OCEAN Challenge

The Challenger Society for Marine Science

Volume 10, No. 1, 2000

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The Magazine of the Challenger Society for Marine Science

The views expressed in *Ocean Challenge* are those of the authors and do not necessarily reflect those of the Challenger Society or the Editor.

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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.

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INSTITUTIONAL SUBSCRIPTIONS

Ocean Challenge is published three times a year. The subscription (including postage by surface mail) is £80.00 ($US 152) per year for libraries and other institutions. New subscriptions, renewals and information about changes of address should be sent to Parjon Information Services, PO Box 144, Haywards Heath, West Sussex, RH16 2YX, UK.

DATA PROTECTION ACT, 1984 (UK)

Under the terms of this Act, you are informed that this magazine is sent to you through the use of a computer-based mailing list.

Cover printed by Albanian Press, St Albans.
Text printed by Halstan & Co. Ltd, Amersham.

ISSN 0959-0161

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The cover was designed by Ann Aldred Associates.

The maps and illustrations were drawn by John Taylor of the Cartography Office of the Department of Earth Sciences at the Open University.

News and Views

Mozambique Floods and a Climatic Oscillation in the Indian Ocean?

Could an El Niño-like oscillation in the Indian Ocean have contributed to the catastrophic floods that afflicted Mozambique last winter? It is at least possible. The Indian Ocean is normally cooler in the west, warmer in the east – a mirror image of the Pacific Ocean, which is normally warmer in the west, cooler in the east. The eastward movement of the western Pacific 'warm pool' of surface water during ENSO events is well documented, and it now appears that an analogous *westward* shift of warm surface water occurs in the Indian Ocean, at intervals of a few years (*Nature*, **401**, 337–8, 356–63). There seems to be no direct relationship between ENSO events and this Indian Ocean oscillation, for it can occur in both El Niño and non-El Niño years.

The process apparently starts in mid-year (during the northern summer), when normally weak equatorial westerlies in the Indian Ocean are replaced by moderate easterlies. Rossby wave dynamics are implicated in the western movement of the Indian Ocean 'warm pool', and the picture is complicated by development of an 'Ekman ridge' just south of the Equator. This results from Southern Hemisphere mass transports, which are to the left of the easterlies along the Equator itself, and of the prevailing westerly winds near 10° S; while westward propagation of the 'ridge' contributes to depression of the thermocline in the western Indian Ocean. The presence of anomalously warm surface water in the western Indian Ocean could be expected to encourage development of more than usually vigorous hurricanes. Is that what happened to cause the Mozambique floods?

It seems at first sight an attractive, even plausible scenario, but some questions remain: first, why did those hurricanes dump all their rain onto *southern* Africa, i.e. mostly south of 20°S? Second, if the eastern Indian Ocean was cooler than average last winter, why was India's eastern state of Orissa (on the north-west shores of the Bay of Bengal) devastated by tropical cyclones and floods in October–November last year? The devastation didn't occur only because shrimp farms have replaced the defensive coastal fringe of mangroves along the Orissa coast – though that must have contributed. Third, why was Mozambique being flooded on a scale not experienced in living memory at the same time as both Ethiopia and northern and western India were experiencing their third successive year of severe drought? And why was last winter the worst in Mongolia for 60 years? Might these disparate conditions be related to the so-called 'Indian Ocean dipole' and if so, how?

Global Warming – Sunny Side Up

The strength of the Sun's magnetic field is reliably reported to have doubled over the last 100 years, which means it has become brighter and therefore hotter (*Nature*, 1999, **399**, 416–17). In addition, an inverse correlation between cosmic ray intensity and solar activity means that a more active Sun results in less cosmic ray activity; and since cosmic rays generate ions which provide cloud condensation nuclei in the atmosphere, a more active Sun should lead to fewer clouds – so the skies get sunnier.

These must at least be contributory factors in global warming, but might they be the principal cause? How encouraging it would be for governments and industries if it could be shown that the Earth is getting hotter mainly because the Sun has become brighter, not because of fossil fuel burning.

A link between solar activity and surface temperatures on Earth can also be used to explain how higher atmospheric CO_2 concentrations correlate with higher temperatures: more CO_2 is released from solution in warmer oceans, more CO_2 dissolves in colder oceans. However, the ~ 1 °C rise in mean global temperature over the last 100 years is nothing like enough to account for the ~ 50 p.p.m. increase in atmospheric CO_2 over the same period by 'effervescence' from the oceans (*Nature*, 1999, **401**, 754) – plus which, the 1990s were the warmest decade of the last century and total solar irradiance was actually no higher in that decade than it was in the 1990s (*Nature*, 1999, **401**, 841).

All in all, OPEC's agreement to increase oil production by $1\frac{1}{2}$ million barrels per day to bring down the oil price seems to make little long-term environmental sense. Nor indeed, does the £100 million government subsidy for the UK coal industry.

More Effects of Rising Sea-level

Concern about sea-level rise has reached Nigeria. Last year, the Lagos *Guardian* ran a feature called 'Taming the Raging Atlantic'. This asserted that '... the rise in sea-level in Nigeria is about 5 mm per year, as against the average global rise of 1–2 mm per year.' Presumably this rapid rise is because of subsidence resulting from petroleum extraction in the Niger Delta, one of the world's major oil fields. Remedies proposed to deal with the rising sea-level included nourishing beaches and making them higher, also constructing groynes and breakwaters.

Continued erosion of Nigeria's coastline could imperil not only fishing and tourism (though Nigeria doesn't as yet have much tourism), but also oil production and export facilities. Spending millions on sea defences may, however, not be the best way to cope with the problem – a policy of managed retreat would be more sensible in the long term (*Ocean Challenge*, Vol. 9, No. 1, p.6).

... and meanwhile, back in Britain

Rising sea-level also worries the UK's nuclear industry, because most of the power stations are sited on coasts, so as to make use of large volumes of seawater for cooling. The older Magnox stations are especially at risk, because they will be the first to be decommissioned. Decommissioning doesn't mean complete dismantling, and one favoured option is to encase the reactor core in thick concrete. But once the pumps stop working, the sea could get in, and there could be vigorous interaction between seawater and a still-hot reactor core (even one protected by concrete). A Chernobyl-style explosion is unlikely, but the older Magnox stations get, the more accident-prone they become.

...while in Antarctica, global warming is not to blame

When the largest iceberg in modern times (about 300 km from end to end and the area of East Anglia) broke off from Antarctica in late March, David Vaughan of BAS was quoted as saying that '... this is what ice shelves do,' and that this was not a result of global warming. Indeed, up until that time, the Ross Ice Shelf was at its most northerly extent for a century.

The iceberg is now beginning to break up, and a chunk 100 km long has broken off from its eastern side. Icebergs have been known to travel at ~30 km a day – these are being being tracked using thermal imaging from the ATSR-2 on the *ERS-2* satellite.

Good Fisheries News (for a change) on licensing ...

Proposals for partial relaxation of licensing rules should make it easier for UK vessels to develop new fishing opportunities outside EU waters. The new arrangements will allow a period of grace not exceeding two years, during which UK-registered vessels can be issued with an 'external waters licence' without having to meet the normal requirement of holding domestic licences that cover their full capacity. Instead, a 50% domestic licence will be sufficient for the two-year period, though after that a full 100% domestic licence will be needed to retain the external waters licence. Applicants will have to satisfy fisheries authorities that they intend to exploit genuinely new fishing opportunities and can meet safeguards designed to ensure compliance with the objectives of UK fleet management.

Fisheries Minister, Elliot Morley welcomed the changes: 'It is important that we do not put unnecessary obstacles in the way of UK fishermen wishing to invest in developing new fishing opportunities outside EU waters. At the same time, we need to be careful to keep a tight grip on the size of the UK fishing fleet. The new arrangements should go a long way towards assisting the industry to exploit new fishing possibilities without undermining our general fleet management objectives.'

... and nets

Moves to help preserve juvenile haddock in the North Sea took another step forward earlier this year, with publication of a consultation document aimed at promoting more sustainable fisheries in the whitefish and prawn sectors. Most notable is the proposed introduction of 90-mm square mesh panels into all demersal and prawn nets, as well as the specification of a maximum thickness for twine in the cod-end. According to a report by the Scottish Executive, members of the Scottish White Fish Producers Association worked alongside scientists from the Aberdeen Marine Laboratory during sea-trials of the square mesh panels.

but ...

Welcome though such developments undoubtedly are, they can be of little benefit to fisheries management or conservation, so long as the EU bureaucracy persists in perpetrating *bêtises* of the kind detailed on p.11 ('The CFP strikes again').

Canadian Lobster Wars

Beware colonial legacies. Canada's Supreme Court has ruled that under the terms of an 18th century treaty, native North Americans belonging to the Mi'kmaq tribe (of what is now New Brunswick in north-east Canada) have rights to hunt and fish unregulated by the country's licensing and conservation laws – which cannot have been in force at the time of the treaty, so this must be a matter of interpretation. The predictable – but quite unanticipated – upshot was that the Mi'kmaqs set out hundreds of lobster pots a couple of weeks before the official lobster-catching season opened last autumn, and started cleaning up. Naturally, there is now strife, tinged with racism and sometimes violence, between the mainly white professional fisherman and the Mi'kmaqs, who have never integrated despite more than 200 years of co-existence. This is not subsistence fishing. Lobsters are a lucrative commodity, fetching high prices, and the Mi'kmaqs live on a reservation where unemployment is high and any extra income is welcome. But the licensed lobster fishermen must make a living too.

The dispute seems likely to spread, because the Passamaquaddy tribe of present-day Maine, just across the border in north-east USA, are claiming rights under the same treaty. Claiming also that the Canada–US border was none of their doing, they are planning to take off into New Brunswick in search of salmon and scallops (and timber too).

It is all very sad. The original treaty was drawn up at a time when there must have been plenty of fish and game around and when the native tribes probably participated in the richly rewarding fur trade of the 18th and 19th centuries. But things are different now. Humans are starting to outnumber animals over large tracts of the planet, and there are no longer enough lobsters, scallops and salmon (not to mention land and trees) to go round. The Justices of the Supreme Court may have meant well, but they achieved little more than to foment another clash over resources that have become scarce through over-exploitation in the past couple of hundred years.

Coastal Wetlands to be Saved from the Sea

Internationally important conservation sites around the English coast are to be saved from inundation by sea-level rise (or be re-created) under new guidelines published in April. This might at first sight seem like unnecessary human interference, but intensive development of coastal areas means that these ecosystems can no longer migrate naturally.

The habitats that will disappear if nothing is done are essential for rare species of coastal birds (including the bittern), important populations of wading birds such as avocet, plants such as sea purslane, sea lavender and saltmarsh grass, and other wildlife.

The areas that have been identified as requiring the most urgent attention are: Winterton Dunes, Norfolk; the coast and estuaries of Suffolk and Essex; the North Kent coast; Dungeness and Pett Levels, East Sussex; and the West Sussex and Hampshire coasts.

Funding will come from the Ministry of Agriculture flood defence budget, which has been increased by £23 million over three years. The plans will be formulated under guidelines of the Coastal Habitat Management Plans, drawn up jointly by English Nature and the Environment Agency in close consultation with MAFF and the Department of the Environment, Transport and the Regions (DETR).

Limpet Miners

Erosion of the chalk cliffs of south-east England is not just a matter of rising sea-levels and stronger wave action. Shellfish are at it too, specifically the humble limpet *Patella vulgata*, which is conventionally supposed simply to cruise across rock surfaces garnering the algae growing on them. An observant but obscure 19th century scientist, known only by the possibly appropriate name of Hawkshore, is reported to have noted that limpets consume rock as well as algae, and calculated that they wear down the surface at a rate of 1.5 mm annually. His findings were ignored for something like 150 years, but new research at the University of Sussex has shown that limpets really do eat chalk as well as algae (as evidenced by analysis of their faeces), eroding the rock at a rate of 0.6 mm per year. That's a lot less than Hawkshore's estimate, but of the same order as sea-level rise. Limpet populations in other places must be similarly erosive, and interest in this research has been expressed in Spain and Portugal, also in France and Sweden.

In fact, limpets aren't likely to cause much shoreline erosion. Cliffs retreat mainly because large blocks fall off when they are undercut by wave action. This should reassure promoters of tourism in the South East who have been expressing concerns that the spread of vegetation is locally discolouring the famous 'white cliffs of Dover'. With the progress of global warming, sea-level rise and (predicted) greater frequency of winter storms will cause more and more rock falls, each exposing fresh cliff faces of white chalk.

Shark Skin for Speed

Fluids don't flow so well over highly polished surfaces because of drag caused by the viscous sub-layer, a mm thick or less, next to the surface. Rough surfaces break down this thin viscous layer, but they also increase drag by generating eddies. Sharks are among the fastest swimmers in the oceans and they have evolved a compromise, in the form of minute corrugations on their skin, aligned along the flow. Giving aircraft a 'shark skin' coating can reduce their drag by as much as 8%, so it is not really surprising that swimmers are now getting in on the act. Significant improvements in performance are reported, and there is talk of Olympic competitors being equipped with tight suits of imitation shark skin. But surely, unless *all* competitors are similarly equipped, will there not be cries of 'foul'?

Mussel Power for Medicine

The byssal threads of mussels enable them to stick to their rocky habitats in the fiercest storms, withstanding the impact of the largest waves. The 'glue' that mussels secrete to fasten the byssal threads (the 'beard') onto rocks – a liquid protein that 'sets' through the action of a catalytic enzyme, much in the manner of epoxy resin adhesives – has the unique property of being able to set both on dry surfaces and on wet ones. Medical researchers have been looking for something like that to help them mend broken bones and teeth. But they can't extract enough from the mussels themselves, at least not without destroying the world's mussel population in the interests of commercial gain. Instead, they have implanted the mussel's 'glue gene' into tobacco plants, so that the natural superglue can be grown cheaply and easily. What a neat paradox that is, to use a plant that kills some people in order to heal others. Could this idea be of use to the beleaguered tobacco industry?

Sunlight and PAHs

The results of a MAFF study at the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) indicate that exposure to sunlight may increase the toxic effects of PAHs – polycyclic aromatic hydrocarbons – in ocean surface waters. The investigation into the potential for ultra-violet light to increase the toxicity of PAHs began in 1998, and involved laboratory-based exposure experiments on fish eggs and larvae, and on invertebrate species.

PAHs are produced by traffic, coal- and wood-burning, and some industrial processes. They tend to concentrate in sediments close to industrialized and urban locations, but are also found in lower (though still potentially significant) concentrations at more remote locations. Certain PAHs can be acutely toxic to aquatic life in highly contaminated locations, and others may also have carcinogenic and other long-term effects under less contaminated conditions.

Free copies of the CEFAS report are available from MAFF, Rural and Marine Environment Division, Marine Branch, Room 150, Nobel House, 17 Smith Square, London SW1P 3JR.

