmospheric boundary layer and the upper ocean mixed layer. It begins with a description of Ekman layers, discusses coherent structures and finally describes and evaluates both mixed-layer models and parametric models of boundary layers.

Chapters 7 and 8 move on to relatively large-scale processes, ranging from internal waves to thermohaline circulation. As acknowledged in the introduction, much of this material has been dealt with more thoroughly by Gill (*Atmosphere–Ocean Dynamics*). Nevertheless, this book provides a new and valuable perspective.

In summary, this is an academically challenging book, but I have found it to be a valuable reference and can recommend it. It is a serious book, but adequately rewards the reader's effort.

David K. Woolf
Southampton Oceanography Centre



Beneath the North Atlantic by Jonathan Bird (1996). Tide-mark Press Ltd, 152pp; £25.95 (US $39.93) (hard cover, ISBN 1-55949-314-3).

This is an attractive book with a striking cover, and a quick flip through reveals some excellent photography which makes it immediately appealing to the underwater enthusiast. The author is a diver and has taken many of the photographs himself.

The introduction provides a summary of the cold-water marine environment, and then describes the current regime along the north-east coast of the United States. Under the influence of the Labrador Current, these waters are much colder than British waters, in spite of their more southerly latitude.

After a brief review of the plankton, the book is devoted to a systematic review of some of the benthic animals found in nearshore waters around the Gulf of Maine. There is a short section on pelagic squid and sharks, and the final chapter takes a look at marine mammals. The text is interesting, liberally illustrated with colourful photographs, and is full of biological detail interspersed with anecdotes about the author's underwater experiences. Throughout, Latin nomenclature is used in addition to common names, and for the uninitiated there is an introduction to 'Latin for Taxonomy' at the beginning of the book.

It was fascinating to browse through this book and to note the parallels and differences between species found in the north-west Atlantic and those in British waters. For instance, the plumose anemone occurs on both sides of the Atlantic (though in the US it is called the 'frilled anemone', which underlines the value of Latin names) and I was surprised to discover that several of the delicate nudibranchs (sea slugs) are also common to both coasts. Then there are basket stars and the Arctic red soft corals which are found on the North American coast but are absent from British waters. I have learnt much from this book, but its title could mislead British readers.

Why is it entitled 'Beneath the North Atlantic'? After all, the North Atlantic is a huge body of water but the book is mostly devoted to describing benthic life along a 300-mile stretch of the North American coast, the coast of New England. A title such as 'Beneath the Gulf of Maine' would be more accurate.

The various groups of animals are described in taxonomic order but this book does not set out to be a scientific text. Only a few representatives of any particular group are mentioned, the choice apparently being dictated by the photographic material available. Some entire groups such as the polychaete worms and the bryozoans are omitted, and anyone interested in seaweeds would be disappointed as they are not even given a passing mention (though I am sure they must be vital to the ecology of the area). So let's revise the title again – 'Animal Life Beneath the Gulf of Maine', and there we have it.

Many of the photographs are excellent. There is a stunning picture of a sea butterfly and some wonderful photographs of basket stars. However, there are a few exceptions, for example a full-page out-of-focus copepod and a low visibility seascape showing an aggregation of sea urchins, both of which definitely let the side down. The author admits to his fascination with colour variations of the northern red anemone and he treats us to three pages of photographs illustrating the point, which seems excessive. An indication of scale would be helpful in all the captions: the size to which organisms grow is often mentioned in the text but where this information is not given with the photograph there can be a misleading impression of size.

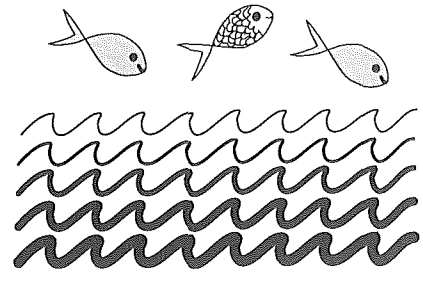
Who is this book for? I know that it would interest New England divers, amateur marine biologists, and those with a casual interest in temperate North American marine life.

The author sets out with the intention of winning 'greater respect and concern for the delicate balance of life in the sea'. I hope he succeeds: there cannot be too many books of this kind available for the general reader. But British readers beware: in spite of the title, this book does *not* encompass the marine life of the north-east Atlantic.