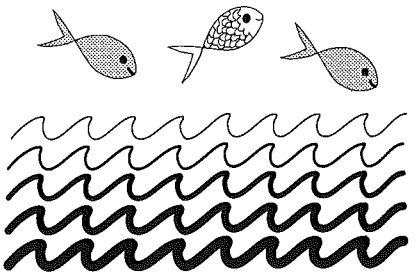
Left hand, right hand: Government Policies and the Marine Environment (an update)

During the last couple of months, various public prints have carried reports of Greenpeace teams occupying oil rigs destined to drill for oil in the Atlantic Frontier region off north-west Britain. But the reports made no mention of 'the High Court injunction requiring the oil industry to set up a network of marine protection areas' (*Ocean Challenge*, Vol.9, No.3, p.4). Nor was any mention made of UK Government concerns about conservation of the marine environment. Why might that be? Perhaps ministers have been persuaded that CO_2 from fossil fuels is not the prime cause of global warming (see item on 'Global Warming – Sunny Side Up' on p.2).

Even so, they can hardly be unaware of the damage that oil industry operations can do in the sea. For example, the *Erika* oil spill off Brittany at Christmas may not have been a direct consequence of the extraction of oil *per se*, but it seems obvious that the more oil the industry extracts, the more there is to spill.

Meanwhile, in Alaska ...

Greenpeace is also protesting about BP Amoco's latest venture on Alaska's north coast, the so-called Northern Project, which involves building up a drilling 'pad' on a small island, using hundreds of thousands of tonnes of gravel transported over ice roads made by freezing millions of gallons of water from the local river system. Independent observers have estimated the chances of an oil spill to be one in four – which is actually rather high – and oil spills in polar regions take a long time to clear (as the *Exxon Valdez* accident in 1998 demonstrated). But the Arctic is a remote region, and oil spills will probably affect only the wildlife – they may not be of much concern to people in the industrialized regions who will be using the oil.



Mangrove Regeneration – from the Air?

Last autumn *The Guardian* carried a feature describing a plan, proposed by a former RAF pilot, for re-foresting large tracts of land that were once tree-covered, by the simple expedient of dropping seedlings from aircraft. The seedlings, plus soil and fertilizer, would be contained in cones which were both biodegradable and sufficiently heavy to penetrate the soil to the right depth.

What a neat idea. Perhaps this elegant concept could be applied to regenerating the mangroves cleared for shrimp-farming along many tropical coasts. Many of these have been forced to close because of pollution and/or mis-management, leaving the coastline barren and unprotected – while the shrimp farmers move on to clear the next stretch of coastline. So why not replant the abandoned areas with mangroves from the air? The projectile shape of young mangrove plants seems ideally suited to aerial dissemination. Large-scale re-planting of mangroves could be achieved by simply shoving the young plants out of aircraft flying low and slow along the coast, preferably with an onshore wind and/or on a rising tide.

As with (nearly) all good ideas, there's a snag, of course. Many mangrove species are viviparous, the seeds germinate *on* the tree, and young plants are shed from it into the water. So before anyone could do any aerial re-planting, they'd need to collect the young plants from the trees first. That would be rather labour-intensive, and collecting *all* the young plants could jeopardize survival of the existing mangrove stand. But at least it would be a start.

Giant GM Salmon

Transgenic salmon may be on their way to a plate near you within a year or two, if recent press reports are to be believed. They grow four to six times faster (and hence get much bigger) than conventionally farmed salmon – let alone wild ones. The American company that created these new organisms (A.F. Protein, in itself an interesting name) claims that GM salmon 'pose no threat to wild salmon because *they are engineered to be sterile*' (our italics). So even if they do escape, they can't breed. That could be disappointing for the female salmon out there, because they apparently prefer larger males.

Killer Dolphins Move to Persian Gulf

The Soviet Navy trained dolphins to kill 'enemy' divers, blow up ships and, no doubt, themselves (*Ocean Challenge*, Vol. 9, No. 3, p.3). But the Cold War is over now, and Russia is poor. The dolphins are expensive to keep, so they have been sold by the Crimean authorities to the Iranians, who hold one side of the Straits of Hormuz and are keen to control this narrow seaway, through which most of the world's oil is exported. Let's hope their new dolphins don't blow up a tanker.

The Moon's Seas – Still Waterless

The dark lunar plains were called *maria* by early astronomers, who thought they looked like seas; but until quite recently few people seriously thought there had ever been water on the Moon. Then one of NASA's space probes detected hydrogen on the Moon, implying the presence of water, probably in the form of cometary ice preserved in an impact crater (*Ocean Challenge*, Vol. 8, No. 3, p.12). To follow this up, in July last year NASA deliberately crashed their *Lunar Prospector* probe into a crater near the Moon's South Pole, which is in virtually permanent darkness and therefore cold enough for any ice that might be there to be preserved. NASA hoped that the impact would sublime or evaporate the water which could then be detected, either as vapour or as the hydroxyl (OH^-) radical. But nothing happened, and for nearly a year there has been no further news of water on the Moon.

Meanwhile, on Mars and Europa ...

If lunar water were found, it could pave the way for colonization of the Moon, in turn opening the way to colonise Mars, where water-ice is known to occur. That is presumably why Hadlow College in Kent has been advertising an ambitious scheme for hydroponic cultivation on Mars (see end of item for details). Plants would grow using martian water plus the CO_2 that dominates the tenuous martian atmosphere. It remains to be seen whether there is more than surface ice on Mars – some scientists suggest there are large quantities frozen underground.

But there can be no oceans on Mars, though once upon a time there may have been. For oceans on other worlds we look chiefly to the jovian satellite Europa, which almost certainly has liquid water beneath its icy carapace, possibly kept warm by hydrothermal vents on the 'ocean' floor The ice surface is criss-crossed by cracks that have 'healed' as water has risen through them and frozen again – which couldn't happen if there were no water beneath.

... but beware – coughs and sneezes spread diseases

Exploring Europa's oceans will present formidable problems, not the least of which will be how to avoid contamination by terrestrial organisms. There is a story that during the *Apollo* lunar missions of the 1970s, an instrument was left on the Moon's surface for a couple of years and subsequently retrieved by a later mission. Some terrestrial bacteria had somehow got onto its surface through handling (or sneezing!) within the spacecraft or prior to the mission. When the instrument was returned to Earth, the bacteria proved viable enough to be cultured in the laboratory, despite having been exposed to unremitting ultraviolet and cosmic radiation and subjected to great extremes of temperature in a total vacuum for two years.

Multicellular life may be fairly fragile and prone to extinction – some of it anyway – but recent discoveries of bacteria in extreme environments on Earth demonstrate that bacterial life is extremely robust (*Ocean Challenge*, Vol. 9, No. 3, pp.13–14). Ensuring that instruments dispatched to probe Europa's ocean carry no bacterial passengers from Earth will therefore not be easy. Luckily, there is a 'Europa test-bed' in Antarctica: Lake Vostok, over 200 km long and about 500 m deep, lies 3.5 km below the surface of the ice-cap (*Nature*, 1999, **401**, 203). If scientists can manage to sample its pristine waters (said to be at least a million years old) without contaminating them, they should be able to do the same for Europa.

For more information about 'Mars – the Planted Planet', contact Hadlow College, Tel./Fax: +44-(0)1732-850551/853207; Email: hadlow@hadlow.ac.uk

Ancient Ice Ages – Tilting at Snowballs

There is good geological and palaeomagnetic evidence for a major ice age at low latitudes during the late Precambrian (Neoproterozoic), some time between ~750 and 650 Ma ago.

A popular interpretation of this event is the 'Snowball Earth' scenario with ice-sheets covering virtually the whole planet, at a time when most land was clustered around the Equator, forming a supercontinent that has been call Rodinia. The story goes (*New Scientist*, 6 November 1999) that ice spead equatorwards from the poles, the resulting 'albedo feedback' being enhanced by removal of atmospheric CO_2 via weathering of the extensive equatorial land areas, and precipitation of limestone.

Eventually, we are told, the whole Earth froze over to an estimated depth of 1 km in the oceans, depriving marine organisms of sunlight so that photosynthesis was much reduced. This would explain the high $\delta^{13}C$ ratios of limestones around this time: low net photosynthesis means minimal fractionation of ^{12}C. The grip of glaciation could only have been broken by enhanced greenhouse warming that resulted from atmospheric build-up of volcanically released CO_2.

Proponents of this hypothesis claim that there was catastrophic melting and accelerated weathering of freshly exposed rock and glacially ground up 'rock flour', drawing down vast amounts of atmospheric CO_2. This would account for the otherwise puzzling occurrence of limestone (including stromatolite) sequences directly overlying the glacial deposits and evidently deposited under warm conditions. In some areas there are also late Precambrian banded iron formation (BIF) sediments, laid down around 700 Ma ago, long after the main depositional period of these rocks, which ended some 2 billion years ago. A possible explanation is that weathering had released large amounts of iron to the oceans, which were then cut off – by the ice – from contact with the atmosphere (itself not yet rich in oxygen, especially with minimal photosynthesis). Once the ice melted and photosynthesis could resume, oxygen was released into the oceans and the iron was precipitated.

It makes a persuasive story, but it has its critics. A principal objection is that the ice-cover would never melt or, at best, would take several million years to do so, and all surface life would have become extinct. That didn't happen (or you would not be reading this!), although there is evidence of mass extinction of single-celled organisms (acritarchs) in the late Precambrian, which may have cleared the decks for the Cambrian 'explosion' of multicellular life (see review of *Earth Story*, p.40). On the other hand, geothermal warming would have kept the deep oceans from freezing, enabling hydrothermal communities to survive – as may be happening beneath the ice-cover of Europa, which is quite a good modern analogue of 'Snowball Earth', in orbit round Jupiter (see also item on 'The Moon's Seas').

Claims that there were at least two cycles of late Precambrian glaciation and perhaps as many as five, should be taken with a pinch of salt – except for one thing. Large tracts of late Precambrian bouldery sediments have been mapped in several parts of West Africa, also in Namibia and in central Australia, and probably occur elsewhere too. Some of these deposits contain angular and very poorly sorted blocks and fragments, others contain well rounded and sorted pebbles and boulders. The nature of these deposits is consistent with some of them being of glacial origin (boulder clay), others of fluvial origin, deposited from large rivers fed by glacial meltwaters. But more detailed mapping would be needed to identify how many depositional cycles there might have been.

An intriguingly different hypothesis is based on the premise that low-latitude glaciation is impossible with the Earth's present obliquity (the angle between the rotation axis and the plane of its orbit), which averages 23.5°. According to this alternative view (*Nature*, **396**, 405–6, 453–5), throughout the Proterozoic (and perhaps the Archaean too), the Earth's obliquity was greater than 54°, which is the angle at which average annual insolation at the Equator is equal to that at the poles. For obliquities greater than 54°, equatorial regions become on average cooler than the poles, facilitating the growth of ice-sheets at low latitudes, especially if continental land masses are mostly in equatorial regions (as they probably were in the late Precambrian)

Early in the Phanerozoic (i.e. about 500 Ma ago), the continents became clustered round the poles, where they could accommodate polar ice-sheets and where they would be isolated from warm poleward-flowing ocean currents (rather as Antarctica is today). As the continents moved polewards and acquired ice-caps, so the story goes, the oblateness of the terrestrial spheroid changed, the obliquity decreased to its present value by a process called obliquity–oblateness feedback, and glaciations became confined to the poles.

Neat though it is, this hypothesis has its problems too. First, the 'average' temperature regimes associated with high obliquity conceal the fact that high-latitude regions would experience permanent day or night for at least three months each year, alternately baked and frozen for long periods. Our familiar day–night alternations could occur only at low latitudes. Second, it is not immediately obvious how continents shifting from equatorial to polar regions and being covered with ice would change the Earth's oblateness, and how this in turn would cause the obliquity to decrease. Third, there is good geological evidence for a low-latuitude glaciation (in West Africa) around 450 Ma ago (the Ordovician), well after the decrease in obliquity should have made such a glaciation improbable if not impossible.

On the other hand, proponents of this 'obliquity hypothesis' claim that it provides an explanation for the 5° inclination of the lunar orbit to the plane of the Earth's orbit (though this is based on the assumption that the inclination was initially zero). If so, tidal regimes in the Precambrian would have been very different from what they are now, not least because the lunar declination cycle would have been annual rather than monthly, and there would be no tidal inequalities in the spring–neap cycle, as there are now. Unfortunately, there is no way of verifying that, since although tidal cycles can occasionally be identified in the sedimentary record, it provides insufficient resolution to show such details. None of which brings us any closer to finding out whether the late Precambrian glaciation consisted of alternating glacial and interglacial periods (and if so, how many), or whether the 'snowballers' or the 'tilters' have the more plausible explanation for it (*Nature* 1999, **398**, 555–6; **400**, 700). Both groups suggest that their version of events can also explain much earlier glaciations, in the Palaeoproterozoic (between about 2400 and 2300 Ma ago). But perhaps neither lot has the answer, and there's another explanation out there waiting to be found.

Prizes to be won at Marine Science 2000!

Presidents' Photographic Competition

The biennial Challenger Society Conference will again include the judging of entries for the photographic competition sponsored by past and present Presidents of the Society. There is still time to take some new photographs or reappraise old ones (not previously entered).

This year, the headings under which photographs may be entered are:

- **The oceans – micro to macro**
- **Oceanographers in action**
- **The end of the cruise**

Photographs should not be larger than A3 and should be submitted to the Registration Desk by noon on 12 September. Please do not send pictures in advance by post.

Can you produce

Winning Words?

As at the last two UK Oceanography events, a prize of £50 will be awarded for the best report of the meeting, which will be published in *Ocean Challenge*.

The report should be a personal impression – highlights and lowlights – rather than a blow-by-blow report. The emphasis should be on lively writing and good communication. For examples of the type of piece we are looking for, see *Ocean Challenge*, Vol. 8, No. 3, pp.18–19.

Entries should be sent to the Editor within three weeks of the end of the conference, and be about 1000 words long (about one page of *Ocean Challenge*).

Challenger Society Awards & Prizes 2000

Harry Elderfield, President

The Council of the Challenger Society is pleased to announce the following awards and prizes.

The Challenger Medal

Peter S. Liss

This is the premier award of the Society, awarded biennially to a distinguished UK marine scientist or other person who has made a single major contribution, or a sustained contribution, to the development of marine science, or whose innovation has opened up new perspectives.

Peter Liss is Professor at the School of Environmental Sciences, University of East Anglia, where he is Director of the Trace Gas Biogeochemistry Group. Peter has research interests in many areas of marine science, including particle surface charge and photochemistry, but his main contribution has undoubtedly been in the field of air–sea gas exchange, in which he is one of the world's leading experts. His research has ranged from the fundamental theory of gas exchange to practical measurements of biogenic gases in the water column and the atmosphere. In recent years he has been a central figure in studies to test John Martin's iron hypothesis and particularly the effect of iron on air–sea gas exchange. His research has been critical in defining the way the oceans influence global climate via gas exchange and the formation of sulphate aerosols.

Thus, Peter's research contribution has been extremely important in atmospheric science as well as oceanography. Indeed a feature of his research has been a refusal to be constrained by traditional boundaries such as that between the atmosphere and the oceans, or that between biology, chemistry and physics.