Vicki Billings
Princes Risborough

Beneath the North Atlantic can be ordered directly from the publisher: Tide-mark Press, PO Box 280311, East Hartford, CT 06128-0311, USA ($39.95 plus minimum $7.50 for postage etc.; Master Card /Visa only).

The UK agent is Lavis Marketing, 73 Lime Walk, Headington, Oxford, UK OX3 7AD; Tel. 01865-67575; Fax: 001865-750079.



Teaching the Oceans as part of the Earth System

It's all the rage nowadays: The Earth as a System in which Everything Relates to Everything Else. Barely a decade ago it was a novel idea, now it's in danger of becoming a cliché. But there are plenty of diehards out there, for whom 'their' discipline and 'their' line of research is the core of all scientific endeavour. They pay public lip service to the concept of multidisciplinary science, but privately regard it as heresy. No doubt I exaggerate, but not much! We need more books like the ones reviewed here.

The Blue Planet: An introduction to Earth System Science by Brian J. Skinner and Stephen C. Porter (1994). John Wiley. 493 pp. £48.95 (hard cover, ISBN 0-471-540-218).

What a pity this book is in hardback, the price will deter many students. What sort of students? It's an American product, evidently aimed at high school/college level, which being interpreted means roughly sixth form/first-year undergraduate in the UK.

However hard you work at being multidisciplinary, it's an uphill task, and your approach is bound to be conditioned by your own background. Both authors are basically geologists (and Brian Skinner was Editor of Economic Geology for many years), so a certain bias towards the solid Earth and its resources tends to show through, as you can tell when you see the list of 'four main themes' under the heading 'About this Book':

1. The interdependence of the Earth's four major reservoirs – the solid Earth, the atmosphere, the hydrosphere, and the biosphere.

2. The connective link between internal convection and the Earth's external features through plate tectonics.

3. The fact that the human race is causing measurable changes in some of the Earth's reservoirs and is influencing the flows of material and energy between them.

4. The need for humans to use the Earth's limited store of natural resources wisely and to understand how human activities change the environment.

I doubt if any marine scientist setting out to write a book on the Earth System would go into the intricacies of mineral identification and silicate structure. Nor would they treat viscosity in relation only to magma, or discuss sediment transport and deposition by rivers and by wind but not by waves and tidal currents. Still less would their index lack the terms carbonate compensation depth, coccolithophores, diatoms, even turbidity currents. (What would you expect to follow 'Physical weathering' in the index? 'Phytoplankton' perhaps? Wrong: You get 'Piles'. Make of that what you will.) I could find no map showing the distribution of sediments on the ocean floor.

But it is easy to carp, and difficult to be objectively multidisciplinary and treat all the parts of a sytem with equal impartiality (is that a tautology?).

At least the authors recognize (unlike some Earth scientists I know) that the Coriolis force exists and that it affects both atmosphere and ocean, though I'm not sure their explanation is wholly satisfactory. Alas, I also fear that those wishing to learn from this book will emerge with the impression that ocean currents are 'rivers in the sea'. In this connection, I thought it a bit odd to find the Oceans in Chapter 8, the Atmosphere in Chapters 12 and 13, followed by The Climate System in Chapter 14. That last chapter has a nice (though not wholly accurate) picture showing most of the interactions, but the text is stronger on the record of climate change than on the mechanisms.

In a book purporting to be concerned with encouraging the 'wise use of Earth's resources' (items 3 and 4 in the list above), it was a bit startling to find that Chapter 10 opens with the techno-fix solution of towing Antarctic icebergs to arid lands at low latitudes to alleviate water shortages.

How easy it is to be critical – reviewing books gives one Power without Responsibility – so it is time I was a bit more positive. It's a beautifully illustrated book, not just the photographs, but also the coloured artwork illustrating concepts and processes such as lapse rate, jet streams, the spectral distribution of solar radiation, plate tectonics (naturally), and so on. There's no shortage of attractive pictures, and there are boxes labelled 'A Closer Look', which go into some topics in more detail. There's one on El Niño, which is quite good, another on the Younger Dryas, and there's even one on Identifying Minerals. Of additional interest are the Guest Essays scattered through the text, expanding on topics as diverse as climate change, mapping the Earth from space, Lake Baikal, and the deep ocean. One that particularly caught my eye, however, is by P.D. Lowman, a distinguished geologist, who accepts the reality of plate tectonics but perversely does not believe in continental drift. I wonder how less confident students will react to this, given that the authors have gone to some pains to demonstrate how we can tell that continents have moved (drifted) and how this can be explained by plate tectonics.