Beyond his research, Peter has served, and continues to serve, the oceanography community with distinction. In the UK he has served on many committees including steering committees of NERC Programmes such as the North Sea project and ACSOE. He was a founding member of the infamous Marine Chemistry Discussion Group. Internationally, Peter has served on many committees, most notably the ICSU International Geosphere–Biosphere Project which he led for several years with great distinction.

Fellowships of the Society

The Society awards up to four Fellowships biennially to marine scientists under 40 years old (and members of the Challenger Society) for their achievements and promise in a branch of marine sciences: marine biology, marine chemistry, marine geology or marine physics.

Chris German • Karen Heywood

Chris German is Principal Scientific Officer at the Southampton Oceanography Centre where he is Head of the Marine Geochemistry Group of the Challenger Division for Sea-floor Processes. Previously he was at Cambridge, MIT and Woods Hole. His main research area is the study of submarine hydrothermal activity and he has been involved in the discovery of four new hydrothermal sites on the Mid-Atlantic Ridge, notably the 'Rainbow' site at 36° N, as well as major contributions to understanding of geochemical processes in hydrothermal plumes and sediments. He is currently a member of the BRIDGE Steering Committee (UK) and the InterRidge Working Group on Global Studies. His work was recognized by the NOAA Outstanding Scientific Paper award for 1996, and he was selected by the Royal Institution as one of this year's 'Scientists for the New Century'.

Karen Heywood is Senior Lecturer in Physical Oceanography at the School of Environmental Sciences, University of East Anglia. Previously, she was at the University of Southampton, the Institute of Oceanographic Sciences, and University College of North Wales. Her main research interests are in large-scale observational oceanography, centred around the World Ocean Circulation Experiment (WOCE) with current emphasis on the polar oceans and the North Atlantic. Since her arrival at UEA, she has built up a large group with strong international links. She was co-Chief Scientist of the WOCE A23 hydrographic section and subsequent *Albatross* cruise. She pioneered the use of oxygen isotopes (which are affected by ice-formation and precipitation), as tracers of water masses. She is/has been a member of the UK WOCE Scientific Steering Committee and of several NERC committees. She is co-Principal Investigator of the recently awarded JIF bid to re-equip the NERC research fleet.

Honorary Membership

This award recognizes substantial contributions to the work of the Society and to the national and international development of marine science.

Angela M. Colling

Angela Colling is Lecturer in Oceanography in the Department of Earth Sciences, at the Open University. She is Editor of *Ocean Challenge*, the Society's magazine, and has been since its launch. For many people, *Ocean Challenge* represents their main contact with the Society and it is chiefly because of Angela that it has been so successful. She has been largely responsible for its development and continuing success, by her meticulous attention to each article so that it is accessible to all readers. She has steadily improved standards of presentation and production, ensuring that *Ocean Challenge* is a major shop-window for the Society. It also plays a key role in communication within the Society and in recruitment of new members. The recent two European issues, in particular, have expanded the Society's international standing.

Prizes

The **Challenger Prize** for the top student of the Open University's Oceanography course has been awarded to **Marion V. Ricketts.**

The Norman Heaps Prize, the Cath Allen Prize and the Presidents' Photographic Prize will be judged at Marine Science 2000.

Travel Awards

Colin Biggin and **Louise Brown** (both of SURRC, East Kilbride)

The Council welcomes nominations and applications for future Travel Awards (*see Ocean Challenge,* Vol. 8, No. 2, p.28).

CHALLENGER SOCIETY FOR MARINE SCIENCE

UK MARINE SCIENCE 2000

The Challenger Society's biennial conference on Marine Science (formerly known as UK Oceanography) will take place at the University of East Anglia, Norwich, 10–15 September 2000.

There will be a programme of talks across the fields of biological, chemical, geological and physical oceanography, plus trade exhibits and social events.

Keynote speakers include:

Dr. R. Dickson, Lowestoft, UK

Prof. W. Jenkins, Southampton, UK

Prof. V. Smetacek, Bremerhaven, Germany

Prof. R. Zahn, Cardiff, UK

We look forward to welcoming marine scientists from the UK, Europe and further afield.

See the conference website at http://ms2000.uea.ac.uk, for contact numbers and registration details.

Professor Tim Jickells
Chair of Organizing Committee
Tel: +44 (0)1603 593117
Email: T.Jickells@uea.ac.uk

UEA
NORWICH

NOW There's a FUNNY THING...

Water shortage? What water shortage?

We are continually being told that water demand is exceeding supply all over the world, and desalination of seawater must soon become an option to be seriously considered even in 'wet' countries like Britain (e.g. *Ocean Challenge,* Vol. 8, No. 2, p.8). Isn't it odd, therefore, that the water table is actually *rising* under some British cities, including London and Liverpool?

Until the 1960s several major industries in both these cities took large quantities of water from boreholes – such large quantities in fact that the water table had been falling since Victorian times. Those industries have since either closed down or moved away, water use has declined and the water table has been rising since the 1960s. In London the rate of rise is 2 m per year and the water table is now within 40 m of ground level, and in places is within reach of parts of the Underground and the foundations of some tall buildings.

70 million litres of water a day are being pumped out from beneath London and back into the Thames. Although that's a lot of water, it works out to less than 1 $m^3 s^{-1}$, which is only about one per cent of the Thames' average discharge. Similar remedial action in Liverpool would have a comparably miniscule effect on the Mersey's discharge. Rumours that coastal waters off south-east and north-west England may soon become fresher, therefore, would be premature, not to say unfounded.

On the other hand ...

Droughts are on the increase, especially in temperate latitudes, and the levels of most rivers are likely to be falling rather than rising, especially in summer, as larger numbers of more affluent consumers annually demand more water. It's a safe bet that pumping a little groundwater back into the Thames and Mersey won't replace what people are using.

The end-result of this trend is likely to be silted-up estuaries. An early-warning example is provided by the Chelmer estuary at Malden in Essex, where too much water taken out upstream has reduced the summer river flow so much that sediments brought in on the flood tide aren't flushed out again on the ebb, and the estuary is silting up. That happens to all estuaries in the end, but not normally on human time-scales – unless the humans interfere with the river.

For many people in other parts of the world, water shortages are real and anything but funny – demand really does exceed supply. According to the UN, a third of the world's population will be short of water by 2025, partly because of population growth and increased food production, plus rising standards of living; but largely because of inefficient use, pollution, and unsustainable 'mining' of groundwater, not to mention leakage and even theft from distribution systems.

What is more, wells and boreholes, in low-lying coastal regions especially, will tap more and more saline water as sea-level rise pushes the saline wedge beneath the fresh groundwater further inland.

But the answer still lies in the sea

97% of the world's water is in the oceans. Within a decade or two, desalination plants will be a commonplace feature of many coastlines in places where the idea of water shortages would have been laughable only a few years ago. If you are wondering where the energy to run them will come from, what do you think all those offshore windfarms are for? Perhaps there'll be 'ice-ports' too, to deal with icebergs towed from the polar ice-caps, which hold another 2% of the world's water. That idea has been around for at least 30 years, and it's a cheaper option than desalination. The snag is that icebergs can only be towed at speeds comparable to those of ocean currents, so they'll have to 'go with the flow'. How inconvenient that the strongest currents are heading in the wrong direction.

Millenial creationism

It is hard to credit. The dawn of the new Millennium coincided with a decree by the School Board of Kansas that evolution shall no longer be taught in the State's schools. Creation Science must be taught instead. Amazingly, it seems that both leading candidates for the US presidency publicly endorsed the ruling. That could have something to do with the results of a poll taken only a few years ago (1997), which revealed that 44 per cent (i.e. *nearly half*) of all Americans accept the creationists' account that 'God created humans [and presumably all the rest too] in their present form within the last 10,000 years'. There are best-selling books out there, claiming that Evolution is anti-biblical, anti-Christian and utterly unscientific. Scientific Creationism is the name of the game, to the extent that the author of a book on the geology of Kansas felt obliged to omit his first chapter, on early fossils, lest he offend somebody ...

I once tried to get a creationist person to recognize the validity of geochronology. The response was: 'God put all that radioactive stuff in the rocks to give scientists something to work on and think about.'

Titanic *culture for travel and tourism*

Technological obsession with size seems to be getting out of hand. Already a giant (300 m long) cruise ship, *Voyager of the Seas,* launched last year at a cost of £500 million, is cruising the world with 5 000 passengers and crew. Now the Norwegians are building a ship twice as big again, to be known as *The World of Residen Sea* (get it?), which will be a self-contained permanently cruising city, in which the wealthy can buy their own apartments – for between about £1 and £4 million. Then there's the contract for a new luxury liner, *Queen Mary 2,* at 330 m long, twice the size of the *QE2.* Belfast's Harland and Wolff yard had hoped to secure that contract, but in the event it went to a French yard instead.

Building bigger ships isn't always the answer, though. The inconvenience of putting cars, coaches and lorries on ferries between Britain and Ireland will disappear if plans to build a 100-km (60-mile) tunnel

under the Irish Sea between Holyhead and Dublin are realized, cutting journey times from 90 to 45 minutes. The estimated cost is £14 billion, which works out to £0.3 billion per travel-time minute saved. Wow! The mind boggles – well, mine does. Do you suppose the Government will consider this project worth subsidising? Probably not. Mind you, they did recently stump up £500 million to subsidise construction of a 650-seater 'flying hotel: the giant A3XX Airbus, referred to as a 'cruise ship of the skies', complete with gymnasium, casino, dining rooms, office suites, even shops. For a similar amount, could they not have ensured that the *Queen Mary 2* contract stayed in Britain, rather than letting it escape to France? Like God, governments move in mysterious ways, so we should perhaps not be surprised by such inconsistencies of behaviour. All the same, somebody should tell them that economies of scale are all very well, but this trend to technological 'gigantism' is not consistent with sustainability.

Close Sellafield? Yes, but why <u>now</u>?

Denmark, Ireland (and Iceland) are initiating legal moves to force the closure of BNFL's nuclear reprocessing plant at Sellafield, under the terms of the OSPAR treaty. But why is this case being brought now, rather than, say, 10 or 15 years ago? That is not a rhetorical question. It merits an answer in light of recent statements by a BNFL spokesman that Sellafield's discharges to the Irish Sea have decreased 1000-fold in the last 25 years, that even people living near Sellafield and eating lots of seafood would get radiation doses comparable to those received by passengers on a flight from London to Tokyo (cf. 'The Irish Sea – *not* the most radioactive sea in the world', *Ocean Challenge*, Vol. 1, Autumn/Winter 1990).

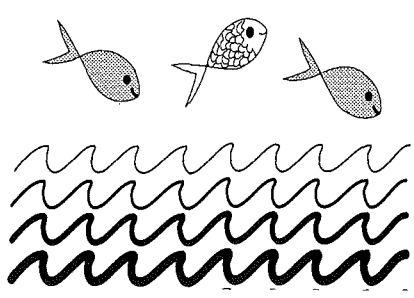
Could the timing of these proceedings have anything to do with the recent furore over BNFL's failure to guarantee the reliability and safety of reprocessed nuclear fuel to its customers in Japan, Germany and Switzerland? Could this be a case of climbing on bandwagons? BNFL must be feeling especially beleaguered this days, for Sellafield is not their only problem. Concerns over the allegedly perilous state of their 35-year-old Magnox station in Somerset (Hinkley Point A), now run by BNFL, have sparked additional adverse comments about the lack of a 'safety culture' there.

The British Government have decided to put plans to privatise BNFL on hold until at least 2002, and are reported to be seriously considering proposals to end nuclear fuel reprocessing and turn Sellafield into a storage facility – despite asservations from Ian Fells and others that nuclear power still has a future. If these experts are right, is it wise to close Sellafield and leave La Hague in France as the world's only major reprocessing facility? That would surely not be consistent with allowing BNFL to be part of a group taking over the Nuclear Weapons Establishment at Aldermaston, where reprocessing constitutes a significant part of the operations. What does the term 'joined up government' actually *mean*?

The CFP strikes again

Inconsistencies of the UK Government's behaviour over ships, aircraft and nuclear fuel (see the two previous items) pale into insignificance against those of Brussels bureaucrats. Earlier this year, fishermen in Lancashire and Northern Ireland were obliged by legislation under the CFP to tie up their boats until April, in order to safeguard Irish Sea cod stocks during the breeding season. At the same time, a legal loophole allowed (at time of writing still does allow) large Belgian trawlers to fish those same waters, taking far more fish than the smaller British boats could ever manage – even though it was the destructive nature of trawling by the Belgians that had decimated cod stocks in the first place and led to the ban. With that kind of madness being condoned (if not actually encouraged) by the CFP, it is small wonder that we'll soon be paying £5 or more for our portions of cod and chips.

John Wright



Announcing 'WaterForum'

WaterForum is a free and open forum for discussion of surface water and groundwater resource issues; including drinking water, water conservation, environmental chemistry, wetlands, wastewater, irrigation, recreational use, fisheries and wildlife use, aquaculture, coastal studies and oceanography, environmental and public health issues, contamination/remediation, computer modelling, climatology, and any other relevent water resource topics. The list is moderated by myself, Ken Bannister, founder of Groundwater-Digest, currently the world's largest groundwater discussion forum.

WaterForum seeks to broaden the discussions held on Groundwater-Digest to include other areas of interest in the water resouces field. A broad range of members from academia, industry, government, and the general public, as well as wide ranging geographic diversity will provide for an interesting and helpful forum. Your membership is valued and your input is welcomed.

If you are not already a member, please consider joining the hundreds of subscribers of WaterForum today!

To join, simply send a blank email to: <u>waterforumsubscribe@eGroups.com</u>

Best wishes and I hope to see you on the new list.

Ken Bannister
WaterForum Moderator

<u>http://www.egroups.com/group/waterforum</u>

Valuing biodiversity

Martin Angel

Stimulated by the debate on Ecology and Ethics held by the British Ecological Society in January '99, a follow-up discussion meeting on 'Biodiversity: Is it worth more than money?' was held at the Linnean Society in October, jointly organized by the Linnean and British Ecological Societies. How to establish convincing and credible 'values' for biodiversity is a critical issue facing the ecological and the environmental movements. How is humanity to be persuaded of the urgency needed to address the problems of sustainability and the critical importance of conserving the rich variety of Nature around us, and thereby ourselves? Most importantly, how are people to be persuaded that the sacrifices of material wealth and traditional freedoms needed to address these problems must be fair and equitable between South and North and between rich and poor?

Most valuations of biodiversity are based on human self-interest, either through direct monetary returns or in terms of the value of ecological services to human societies at both local and global scales. However, since the values of these services are often indirect, sceptics called upon to pay for them are reluctant to believe they are real. Nature also offers us vast uncosted (and perhaps uncostable) reserves of potentially useful products in the form of organic compounds and genes. The frightening costs of ultimate failure suggest that in addition to economic values, we should value biodiversity in ethical terms, bestowing it with 'values' that find expression in concepts such as transgenerational responsibility, stewardship, maintaining the integrity of Creation, and personal spiritual beliefs.