Each chapter ends with the now obligatory summary, also lists of 'Terms to Remember', followed by 'Questions for Review', 'Questions for a Closer Look', and 'Questions for Discussion'. Alas, no answers are provided. The Appendices are numerous and varied, covering topics such as units and conversions, star charts, and maps; and of course there is a Glossary at the end.

There is a huge body of accompanying support materials, all obtainable from the publishers. Copies of 75 of the line illustrations are available as slides and as overheads, and all the pictures are on a CD-ROM. We also have both *Study Guide* and *Laboratory Manual.*

Study Guide by Michael A. Jordan (1995). 180pp. £16.99 (flexicover, ISBN 0-471-599-255).

The Study Guide has lots of additional questions of three main kinds: 'fill-in-the- spaces' (from your reading of the book); multiple choice (select from the list); and 'open-ended' (requiring a short paragraph). Answers are provided for all of these, though without explanations for the first two categories, where the questions inevitably contain ambiguities – but then, if these are for classroom use they can be ironed out.

Laboratory Manual by Monica C. Bjørnerud, John M. Hughes and A. Dwight Baldwin Jr. (1995). 190pp. £24.99 (flexicover, ISBN 0-471-306-290).

This isn't really a ' Laboratory Manual' in the usual sense, because students are not expected to do many *experiments*, just rather a lot of plotting graphs, drawing diagrams, and answering numerous questions. There are some simple exercises involving minerals and soils, weathering and permeability, fossils, and the like – I saw no reference to seawater anywhere, and the biosphere seems to be dealt with more from the point of view of cycles than of organisms. But I'm carping again, there is plenty

for students to do and to think about with the diverse set of activities suggested in this Manual – though some adaptations will be needed, because the examples are perforce all drawn from the US.

At this point, I feel I must put in a word for a worthy predecessor in the same field:

Planet Earth: cosmology, geology, and the evolution of life and environment by the late Cesare Emiliani (1992). Cambridge University Press, 719pp. £22.95 (flexicover, ISBN 0-521-40949-7).

This 700-plus page volume covers at least some of the same ground as Skinner and Porter do, but in considerably greater depth (except, alas, for the chapter on Oceans), and hence must be for the more advanced reader. However, for such a literally weighty tome there are some fairly glaring omissions, and treatment of the oceans can only be described as rather superficial. It is a work of reference rather than something you want to sit down and *read*. That may be in part because many of the line diagrams are extremely detailed and all the illustrations are in black-and-white.

Tales of the Earth: Paroxysms and Perturbations of the Blue Planet by Charles Officer and Jake Page (1993). Oxford University Press, 226pp. £9.50 (flexicover, ISBN 0-19-509048-9).

Now there's a thing. I open this book and what do I find? 'The Year Without a Summer' kicks off the first chapter, just as it does the Introduction to Skinner and Porter's book (see p.42). The resemblance ends there, however. This is a book that should be on the recommended reading list from COPUS (the Committee for the Public Understanding of Science).

The aim of the book is to explain the basics of the science behind natural events that have affected humanity in the past, and ways in which human activites have contributed (and continue to contribute) to global change. Famous natural disasters are placed in their historical and social/cultural contexts. Examples include the poor harvests following the 'year without a summer' that led to food shortages and widespread unrest, even rioting; and the religious controversies sparked off by the Lisbon earthquake and tsunami. Explanations and analyses are offered for the 'flood legends' of Noah and of Gilgamesh, and for the Atlantis story, but there are also chapters on meteorites, climate change, extinctions (both natural and 'man-made'), and so on.

I think it is a super book – it weaves history, legend and science into a really compelling read, with simple line diagrams, a few photos and plain English. Each chapter tells a different and equally exciting story, without either talking down to the readers or blinding them with science. Best of all, perhaps, the book takes a truly multidisciplinary approach, indeed one might almost say non-disciplinary – there are no overt references to any particular branch of science as having been important in identifying this or that piece of evidence, or in resolving this or that problem. The authors are healthily sceptical too. For example, they evidently find it hard to accept that an asteroid impact was responsible for finishing off the dinosaurs, and go to some lengths to explain why. You don't have to agree with all their conclusions to enjoy the book.