At the meeting, Fiona McConnell, who had headed the UK's delegation to the meetings at which the Biodiversity Convention was negotiated prior to being signed at the Rio Conference in 1992, gave an account of the political battles that led to its inception. It originated in the 1983 Brundtland Report and the desire of the USA to rationalize the complex international conventions that had hitherto been negotiated piecemeal. Little interest was shown until the Climate Change Convention highlighted the potential dangers. The first two negotiating meetings on Biodiversity made no progress – even the basic requirement to appoint a chairperson proving too difficult at the first meeting, only being resolved at the second meeting by appointing two chairs. It was John Major's announcement that he would go to Rio and sign a Climate Change and Conservation Convention that began to focus minds. Even so, there was no progress in drafting the convention until, at the at the eleventh hour, Mostapha Tolba, then Director of UNEP, arrived at the final negotiating meeting and dispensed with all international protocols. He bullied the representatives into completely redrafting and finalizing the text, article by article, in three days and three nights. Although not all countries signed the Convention at Rio, it has continued to evolve at subsequent negotiating meetings. Problems of funding the Convention through the Global Environmental Fund (GEF) have been caused by the arrogance of the World Bank in insisting that recipient countries make structural changes to their economies. There is now a major need for a Global Convention on Nature Conservation.

Loren Wilkinson (University of British Columbia) addressed the problem of how both Governments and people might become more persuaded of the importance of biodiversity. The Earth needs to be cherished, and people must take responsibility for the stewardship of Creation. 'Value', however, is an intrinsically difficult concept. In the developed world, societies base valuations on economic criteria, whereas *individuals* apply spiritual, emotional and moral criteria. Scale is also important, however, and to put a value on biodiversity globally requires a large-scale framework. Wilkinson suggested five frameworks, two pragmatic, and three spiritual.

The first pragmatic approach that could be adopted is based on environmental economics, whereby the natural world is costed according to its perceived market value. Asking whether biodiversity is worth more than money, is meaningless to an economist – there *is* no 'value' other than monetary. No market = no value! Conflicts of interest arise when there is a choice between the immediate realization of a resource's economic potential and its aesthetic value, but economic value is determined by peoples' willingness to pay *now* (rather than at some unspecified later date). The pristine temperate rainforests of British Columbia contain a very valuable biomass of wood, but in the long term ecotourism will yield greater returns than clear-felling. Unfortunately, the value of genetic information is now leading to unseemly and avaricious claims of ownership (should *anyone* own the information in my DNA?).

Common property is often abused. But if the seas were owned by the tanker companies and the whales by the Japanese, would there be an end to pollution and over-exploitation? Furthermore, ecosystems that are considered valueless locally may have overwhelmingly large global value, which becomes obvious if they are lost – mangrove swamps are a good example.

The second pragmatic approach is based on inter-relatedness in biosphere networks. The Gaia concept, that Life 'tailors' the Planet, implies that if the life-support system is degraded, the global ecosystem will be damaged. Human self-interest is expressed in terms of 'functional equivalents': thus, tropical rainforests are described as the 'lungs of the Planet'; but ascribing functions to life and lifestyles in terms of economic value still fails to provide an adequate framework.

Can spiritual and religious concepts provide better frameworks for valuation? According to pantheism, the first of Wilkinson's spiritual frameworks, all life is divine: the wholeness and integrity of Nature is considered beautiful, attitudes tend to become biocentric, and Nature has priority over human needs. Devotees may apologize to trees before they fell them and to animals before they kill them, but the ultimate expression of pantheism is for people voluntarily to starve to death – perhaps not a good selling point in most forums.

The second spiritual framework is theistic. God created all creatures and Mankind has responsibility for them. Humanity has both dominion and a duty to watch over, tend, protect, and serve. According to this 'Ark' concept, Creation is paramount and is to be neither degraded nor lost. God, the 'Divine Watchmaker', has created an orderly system that relies on faith to fill the gaps in our understanding. There is awe and wonder

about creatures because they are the product of a Creator, and God is in all Nature. Scientists continuously strive to close those gaps in our understanding (in which the Divine Watchmaker resides), and they tend to be agnostic or atheistic because they find it intellectually unsatisfying to rely on faith alone.

Wilkinson's third and final spiritual approach was that of Science itself. Science is based on humanity's curiosity, awe, wonder and sense of mystery. A wonder-driven search for knowledge is based on an intensely held belief that through scientific dialogue and curiosity, the Earth and its systems can eventually be understood. There is a general personal belief in the importance of species, which was epitomized in the writings of E.O. Wilson ('the first step to wisdom is giving things the right name'). Evolution is envisaged as a grand drama acted out on the Earth, while human behaviour is perceived to be rooted in global survival and to be full of a love of living things – through which we have stewardship for the diversity of life. By taking on its valuation we assume responsibility for Creation, and in this context, what seems to emerge out of Rio is that all we need to do is to stop being nasty.

There were then four short presentations of personal approaches to valuing biodiversity. John Healy (University of Wales, Bangor) spoke about his experiences of a biodiversity project in Cameroon. In developing countries, local people value natural resources according to non-market criteria. They are intensely interested in species that provide them with products and/or have cultural importance. They name the important species, often distinguishing between taxonomically similar ones, but have zero interest in rarities and endemics. Their values are dynamic and based on perceptions that contrast to those of global stakeholders who are preoccupied with science and with the need to understand the diversity.

I myself discovered, when participating in an expedition to a rainforest in Guyana, that the local Amerindians had names for nearly a thousand species of tree, but only a single term, 'small worm', for all insects. Even within local societies there are disparities in the values attributed by men and women, by different age groups, and by different ethnic groups. Despite their direct and often high dependence on local diversity, they have no interest in what ecologists consider to be the key characteristics of biodiversity: species richness and the existence of rare species.

David Goode (London Ecology Unit) emphasized the importance of involving local interest groups in the conservation of biodiversity. More and more planners feel responsibility for biodiversity, whereas engineers still regard it as irrelevant to their work. In the UK's Biodiversity Action Plan there was an obsession with targets and a lack of underlying philosophy. It was stolidly based on scientific criteria and lacked wonder at the magic of Nature, and so it has failed to inspire ordinary people. Local Biodiversity Action Plans are beginning to identify those enthusiasts who are willing to take responsibility on the ground. Even so, the implications of biodiversity loss are still not being reckoned in financial terms, and there is still no sense of urgency about maintaining and conserving the remnants left to us.

Sir Martin Holdgate (President of the Zoological Society) spoke with lucidity and authority. Based on his experiences as Chief Scientist to the Department of the Environment and, later, Director of IUCN (International Union for the Conservation of Nature and Natural Resources), he envisages biodiversity as encompassing the total richness of Nature. The various methods for evaluating biological systems are inevitably selective, and basically there are two approaches – market-based and belief-based.

Economics is the dominant driving force in our Society, and facing up to 'market economics' is the optimal way to drive decision-making. Ecology is currently too obsessed with a 'cherry-picking' approach and arguments about use-related functions, and must become more pragmatic. Ecological services, such as renewal of atmospheric oxygen, are difficult to assess and have little, if any, relationship to species composition and community function. The key question is 'value to whom'? If a forest is logged, for example, who gains economically and who loses?

Belief values are non-utilitarian and unselfish. Sustainability looks towards intergenerational equitability and an intangible belief in the future importance of gene-pools. The challenge is how to make beauty and curiosity as important as, or even more important than, economics. Unfortunately, rubbishing the belief systems and spiritual values of others has become habitual, because of the arrogant belief prevalent in science and economics that they are objective – patently they are not. Far better information about the various issues is needed at all levels of society, but especially for decision-makers and industry. Basically, the essential need to maintain biodiversity will have to constrain human activity and markets at all levels.

Alan Holland (University of Lancaster) discussed some philosophical aspects of biodiversity and evolution. Standing beneath a portrait of Charles Darwin, he pointed out that with so little understanding about what biodiversity means or implies, its valuation continues to be fraught with problems. Biodiversity is a product of evolution and so evolution needs to be better understood. Evolution in the Darwinian sense is not strictly an evolution because it has no direction. The 'struggle' for survival is not really a struggle, because competition between species is seldom evident. The word 'fitness' is not a particularly meaningful word because, as when a glove is fitted, fitness can only be judged after the event. The question of whether biodiversity can be conserved gives rise to misleading comparisons, often related to trade-offs. Basically, 'value' is the wrong term because of its assocation with money.

David Gibbon (RSPB) expressed the view that the values of biodiversity cannot be captured by monetary values alone, since species with spiritual and cultural values tend to lack economic value, so the contribution of biodiversity to the 'quality of life' cannot be assessed in monetary terms. We should be valuing those species that count, rather than those that can be counted – but who decides which ones count? Some believe that natural capital can be traded against financial capital, but under such a regime biodiversity will always lose out.

Sam Berry (University College, London) rounded off the meeting by asking for feedback about how the scientific and environmental communities can take this debate further.

So where did this meeting leave me? First, it was evident that the meanings of the words we use are critical in communication. Many people are confused by the term 'biodiversity', and throughout the meeting it was repeatedly used in different contexts and with different meanings. 'Value' has an inescapable monetary connotation, but what other term can we use without inventing a new jargon?

A few weeks after this meeting (on 14 January, 2000), another meeting ('The Role of Environmental Economics') was held at the Royal Society, organized by UK SCOPE (Scientific Committee for Problems in the Environment). At this meeting, some of the gurus made a convincing case that much can be gained from economic valuation of natural resources and functions. It also became clear that each of us needs to clarify our personal perception of the ethical importance of sustaining biodiversity. These perceptions will depend on our individual background experiences, and on the time- and space-scales with which we each view the world. As an oceanographer, I am conditioned to being global in my perceptions and find myself becoming irrationally impatient with the rather parochial attitudes of many others. Holdgate's warning about not rubbishing the beliefs of others touched a nerve. We in the developed countries should remember that starving peasants living hand-to-mouth have no time for global issues, worrying about rarity, or even the beauty of the surrounding landscape. Gnawing hunger-pains tend to push out spirituality. Only when the belly is full can the scope of our concerns and perceptions expand. Hence, greater equality in resource-partitioning is ecologically desirable.

At the other end of the scale, we need to escape from a tendency to resort to conflict. Environment will not have featured in the thoughts of military commanders who were bombing Kosovo or shelling Chechenya (cf. p.15). For them, the imperative was to destroy the local infrastructure. The need to punish violations of human rights on the one hand, and terrorism on the other, dominated the minds of the politicians who justified the morality of their actions.

With all these arguments there are 'horses for courses'. Environmentalists need to become far more skilled at tailoring their arguments to the occasion. While a spiritual and moral dimension is fundamental, its sole use will be ineffectual in arguments before agnostic forums whose prevailing ethos lacks morality and spirituality. We cannot afford to lose these arguments. So we must engage at the right level using the appropriate terms, while still taking the moral high ground. Our arguments must focus on the clear long-term gains to be achieved in moving environmental issues to the top of our list of priorities. We also have to recognize that not all ecosystems and species have a clear socio-economic value. There is also an underlying danger in using economic values inappropriately. If the measurement is inappropriate the value will be meaningless or even misleading.

At global, national, regional and local level our society needs to develop a more integrated approach to the management of natural resources. Our evolutionary past makes us give top priority to immediate survival and to short-term gain over longer-term advantage. We demand a rapid return on capital, our spatial awareness tends to be parochial, and issues tend to be dealt with case-by-case in a piecemeal fashion – remember *Brent Spar*! There is a lack of spiritual ethos that could serve to guide us when the going gets tough and the issues become difficult. There is a need to achieve fairness and equality for all humanity, and between us and the rest of Creation.

I hope that this and future meetings will be effective in imbuing us with a greater ethical sense of our responsibilities to future generations and to the whole of Nature, no matter whether we couch that ethos in terms of religion, spirituality, stewardship, scientific curiosity or plain commonsense.

Perhaps we should be more mindful of the final words of Thomas Malthus in his first essay on population:

'Evil exists in the world not to create despair but activity. We are not patiently to submit to it, but to exert ourselves to avoid it. It is not only the interest, but the duty of every individual to use his utmost efforts to remove evil from himself and from as large a circle as he can influence; the more he exercises himself in this duty, the more wisely he directs his efforts, and the more successful these efforts are, the more he will probably improve and exalt his mind and the more completely does he appear to fulfil the will of his Creator.'

Martin V. Angel
Southampton Oceanography Centre

Further Reading

Malthus, T. (1798) *An Essay on the Principle of Population as it affects the Future Improvement of Society*, edited by Antony Flew and reprinted in Penguin Classics 1985, 291pp.

Webb, N.R. (1999) Ecology and ethics, *Trends in Ecology and the Environment*, **14**, 259–60.

8 June is World Oceans Day

At the 1992 Rio Earth Summit, where the Convention on Biological Diversity was signed, 8 June was delared as World Oceans Day. World Oceans Day never seems to be a well-publicized occasion, but this year a wide variety of events have been organized in the UK for the week 3–10 June. Rock-pool rambles, wildlife cruises, treasure hunts, exhibitions and roadshows are being held at Shoreham-by-Sea in West Sussex, Flamborough in Yorkshire, St Agnes, Truro and the Helford and Fal estuaries in Cornwall, Mortehoe in Devon, and the Shetland Isles.

International Biodiversity Observation Year 2001–2002

International Biodiversity Observation Year will be officially launched on 31 December 2000. A website is already online at: http://www.nrel.colostate.edu/IBOY

A new marine diversity project, 'Biodiversity at sea: a set of sustainable indicators' is being planned. The project will be developed at different geographic scales. A proposal has been made in the EEC 5th RTD FP, through MARS (European MARine Station network). It will also develop through IMBiN (International Marine Biodiversity Network).

For more information, contact Jean-Pierre Feral, Observatoire océanologique de Banyuls, UMR CNRS 7628, Modèles en biologie cellulaire et evolutive, BP 44, F-66651 Banyuls-sur-mer, France; Tel. +33-(0)4-68-88-7318, Fax: +33-(0)4-68-88-7383 mailto:feral@obs-banyuls.fr

New Biodiversity Database for Copepods

A new database on the Biodiversity and Biogeography of Planktonic Copepods can be accessed at the website of the Laboratoire Arago under 'informations scientifiques diverses'or (preferably) via the URL http://www.obs-banyuls.fr/RAZOULS/WEBCD/RAZOULS1.htm

For more information, contact Francis de Bovée, Observatoire océanologique de Banyuls, Laboratoire Arago, F 66650 Banyuls sur Mer; Tel. (+33)-(0)4-68-88-7336; Fax: (+33)-(0)4-68-88-1699; Email: fdebovee@arago.obs-banyuls.fr

Environment, Wars and the EFMS

In July 1999, a letter was sent to the EFMS Secretariat by Dr Emmanuel Dassenakis, Secretary-General of a member society, the Association of Greek Oceanographers. The letter expressed concern about the environmental effects of the Kosovo conflict, and was sent during NATO's active involvement in that conflict, which ended not long after (although the conflict itself cannot be said truly to have ended even now). Here is what the letter said:

> The executive committee of the Greek Oceanographers Association believes that EFMS should express an opinion about the effects of the NATO bombing in Yugoslavia. Apart from political opinions of individual EFMS members about the necessity of NATO attacks against Yugoslavia, it has become clear that the bombing of chemical industries, oil refineries, oil tanks etc. leads to the production of highly toxic substances (dioxins etc.) that will adversely affect both the environment and the health of the inhabitants over large areas for many years. Radiation from U-238 contained in the bombs is a serious additional factor in the environmental degradation and could make it more difficult for refugees to return to their homes. Transport of pollutants to the sea (mainly Adriatic, Black Sea and Aegean) via atmosphere and rivers may have significant and deleterious effects on marine ecosystems, and damage to marine biodiversity in a very sensitive area cannot be excluded. We believe that the loss of innocent human lives due to 'mistakes' of 'clever bombs', and the threat of ecological disaster, is enough reason for marine scientists in Europe to express their deepest worry about the war activities in the Balkans and to demand the immediate cessation of bombing and withdrawal of NATO forces from the area.

A copy of this letter appeared in *DGM Mitteilungen* 2/99, accompanied by comments from Thomas Höpner (Chairman of DGM), who stressed that they *expressed only his personal views*, not those of the DGM, let alone EFMS. With his permission, we present here an edited translation of Professor Höpner's comments. Although the Kosovo War occurred some time ago, the issues that it raised still remain.

"The EFMS Secretary-General was against the EFMS adopting such a resolution, citing statutes of the French UOF, which prohibit political statements to be made. The British CSMS likewise takes the view that such resolutions are not within the remit of the EFMS. The President of the Italian AIOL suggested that the EFMS might prepare a document expressing sorrow at the loss of human life and fears of an ecological disaster in the Adriatic Sea (which he considers to be 'a very delicate environment'), but should not call for suspension of the bombing, as that could have adverse political consequences.

So much for the views of some EFMS members. We turn now to the DGM's experience. An attack on fuel tanks near the Danube prompted phone calls from the media to me (Thomas Höpner) as Chairman of the DGM, enquiring what the ecological consequences would be if fuel tanks near the river were destroyed. As a scientist, I cannot make formal public statements in response to such questions without adequate supporting data. Even though I am entitled to hold personal opinions about these matters, must I (and other scientists) remain silent?

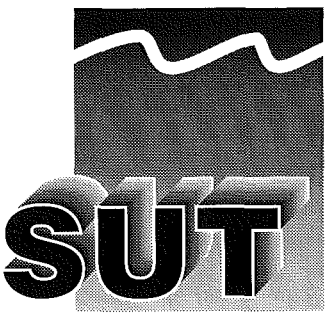
With regard to ecology, the Kosovo War is no different from other wars. Every war has adverse ecological impacts, even where there is no deliberate environmental destruction of the kind we saw in the Gulf War of 1991. Even scientists do not need quantitative data to recognize that. The Kosovo War may be over, but the associated environmental damage continues. It is of course not confined to the marine pollution mentioned by the Greeks and the Italians, and crowded refugee camps do not help. But when any war comes to an end people become preoccupied with their own affairs, leaving Nature to heal herself.

As scientists, therefore, should we not support those groups and organizations which demand monitoring and evaluation of environmental damage inflicted by wars? Is it not high time that any war be subject to an environmental study, even if it is only after the event? When Dr Karl-Jürgen Hesse and I ran for office on the DGM board at the end of 1995, we proposed procedures for DGM responses to environmental catastrophes. At that time the issue was French nuclear tests on Mururoa atoll. Our proposal seemed reasonable to us, but despite two years of discussion and hard lobbying, it was not adopted. The Kosovo War has brought these issues closer to home. It is easy enough to say that the fault lies with the warring factions. In my opinion, it is also partly our fault, because we believed in 'clever bombs' and in the 'surgically precise' or 'chemically clean' bombs and missiles we were shown during the Gulf War, which gave the impression that this has become an acceptable form of aerial warfare. But that is not true: war has not become any more acceptable and is not likely to become so in future.

We take our Greek and Italian colleagues very seriously, not least because they are geographically closest to the Kosovo 'catastrophe'. They have expressed their concerns to the EFMS and its constituent societies, and asked for support. The question is, should scientific societies have an official view on the environmental consequences of conflicts such as the Kosovo War? As scientists we should be able to find some answers, but following foundation of the EFMS the number and variety of opinions is likely to grow, and it may become increasingly difficult to arrive at a consensus view." T.H.

We stress again that the foregoing expresses only Thomas Höpner's personal opinions and should not be taken to represent those of the Challenger Society or any other member society of EFMS. But we ask our readers how *they* would answer Professor Höpner's question: Should scientific societies have an official view on the environmental consequences of conflicts such as the Kosovo War? Eds

The Society for Underwater Technology



The SUT is an international body actively promoting the development, dissemination and exchange of ideas, information and technology arising from or related to the underwater environment.

Founded in 1966, the Society brings together organisations and individuals from over 30 countries with a common interest in underwater technology, ocean science and offshore engineering.

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- **Forum for networking** and communication between members through a newsletter, a members' directory, branch membership and events.
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- **Careers information** fact sheets, *Oceans of Opportunity.*
- **Comprehensive services** via the internet at *www.sut.org.uk*
- **Reference facilities** in the IMarE Marine Information Centre and adjacent SUT Head Office in London.

For further information please contact:

SUT Head Office: *80 Coleman Street, London EC2R 5BJ, UK. Tel: +44 (0)20 7382 2601, fax: +44 (0)20 7382 2684.*

SUT Aberdeen Office: *Innovation Centre, Exploration Drive, Bridge of Don, Aberdeen AB23 8GX, UK. Tel: +44 (0)1224 823637, fax: +44 (0)1224 820236.*

www.sut.org.uk

Sustainability – a matter of time and space

Martin Angel

Previous issues of Ocean Challenge *have featured a number of pieces on sustainability. All have taken the view that most politicians, economists and industrialists (perhaps quite a lot of scientists too) either don't understand the concept or don't care about it. Does Martin Angel agree with this view? Read on and find out. Eds*

The definition of sustainability demands we look to the future and assure ourselves that our current activities are not compromising the quality of life for our successors. It is not just an issue of ethics and citizenship, it is a major issue affecting our long-term socio-economic survival in a resource-limited world. However, human society is not organized according to ecological criteria but according to the economics of market supply and demand. Political decision-making is dominated by monetary profit and loss accounts, by the aims and objectives of very powerful minorities such as the pension funds, by policies focussed on short-term job creation, and by the perceived need to get 'value for money'.

Achieving sustainability will require major revisions in societal attitudes, which are currently too focussed on wealth-creation and instant provision of material and 'cultural' benefits – the 'Now Society'. The UK's financial affairs have been handed over to the Bank of England, which reviews economic policy monthly and whose models extend forward in time a year or so. The criteria on which the Bank is instructed to run its affairs are, inevitably, based solely on economics and the need to control inflation. There is a mismatch between the goals of our financial, political and industrial masters on the one hand, and the priorities that ecologists such as I (along with many other far more eminent environmentalists) see emerging, on the other.

A few years ago, the Government issued a White Paper on Science in which it was argued that the function of State-funded science is to create wealth and to improve the quality of life. However, since our society is ruled by economics, it considers that quality of life can be purchased, and so the primary function of science must be wealth creation. Economists have been given Nobel Prizes for saying that economic growth is sustainable for the foreseeable future – a notion that Sir Crispin Tickell has described as 'crazy economics'. A cynic might be forgiven for concluding that economists receive such awards because they are telling our decision-makers what they want to hear.

Surely those economists can never have looked at pictures from space with even a modicum of understanding. Their time perspectives are too limited – for them, the 'foreseeable future' is the next couple of years, not even a decade, never mind a century. Governmental agendas are short-term, because politicians' visions of the future seldom extend beyond the next political milepost: usually the next election or annual Party Conference. Only a few sectors of industry – particularly the extractive industries – have time perspectives of as much as a few decades, as distinct from 'next year'.

The concept of sustainability is profoundly affected by the scales in time and space against which it is assessed. Answers to questions, solutions to problems, and priorities for action, change drastically according to these scales. The need to make the right measurements is critical. For example, a few years ago the invitation to tender for conducting surveys of potential sites for the disposal of *Brent Spar* landed on my desk. To me the tender document was fatally flawed. It asked the wrong questions, proposed the use of inappropriate techniques of assessment, and overlooked some key issues. Thus, it required a survey of a large area of sea-bed using point samples collected using a systematic grid of 300 box cores which, even if they could have been analyzed fully in the time, would not have provided an adequate picture of the patchy environment. Nor did the document ask what features and creatures ocurred in the area, still less did it propose discovering whether any of them deserved protection.

The dilemma for me and my colleagues was: Should we submit a tender that might earn the money, but would fail to answer the (wrong) questions in the document? Or should we submit a tender to conduct the surveys so as to answer what we considered to be the right questions? We chose the latter option and failed to win the contract. Maybe our tender was just too expensive, but more likely it failed because we were not prepared to operate according to the flawed terms of the tender.

Perspectives of what the future may hold are based upon the models that scientists develop using information extracted from ocean and lake sediments, from tree rings, from ice-cores and so on, all of which provide evidence of long-term natural climatic fluctuations. However, evidence of anthropogenically induced change in climate is still being dismissed by vested interests as an artifice created by scientists to ramp up their funding – although the number of such dissenters is now decreasing, as the evidence accumulates.

There is inevitably uncertainty in science, resulting from lack of knowledge and/or understanding of the inherent instabilities of many natural systems. But it contributes significantly to a general public distrust of science. Scientists face a dilemma. If they admit to uncertainty, their science tends to be disregarded, but for a scientist to disavow uncertainty is tantamount to dishonesty. Social assessment of risk is even more fickle – I am allowed to buy cigarettes but until very recently not beef on the bone. There is general public disquiet about manipulating the genomes of plants and animals, but almost none about the dangers of driving a motor car.

In 1994, the journal *Ecology* published the text of the MacArthur Award Lecture, one of the most prestigious ecological lectures in the USA, given that year by Peter Vitousek. In the lecture he identified three certain anthropogenic impacts that can be expected to have a major effect on the global environment. They are as follows:

1. Rapid growth of the human population has resulted in substantial shifts of land use. Thus, the total area of the planet is 51.6×10^9 hectares, of which 15.3×10^9 hectares are land and 36.3×10^9 hectares are ocean. That provides an area of roughly 2.5 hectares of land and about 6 hectares of ocean per person (for a global population of 6×10^9). But how much of the land is useful? Much of it is covered with ice (10.7%), desert (12.6%), tundra (4.8%), urban sprawl (2.2%), and so is unproductive. Productive areas include cropland (9.1%), rangelands (25.4 %), forest (tropical 12.4%, temperate 19.3%), and wetlands and rivers (3.6%). But only about a third of that productive area is still natural or semi-natural, so there is only something like half to three-quarters of a hectare *per capita*, of natural ecosystem to maintain the planet's ecological services on which we rely. Humans already have an impact on an estimated 40% of terrestrial productivity and 8% of oceanic productivity (locally in some shelf seas we are exploiting 25–35%!), and we presently intercept 50% of the freshwater resource.

2. Burning of fossil fuels is leading to further rapid increase in atmospheric carbon dioxide that is, in all probability, causing climate change (it is likely also to affect the ecology of terrestrial plants and the interrelationships between plants and insect herbivores). Expansion of the UK's offshore energy industry will nonetheless continue over the next decade or more, providing employment and wealth, especially in Scotland. It will also provide taxes to Government, plus a measure of national political stability for the UK, which will continue to enjoy an energy supply that is independent of other, possibly less stable, nations. However, the UK Government has led the way in committing itself to achieving what it fondly believes to be substantial cuts in carbon dioxide emissions. In the longer term, it is admitted that emissions of carbon dioxide will have to be drastically cut (by something like 60%) rather than merely held, if climatic changes are to be prevented. If the global population doubles, then emissions *per capita* will need to halve merely to keep total emissions at current levels!

In this context, the extraction of yet more hydrocarbons from slope environments makes very little sense, particularly since these offshore regions are where wind, wave, current and tidal energy are available in abundance. Development of technologies for extracting these 'renewables' should be receiving much more investment from our energy industries than it presently is, even though such development will almost certainly carry environmental costs – the technology is not as 'clean' as some environmentalists would have us believe.

The biological and ecological impacts of excess CO_2 would be more than enough to have its manufacture banned – if, like the CFCs, it were a synthetic chemical! Alternatively, another future of the offshore industry might lie in disposing of some of the excess anthropogenic carbon by pumping it into deep geological deposits. This is already happening in the Norwegian sector of the North Sea, where carbon dioxide stripped locally from a natural gas supply is immediately injected into brines in deep geological deposits. The economic costs of extending this approach to the disposal of industrial carbon dioxide emissions would be enormous, even if there were to be a breakthrough in the necessary technology (see also *Ocean Challenge*, Vol. 9, No. 2, p.10, p.51).

3. Addition of nitrogenous compounds to the global environment has been more than doubled by industrial fixing of nitrogen in the manufacture of fertilizers, by the growing of leguminous crops and by burning of fossil fuels.

All of these anthropogenic influences have for some time been profoundly altering the global ecology, with huge impacts on biodiversity, including marine biodiversity. Generally the oceans are rich in types of organisms (phyla), and are often locally rich in species, which have far more extensive distributional ranges than do terrestrial species. The total inventory of benthic species is considerably larger than that of pelagic species, but it probably does not even approach, let alone exceed, that of terrestrial ecosystems. Distributional ranges tend to be very large. For example, the bottom-living fish, the orange roughy (*Hoplostethus atlanticus*) occurs off New Zealand and Australia as well as in the North Atlantic.

The now famous deep-sea coral (*Lophelia pertusa*), which forms massive mounds of carbonate at depths of 500–1000 m, has a very broad distributional range: from the Mid-Atlantic Ridge to north-west Africa, and along the continental slope into the Norwegian Sea. However, sampling over these mounds is difficult, and like all deep-sea environments they have not been extensively studied. So far, available published data suggest that while numbers of species associated with them are quite high, they are not exceptional; and very few species appear to be endemic to the mounds.

At present levels of exploitation, the likely impacts of UK offshore hydrocarbon development on marine biodiversity seem likely to remain small, especially relative to the destructive impact of current deep-sea fisheries. Even so, the recent court case won by Greenpeace (see *Ocean Challenge*, Vol. 9, No. 3, p.4) means that there will be greater control of industrial development. But will fishing activity be controlled? It is extremely doubtful that EU bureaucrats will allow the Habitats Directive to affect the Common Fisheries Policy. Yet the draft Quality Status Reports for the five subregions of OSPAR (the OSlo and PARis Commission), which seeks to reduce pollution in the north-east Atlantic, all identify fishing activities as the greatest current threat to the Atlantic environment.