It's not often that you can say of a science book, 'I couldn't put it down' – and mean it! This is such a book. I'd love to be able to write about science as well as these guys do.

Actually, the approach in *Tales of the Earth* is not a million miles away from that in another broadly contemporary tome, the second edition of:

New Views on an Old Planet: A History of Global Change by Tjeerd Van Andel (1994). Cambridge University Press, £17.95 (flexicover, ISBN 0-521-447550) and £50 (hard cover, ISBN 0-521-442435).

This also deals with various aspects of the evolution of Earth and Life but concentrates on the 'facts' of geological history rather than dealing with the 'legends' of human history and culture. It is a kind of half-way house between the Good Read you'll get from Officer and Jakes' *Tales of the Earth* and the Serious Science (for reference only) in Emiliani's *Planet Earth.*

And finally we come to:

Oceanography: Contemporary Readings in Ocean Sciences (2nd edn) edited by R. Gordon Pirie (1996). Oxford University Press, 425pp. £22.50 (flexicover, ISBN 0-19-508768-2).

This is an anthology of contributions describing recent trends in all fields of oceanographic research. The second edition came out in 1977, a time when mesoscale circulation was only just starting to be widely recognised, and before the first hydrothermal vents and their unique fauna were actually discovered (though their existence had been predicted for some time). The same could probably be said of gas hydrates. In those days, overfishing had not yet become an issue, at least on a global scale, concern about climate change had not yet emerged from its 'global cooling' mode, and rising sea-levels were simply the result of continuing recovery from the last glacial maximum, not of anthropogenic global warming. All these topics, and many more, are now covered.

I started this set of reviews with a multidisciplinary student text, I conclude with a multidisciplinary collection of essays and reviews by and for specialist researchers. It is to be hoped that the marine scientists who read this book look at contributions from authors in fields other than their own: for example, that those who track and model eddies will be sufficiently interested to read about pelagic biodiversity and/or the ecology of hydrothermal vents; that those whose interests lie in the field of global warming, melting ice and sea-level rise take the time and trouble to read about management of the Antarctic krill ecosystem – and *vice versa* in each case, of course. It should be easy enough in all conscience, none of the chapters is long, most are short, and the majority are a fairly easy read – though it has to be said I found some of them more informative than others.

There are 37 contributions divided into five main sections: 1. 'Exploring the Sea'; 2. 'Currents, Chemistry and Climate': 3. 'Geology and Sea Life'; 4. 'Ocean Resources'; and 5. 'Ocean Pollution'. I must say I thought the juxtaposition of 'rocks' and 'biology' in Section 3 a touch forced, till I looked more closely and discovered that only one chapter is really about 'rocks' (distribution of guyots). There's also an interesting one linking delta formation with decelerating sea-level rise (sea-level is still rising, but not as fast as it was around 2000–3000 years ago). But most are biological: sharks, whales, reefs, hydrothermal vent fauna, red tides – even mermaids.

Actually, the mermaid story is quite a nice one, and it exemplifies the somewhat eclectic choice of subject matter; and as I remarked above, the quality of

different chapters is a bit uneven. What's more, as hinted above the chapters do tend to cover somewhat narrow fields, they lack the broad sweep you get in *Tales of the Earth*. It is a book for dipping into for reference rather than for sitting down and reading. That's not really a criticism, it's probably what the editor intended.

I wonder if it is a sign of the times that nearly a third of the book is on resources and pollution. Reviewers are not immune from hubris. Having been snooty earlier about moving Antarctic icebergs to the tropics, I find no less an authority than Peter Wadhams writing about the logistics of such operations.. I must confess to some surprise. Are we to suppose that the amounts of ice which puny humans might remove would be so trivial as to have negligible effect on the ice cap? I don't know, but I have a sense of fiddling while Rome burns, of the applications of research inclining more towards exploitation than conservation. Of course there are several chapters that deal with environmental issues, with the consequences of human activities; but even in those chapters I sometimes felt the focus to be more on analysing the problem than on how it might be ameliorated. Why not buy the book and see if you agree?

John Wright

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OCEAN Challenge

The Magazine of the Challenger Society for Marine Science

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