The maintenance of 'sustainable economic growth' requires that both hydrocarbon exploitation and intensive fishing will continue in the coming decades. Their cumulative impacts are bound to increase commensurately, and neither activity in its present form can be considered to be truly sustainable, even over the next decade or so. Given the prevailing wave of optimism that greeted the dawn of the new Millennium, it is going to be difficult to get over the message that time is not on our side and that technology is not likely to provide the answers. In fact, if (as seems likely) technology enables a selfish few to live for ever, it will only make things worse. Only optimists like me believe we can halt our present downward spiral to disaster. But human salvation beyond the time when my mortal body is recycled, lies only with frugality and accepting sharp reductions in our society's current greediness.

Martin (Cassandra) Angel
Southampton Oceanography Centre

'Calicide' can damage your health – especially if you're a crab

Calicide is a trade name for teflubenzuron, a benzoylphenylurea insecticide. Proposals have been put forward by the Scottish Environmental Protection Agency (SEPA) to license its use as a sea-lice control agent on salmon farms. Teflubenzuron has been used as an insect growth-inhibitor and has been principally studied in its role as an insecticide. However, there have been few studies either on its toxicity to marine organisms (other than sea-lice), or on the ecological effects of its use in the marine environment, despite the manufacturers' statement that it is toxic to aquatic organisms and may cause adverse long-term environmental effects.

Teflubenzuron is a non-specific inhibitor of chitin synthesis that acts by blocking the incorporation of *N*-acetyl-D-glucosamine into chitin, the main component of the exoskeletons of insects and crustaceans. As SEPA themselves acknowledge, teflubenzuron 'therefore exerts an effect at a moulting stage in the life cycle of exposed organisms'.

The distinguishing feature of all arthropods is the chitinous exoskeleton, and the phylum Arthropoda includes more than three times the number of all other known animal species combined. Production of chitin is not unique to the Arthropoda, however, which are thought to have evolved from the phylum Annelida ('worms'). These also produce chitin – the setae ('hairs') of the body segments, which have evolved into a range of structures with functions ranging from locomotion (e.g. ragworms), to protection (e.g. fireworms). Teflubenzuron could thus be lethal to them all.

The second largest invertebrate phylum is the Mollusca, also thought to have evolved from the Annelida. They have radiated into many forms, but their generalized mouthparts consist of a chitin-lined cavity containing the uniquely molluscan feeding organ, the radula, which bears rows of chininous teeth that wear out and are continuously replaced. In addition, the stomachs of molluscs are lined with chitin, which prevents damage by sharp objects – and although bivalve molluscs do not have radulae, they do have a chitinous stomach-lining. Teflubenzuron could be more lethal to molluscs than to arthropods, which are affected only during ecdysis (moulting).

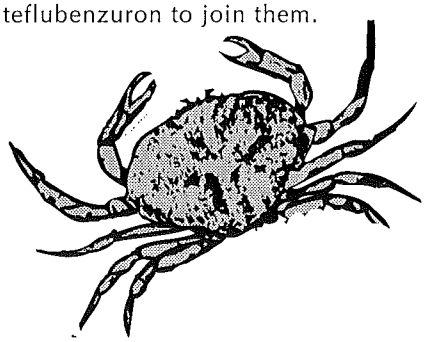
If both the molluscs and the arthropods evolved from the annelids, the mechanism of chitin-synthesis is probably similar in all three phyla and could be equally susceptible to teflubenzuron. The lethal effects are prevention of growth in arthropods, prevention of movement in annelids, and starvation plus internal damage in molluscs. However, there have been no studies on LC50 values (the concentration of teflubenzuron required to kill 50% of a sample of animals) for any marine species of these three major phyla, either as adults or during their larval stages in the zooplankton. Nor have there been any studies on the effects on adults or larvae of commercially important species of crustaceans (crabs, lobsters, prawns etc.) or molluscs (e.g. scallops, mussels, cockles, whelks, winkles, etc.), many of which have extended planktonic larval stages. Elimination of any of these species, even in a limited area, can cause signficant changes to the composition of benthic communities.

SEPA have stated that 'teflubenzuron is relatively non-toxic to most marine species (e.g. fish, algae, shellfish)', but there have been no studies of long-term ecological effects of using teflubenzuron. Such effects could be immense, but have not been considered in its proposed use as 'Calicide'.

Teflubenzuron is not readily biodegradable, and is partially soluble in water. Available evidence suggests that after the use of teflubenzuron, bioturbation in sediments would be significantly reduced, and that teflubenzuron would continually dissolve into the water column, with possibly adverse effects on zooplankton. Areas under salmon cages that have been left fallow have been shown to return to a polluted state when aquaculture operations resume. This is likely to happen in the case of teflubenzuron, as it is only partially metabolised by vertebrates and a large proportion of that ingested by the salmon may be released in faeces shortly after treatment.

There is also some evidence that teflubenzuron can affect predators and parasites of target organisms (including species used for biological control in several countries), and that it can adversely affect the metabolism of some mammals. Furthermore, at least some target organisms have been shown to develop resistance to teflubenzuron.

Since teflubenzuron inhibits chitin formation, and more than three-quarters of all known animal species produce chitin, there would seem to be a need for more research to be done, *before* teflubenzuron is considered for licensing as a sea-lice control agent. The lessons of environmental and economic damage caused by the release of inadequately researched toxic compounds into aquatic environments should not be ignored, not least because the list of such compounds is long. It includes DDT, PCBs and TBT – surely it would be prudent not to allow teflubenzuron to join them.



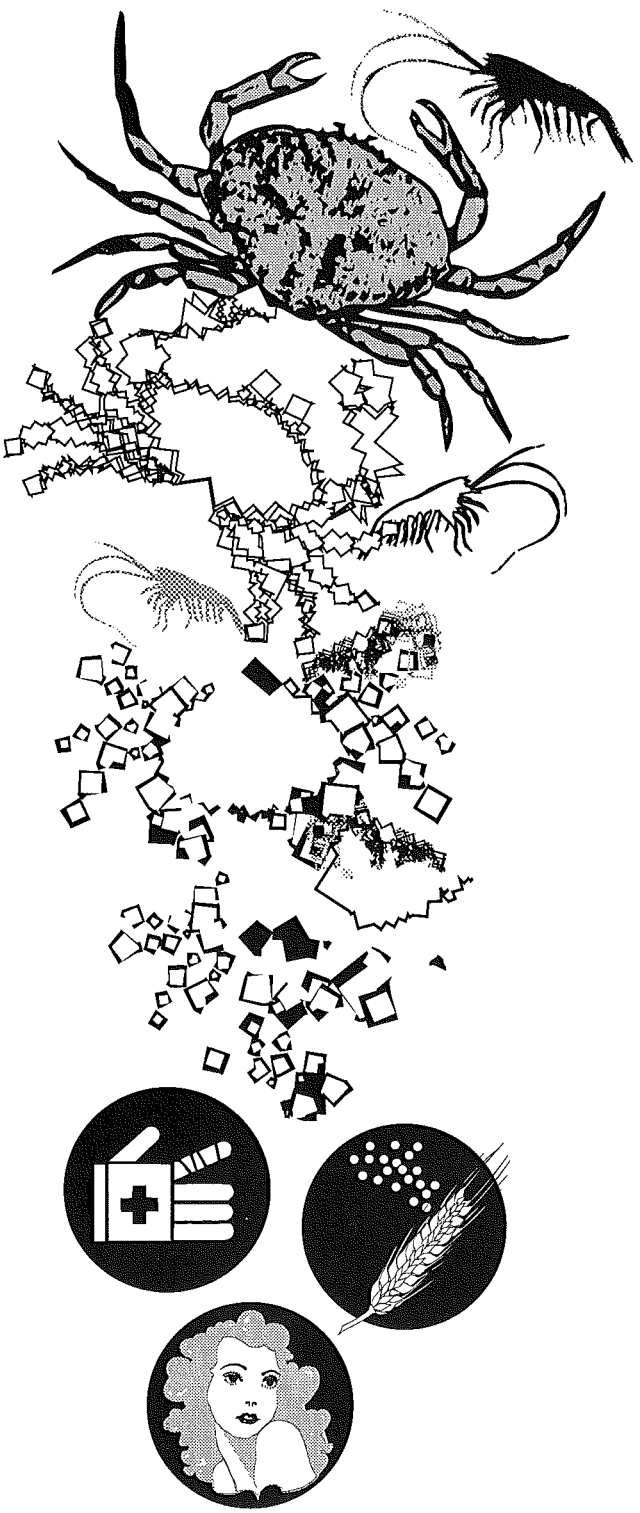
Information condensed from a long and heavily referenced email circular, forwarded by Andy Horton, British Marine Life Study Society.

For more information about chitin, see the following article 'Chitin and chitosan – natural polymers from the sea' by Klaus-Dietrich Sturm and Karl-Jürgen Hesse.

CHITIN AND CHITOSAN

– natural polymers from the sea

Klaus-Dietrich Sturm and Karl-Jürgen Hesse



Chitin, a cellulose-related polysaccharide, is the second most abundant natural polymer after cellulose. Chitin was described for the first time in 1811 by Henri Braconnot, a professor of Natural History in Nancy, France. In 1823, Odier called the substance that Braconnot had isolated from an edible mushroom 'chitin', a word derived from the Greek 'chiton' meaning tunic or envelope. In 1859, Charles Rouget found that chitin boiled in concentrated potassium hydroxide solution becomes soluble in organic acids. This 'modified chitin' was studied in Germany by Ernst Hoppe-Seyler, who named it 'chitosan'.

Sources and cycles

Chitin is present in the cuticle or exoskeleton of most invertebrates and it is the dominant component of the exoskeleton in insects and crustaceans. In the biosphere, chitosan is enzymatically produced from chitin by action of the enzyme chitin deacetylase, and chitin and/or chitosan are constituents of the cell wall in most fungi, moulds and yeasts. It is also synthesized by a number of unicellular organisms such as diatoms, chrysoflagellates and protozoans, especially ciliates.

The amount of chitin with respect to total dry weight is highest in the protective shells of crustaceans such as crabs and prawns. The amount of chitin obtained annually from harvested shellfish is estimated to be over 39 000 tonnes. This estimate does not include krill, which has a potential of 56 000 t yr^{-1}.

At least ten billion tonnes of chitin are produced in the biosphere each year, chiefly in marine environments. Nearly all of this enormous quantity is recycled relatively quickly in the carbon and nitrogen cycles. Only very small amounts are buried and fossilized in sediments. The recycling is mainly carried out by the microbial food web, i.e. by bacteria, fungi and protists. The enzymatic biodegradation pathway is mediated by a family of chitinolytic enzymes known as endochitinases, exochitinases and *N*-acetylglucosaminidases. These enzymes attack the chitin, acting not only in consort but also in synergy with proteases and other lytic enzymes, to yield the monomer, *N*-acetylglucosamine, which – as shown in studies of chitin degradation – can be directly used as a sources of carbon and nitrogen by microbes. In 1997, Andrew Gooday found that a second main pathway of chitin degradation in the sea is through deacetylation of the chitin to chitosan, followed by the degradation of this intermediate product by chitosanases. These two major biodegradation pathways of chitin and chitosan are shown in Figure 1.

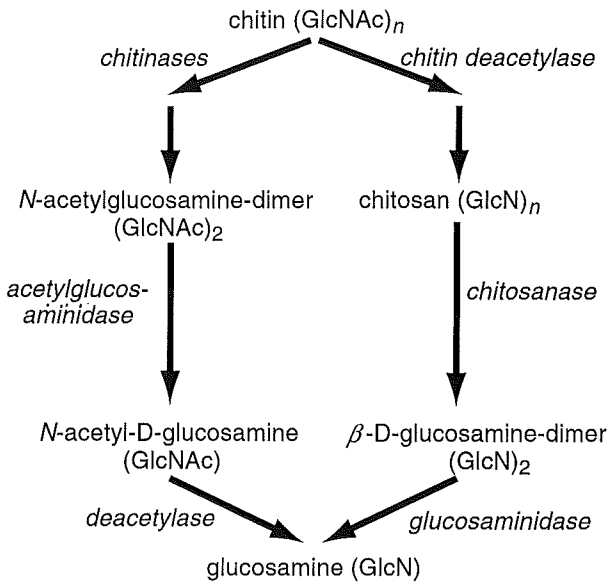


Figure 1 *Natural biodegradation pathways of chitin. On the right is the best known pathway, and on the left is an alternative pathway found by Andrew Gooday (Southampton Oceanography Centre), for degradation in the sea (see text). Enzymes are shown in italic.*

Structural similarities of chitin, chitosan and cellulose

The linear structure of these polysaccharide molecules is illustrated in Figure 2. The basic polyglucose structure is common to all three, but in chitin many of the hydroxl groups (OH) that characterize cellulose are replaced by *N*-acetyl groups (NHAc). In chitosan, these NHAc groups are in turn converted into amino groups (NH_3^+) by a process called deacetylation.

Chitosan is a linear polyelectrolyte at acidic pHs, with a high charge density (one positive charge per glucosamine unit). Since materials like proteins, nucleic acids and anionic polysaccharides carry negative charges, the cationic chitosan interacts strongly with negative surfaces to achieve electrical neutrality. Moreover, unlike chitin and most other polysaccharides, chitosan can be modified by a variety of processes (alkylation, reductive alkylation and acetylation), to produce a range of chemically selective covalent modifications, involving bonds to N or O. As a consequence of its capacity to form a variety of derivatives, coupled with its biodegradability and very low toxicity, chitosan has great potential for the development of high value products in the fields of pharmacology, food-processing and cosmetics.

Chitosan is only one of the molecules formed during the biodegradation of chitin

Chitin and chitosan production

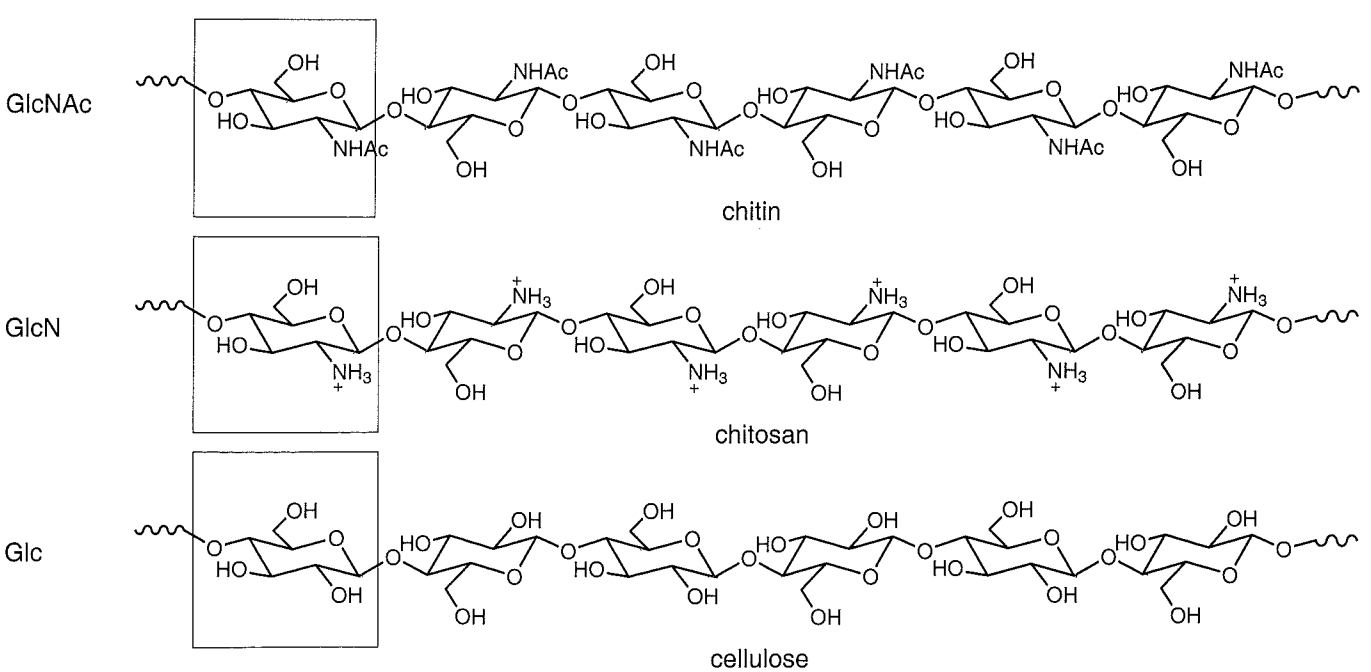
The common raw material for the industrial production of chitin and chitosan are the exoskeletons of crustaceans such as *Chionoectes japonica* (red crab), *Paralithodes camtschatica* (king crab), *Peneaus monodon* (tiger prawn), *Euphausia superba* (krill) and *Pandalus borealis* (Norwegian deep-water prawn) (Figure 3 (right), *overleaf*). The crustacean exoskeleton consists of a multilayer system of different matrices (as shown in Figure 3(left)).

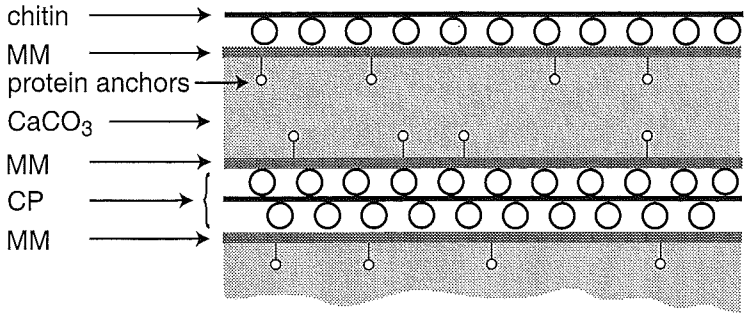
The typical composition of shell waste from the prawn-peeling industry, using *Pandalus borealis*, is as follows:

protein:	36% of dry matter
oil:	2.5% of dry matter
ash:	37% of dry matter
chitin:	24% of dry matter
astaxanthin:	230 p.p.m. of dry matter

Chtin, chitosan and cellulose are structurally very similar

Figure 2 *Structure of the polysaccharides chitin, chitosan and cellulose. Monomers (in boxes) are N-acetylglucosamine (GlcNAc), glucosamine (GlcN) and glucose (Glc), respectively.*





Crustacean exoskeletons owe their mechanical properties to the linked layers of chitin and protein

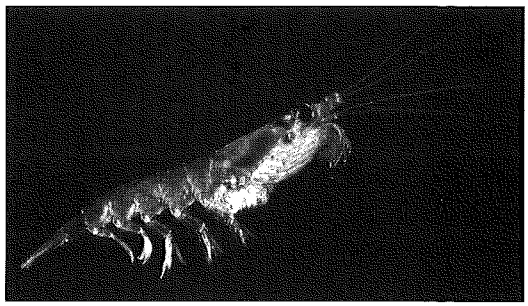
Figure 3 Left *Schematic structure of the crustacean exoskeleton, after Mathieu Poulicek, Liège University.*

MM = Mineralization matrix, consisting of an acidic protein fraction with a strong affinity to calcium ions.

$CaCO_3$ = Matrix consisting of calcium carbonate crystals arranged in a kind of sandwich structure. Carotenoid oils are embedded in this matrix and protein anchors protrude into it from the MM-layers.

CP = Carrier protein layer, a high molecular weight chitoprotein complex, without affinity to calcium ions. The protein is probably bound covalently to chitin.

Right *Two producers of chitin, at different ends of the size range.* ***Upper*** Euphausia superba, *krill (by courtesy of Inigo Everson, British Antarctic Survey);* ***Lower*** Paralithodes camtschatica, *the king crab (by courtesy of Heinz Teufel).*



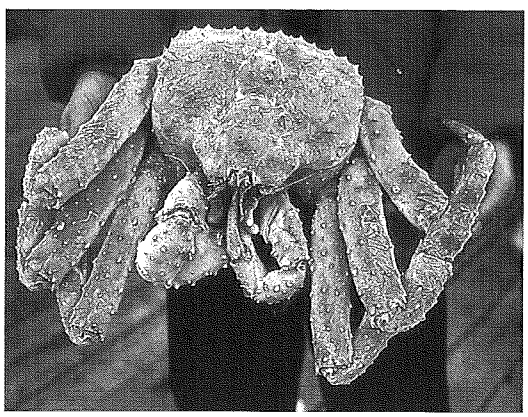
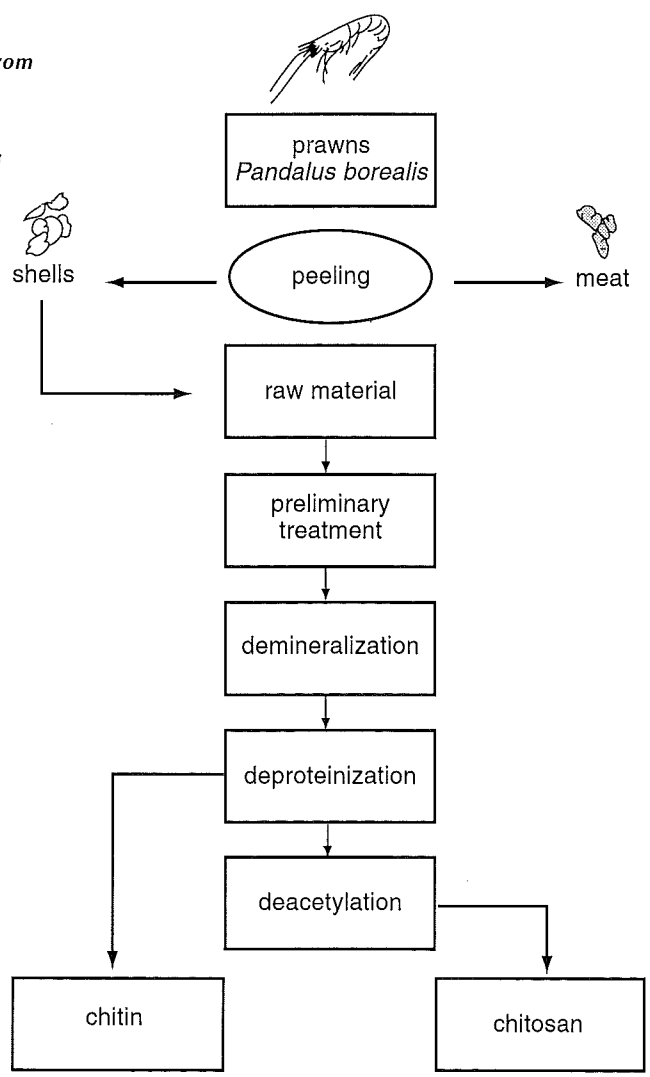


Figure 4 *Simplified diagram of chitin/chitosan production.*

Chitin/chitosan production involves removing from the shells the $CaCO_3$, the protein and the oils



Chitin production

Traditional processing to obtain chitin starts with grinding the prawn (or other crustacean) shells in a mill, followed by demineralization of the shells by hydrochloric acid treatment, in order to remove the $CaCO_3$ which is washed off from the rest of the shell components. In the next step, the protein and oil are removed by hydrolyzing in 2% sodium hydroxide solution at 100 °C for 2–4 hours. During this process, the protein is digested to soluble peptides and amino acids, and the oil is hydrolyzed to soap. The chitin is purified by washing several times in hot water. The process is shown schematically in Figure 4.

Chitosan production

In contrast to the natural deacetylation pathway for producing chitosan from chitin (right side of Figure 1), the conventional technical production process for chitosan is deacetylation by treating the chitin with sodium hydroxide (NaOH), which gives higher yields than older methods using potassium hydroxide, KOH. Optimum processing conditions involve immersing the crushed shells in 40–60% NaOH at 50–110 °C for two to six hours. During this reaction, most of the acetyl groups are removed in the strong alkaline solution, which consumes approximately 2.5 kg sodium hydroxide per kg of chitosan produced. The chitosan is then purified by neutralization and washing. Large volumes of sodium hydroxide are required, at a high concentration, so to reduce costs and minimize pollution, the solution is reused in subsequent chitosan production cycles.

Applications of chitosan

As it is a natural, non-toxic, biodegradable polysaccharide, there are great advantages to using chitosan for a wide range of different applications in medicine, pharmacology, agriculture, biotechnology, food-processing, cosmetics, water clarification and waste-water treatment. Chitosan is much better suited for these uses than chitin, because of its greater solubility in organic acids.

Table 1 *Important properties of chitin and chitosan in the context of their medical, pharmaceutical and cosmetic potential.*

Property	Chitin	Chitosan
biodegradable	yes	yes
antibacterial	yes	yes
hydrolyzable	yes	yes
easily forms derivitives*	yes	yes
allergenic	no	no
toxic	no	very low
selective binding of bile acids	no	yes

*In chitin this occurs by binding to other substances at the OH^- groups, forming O-bonds. In chitosan it occurs by binding at both OH^- and NH_3^+ groups, and chitosan is thus capable of forming a greater variety of derivitives.

Medical uses

Chitosans have demonstrated a powerful ability to reduce serum cholesterol levels. In pharmacological experiments (animal tests) the substance proved to be a leading candidate as a hypocholesterolemic agent for humans.

In the search for immunogenic properties of various chitin derivatives, chitosan was found to have immunity-enhancing properties (e.g. by stimulating *T*-lymphocytes), according to its degree of deacetylation. The strongest immuno-enhancing agent, with respect to its capacity for stimulating peritoneal macrophages in mice, was a 70% deacetylated preparation.

Chitosan has been shown to be suitable as eye bandage material and may also have some potential for use in contact lenses. For surgical purposes, the polymer can be transformed into strong fibres that can be used for sutures, and it may also be used for wound dressing if chopped fibres are incorporated into a non-woven matrix. Since the material is biodegradable (it is depolymerized by lysozyme, a common enzyme found in various mammalian tissues), sutures and wound plugs can be gradually absorbed by the organism. For the same reason, drug-impregnated chitosan can be used as a bioerodible matrix to deliver pharmaceuticals at a controlled rate (so-called 'controlled-release' technology). Depending on the particular purpose within the body, the chitosan may be in the form of granules, beads, tablets or sponges.

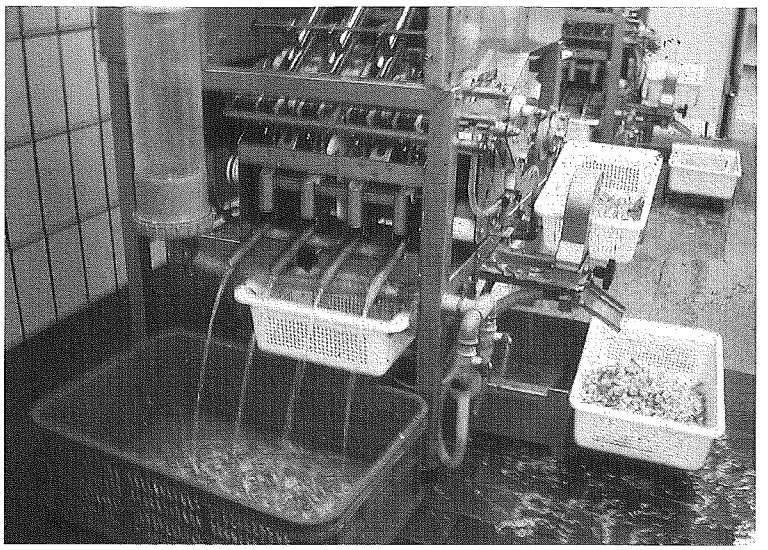


Figure 5 *Peeling machine for shrimp* (Crangon crangon) *in a fish-processing company in Germany.*

Processing crustaceans automatically provides the raw material for chitin and chitosan production

Cosmetic uses

Due to its cationic character and its adherence to proteinous surfaces as well as to anionic polysaccharides and nucleic acids, chitosan and its cationic hydroxylalkyl derivatives are used as non-toxic polymers in hair treatment and skin care. Chitosan is an excellent moisturizer that adheres better and is cheaper than hyaluronic acid. Consequently, it is increasingly used in cosmetics and for personal care applications – including sun protection, since it absorbs ultraviolet radiation. It also forms a promising substitute for potential 'nuisance substances' such as synthetic complexing agents in dermatological preparations.

Agricultural uses

Because of its antibacterial properties, and because it inhibits the growth of fungi, chitosan has been used as a wheat seed coating; and coated wheat seeds have indeed been shown to result in increased crop yields. It seems that chitosan triggers a physiological response in the seed, signalling the plant to protect itself from natural predators, like pathogenic fungi, most of which have chitin in their cell walls. Best results were achieved with depolymerized chitosan and chitosan oligosaccharides. Chitosan has also been added directly to agricultural land in order to stimulate the natural microbes that provide protection to certain crops.

Due to their antibacterial properties and low oxygen-permeability, N,O-carboxymethyl-chitosan films are used for fruit conservation. The Canadian Department of Health and Welfare has approved the use of these non-toxic substances for coating fruits. Chitosan is also used as a controlled-release agent for pesticides, herbicides and insecticides in soils.

Perspectives on chitosan production in Germany

In recent years there have been several research projects on chitosan in Germany, mainly focussing on practical applications. Apart from developments carried out exclusively within the private industrial sector, principally in the field of cosmetics (e.g. by Wella AG, Beyersdorf, CIBA), research projects have dealt with macromolecular characterization of chitosan, and with uses of chitosan for heavy-metal chelation in waste-water treatment, for the manufacture of loudspeaker membranes and non-woven fabrics, as well as products intended to inhibit wood-decaying fungi, and in food technology (including packaging). Only three German projects have concentrated on developing alternative processes for producing chitosan. In a current interdisciplinary project, the possibilities of chitosan and glycosamine sulphate production based on cultivated insect larvae are being investigated, along with physicochemical characterization of insect chitin and chitosan and new formulations for a matrix for chromatographic purposes and for growing liver cells.

Catches of grey shrimp (*Crangon crangon*) of about 6 000 tonnes a year along the west coast of the state of Schleswig-Holstein have formed the background for a study initiated by the local Ministry for the Environment to investigate possibilities and potentials of chitin and chitosan and their derivatives for economic purposes. An inquiry made among 50 regional enterprises involved in production and service industries relevant to potential chitosan application, revealed that most of the persons responsible had never heard about possible uses of chitin and chitosan. However, half of them manifested general interest in further information.

As a result of this study, a network of scientists, administrators and business people was set up to promote chitosan research in the region, with the aim of setting up a pilot plant for chitosan. A couple of R&D projects on chitosan production and chitosan application were initiated within this framework. Research was conducted into enzymatic chitin-processing for chitosan production, as well as into on-line monitoring of the production process. In the field of chitosan application, research has concentrated on the formulation of additives for paints, varnishes and waxes (including antifouling agents), as a matrix for controlled release systems, as a flocculant for dairy effluents, and as a latex substitute for foils and film coatings.

Future activities in the field of chitin and chitosan research will deal mainly with the optimization of production processes for high quality chitosan preparations, both in conventional and in enzymatic production pathways. With respect to the latter, the search for new and more effective deacetylases, predominantly from marine microorganisms, is pertinent. In addition, research will be focussed on the suitability of chitosan derivatives for pharmaceutical technology.

Further Reading

A full reference list is available from the authors. The following books provide an introduction to the subject.

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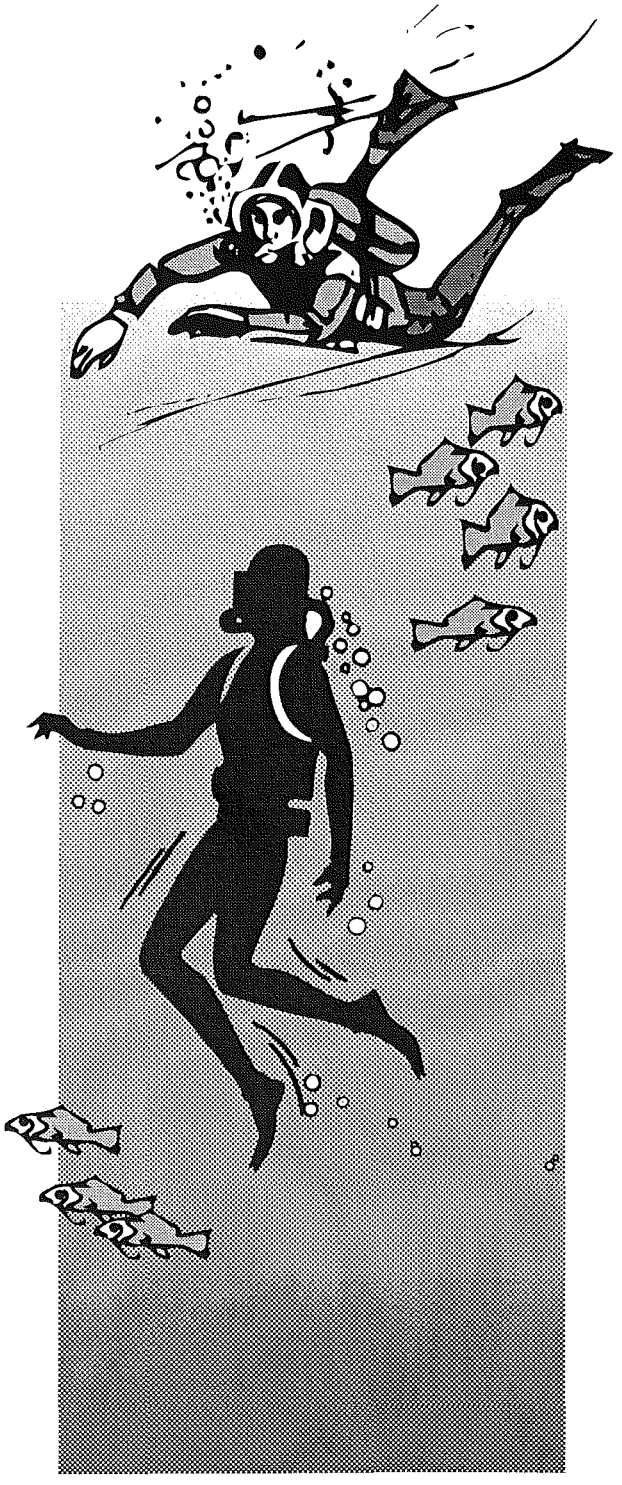
If you are interested in chitin, or in the relevance of the ocean to human health, see also: 'Calicide' can damage your health – especially if you're a crab (on p.19), and the review of the book From monsoons to microbes: understanding the ocean's role in human health *(on p.43).*

Training scientific divers – *Italian style*

C. Nike Bianchi and Carla Morri



Scientific diving was born in the Mediterranean as early as the end of the eighteenth century, when the Italian naturalist Filippo Cavolini reached submerged caves on the coast of Sorrento with the aid of very simple equipment. The practice of exploring underwater continued during the nineteenth century, when the zoologists Henri Milne-Edwards and Anton Dohrn used helmets and diving suits to observe and collect marine fauna around Sicily and in the Bay of Naples. In the 20th century, 'modern' scientific diving had one of its major pioneer phases in Italy, from where it rapidly spread to other Mediterranean countries and all over the world.

While Italy was one of the cradles of scientific diving, the Italian scientific establishment was slow to acknowledge the importance of diving for the advancement of marine research, maintaining for a long time that scientific institutions should not be 'disrupted' by 'sporting activities'. Italy was one of the first countries to develop diving as a sport and for years (in contrast to what was going on in other European countries and in the USA), marine scientists preferred to take advantage of co-operation by sports divers, rather than 'getting wet' themselves.

To give just two examples from the Ligurian Sea (north-west Mediterranean): Enrico Tortonese undertook fundamental research on the benthos of the rocky bottoms off Portofino in the late 1950s, using descriptions and samples taken by the divers of the Centro Subacqueo of Genova-Nervi (directed by Duilio Marcante). Lucia Rossi did the same a few years later at Punta Mesco, describing rocky subtidal communities on the basis of underwater photographs taken by Gianni Roghi.

Things started to change in the 1970s and 1980s, and nowadays nearly all major scientific institutions working in marine sciences in Italy include scientific divers among their staff. Nonetheless, the training of scientific divers is still largely neglected by the Italian scientific establishment, and people who use diving as a part of their scientific research are still typically self-taught.

In the last decade, initiatives have been taken in Italy to meet the need for proper training of scientific divers, not only for purposes of pure research but also in the allied field of popularization of science, for underwater guides in marine parks, and for amateur divers, both of whom may even have the opportunity to play a true scientific role through voluntary participation in monitoring and survey projects. Three such initiatives are described below.

The International School for Scientific Diving

Since 1986, courses in scientific diving have been organized annually by a group of professional diving scientists from various universities and other research institutions. Since the fourth year, these courses have assumed a more formal status within the constitution of the International School for Scientific Diving (ISSD), a non-governmental organization recognized by CMAS (Confédération Mondiale des Activités Subaquatiques) and UNESCO.

Box 1 Typical programme of an ISSD course

Day 1	
14:30	Registration
15:30	Pool test
17:00	Introduction to the course and the teaching staff
18:00	Lesson: Introduction to transects
Day 2	
08:30	Dive: Transect layout and basic survey
14:30	Data management and interpretation. Discussion
17:00	Lesson: Topographic survey
18:00	Lesson: Basic geomorphology
Day 3	
08:30	Dive: Topography and geomorphology along depth transects
14:30	Data management and interpretation. Discussion
17:00	Lesson: Basic sedimentology
18:00	Lesson: Seagrass meadows
Day 4	
08:30	Dive: Seagrass meadow phenology and mapping
14:30	Data management and interpretation. Discussion
17:00	Lesson: Epibenthic sampling – harvesting methods
18:00	Lesson: Epibenthic sampling – visual methods
Day 5	
08:30	Dive: Epibenthic sampling on subtidal rock
14:30	Data management and interpretation. Discussion
17:00	Lesson: Oceanographic techniques
18:00	Lesson: Visual fish census
Day 6	
08:30	Dive: Deployment of oceanographic instrumentation.
14:30	Data management and interpretation. Discussion
17:00	Lesson: Introduction to marine phycology
18:00	Lesson: Introduction to marine invertebrate zoology
Day 7	
08:30	Dive: Visual fish census
14:30	Data management and interpretation. Discussion
17:00	Lesson: Video surveying techniques
18:00	Lesson: Sampling design
Day 8	
08:30	Dive: Interdisciplinary study of a coastal tract for final examination
14:30	Data management and interpretation
17:00	Reports and examination. General discussion
Day 9	
08:30	Dive: Visit to a diving site of scientific interest
14:30	Close of the course

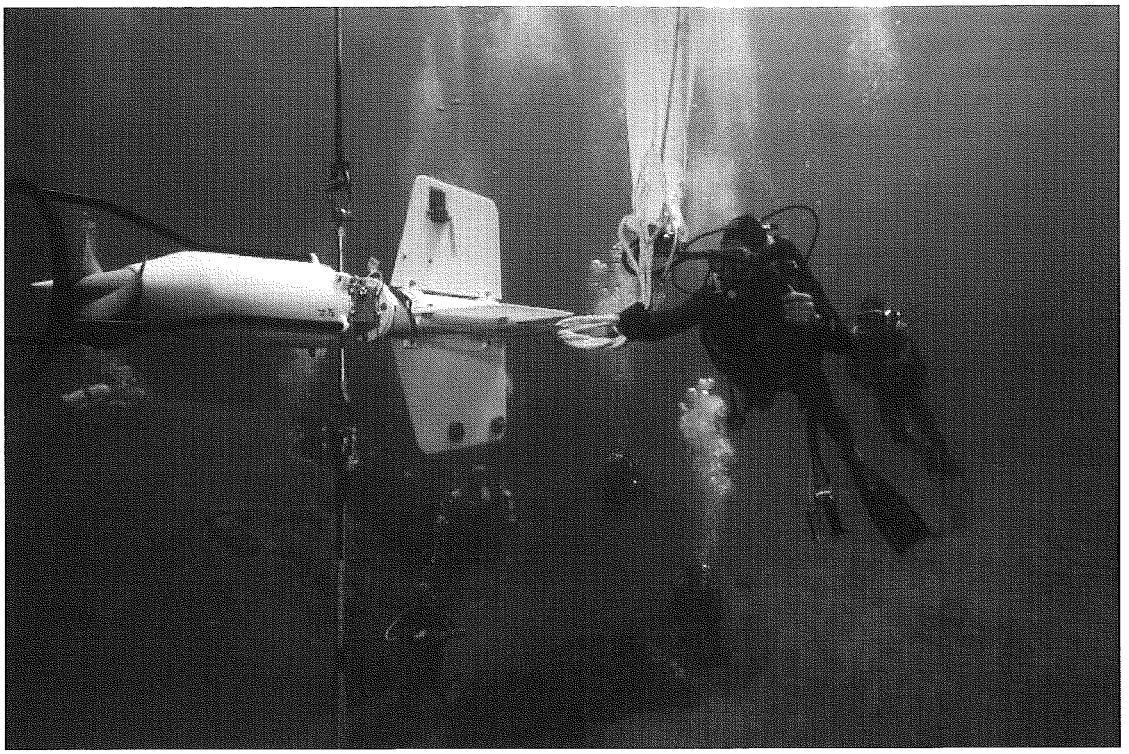
The control board of ISSD includes specialists from different disciplines (biology, ecology, geology, physical oceanography) so as to provide students with the broadest possible background in marine sciences. A typical ISSD course lasts nine days and includes both theory and practice in scientific diving (see Box 1 and Figures 1 and 2, pp.27, 28). The course provides a general introduction to all aspects of sub-aqua surveying methods and is attended each year by 18 to 32 students. These are selected according to their application form and *curriculum vitae*. Students are provided with a specially produced textbook and scientific diver logbook, and with a specially designed diver's slate. The course has a final examination (based on the results of an interdisciplinary surveying exercise at a selected site). Successful candidates receive a Scientific Diver Certificate. To date, more than 200 Scientific Diver Certificates have been issued.

Attendees at an ISSD course are mainly undergraduates and young graduates in Life Sciences, Earth Sciences, Environmental Sciences or Natural Sciences, together with some commercial divers and scientific technicians. In 1997, a special seminar for instructors of European scientific divers was held with the support of EC–MAST, in co-operation with CMAS, EUF (the European Underwater Federation) and several European universities and scientific institutions.

Photosub / Naturalist Diver

Photosub / Naturalist Diver is a private non-profit-making organization whose aim is the education of volunteer and amateur divers. It was created in 1988 in Genoa by a group of underwater photographers and marine life enthusiasts with long established diving experience. In its early years, Photosub / Naturalist Diver was mainly concerned with training instructors in teaching underwater photography. It soon became evident that virtually all underwater photographers, and most divers, were interested in submarine life, and since 1992 courses have been held in underwater natural history, aimed at all divers, whether photographers or not, who want to know more about the marine flora and fauna of the Mediterranean Sea and the tropics.

Photosub / Naturalist Diver is organized like a school, training instructors who, in turn, are qualified to give courses to their own students. To date, there are more than 80 Naturalist Diver Instructors and over 700 certified Naturalist Divers all around Italy. Three different Naturalist Diver certificates are issued by the school: Guide, Leader and Master (Box 2, *opposite*). Courses for Instruc-



Students on an ISSD course gain experience in reconciling work requirements and diving constraints

Figure 1 *Positioning a current meter on a shallow coastal bottom during an ISSD course. This exercise is also useful for improving underwater skills, helping divers to learn how to reconcile work plans and diving constraints.*

tors last three days and are intensive, covering theory, diving practice in the context of natural history, and a final examination under the supervision of professional marine scientists.

Newly qualified instructors are provided with a complete set of teaching aids for their future students, including a diver logbook with a special layout for observations of the underwater environment and marine life, and a specially produced diving slate, together with species identification sheets for use by divers and snorkellers. Instructors also receive a set of 90 colour slides and a textbook to help them prepare their lessons. They in turn provide their own students with courses of 6 hours, including at least one dive: this means that in diving clubs, the course can be held as a series of five classes with colour slides (or overheads, videos, CD-ROMs) plus a final dive. In diving centres, the course may take the form of six guided dives, plus short briefings and debriefings, in a full week or two weekends.

Box 2 Structure of the Photosub / Naturalist Diver Guide, Leader and Master courses

GUIDE	LEADER	MASTER
Organisms and their mode of living	**Habitats and communities**	**Ecology and biogeography**
1 Fundamentals of marine biology and systematics	**1** Biological and ecological features of the Mediterranean Sea	**1** Ecological zonation, biotic and abiotic factors, indicator species
2 Algae and seagrasses	**2** Littoral/sublittoral fringes, algal beds, seagrass meadows, soft bottoms	**2** Principles of marine biogeography
3 Sponges, coelenterates	**3** Coralline algae banks, submarine caves, pelagic environment	**3** Biogeographic sectors within the Mediterranean Sea; the eastern Atlantic
4 Worms, bryozoans, molluscs, crustaceans	**4** The biota of the tropical seas	**4** The Caribbean and tropical Atlantic; the eastern tropical Pacific
5 Echinoderms, ascidians, gelatinous macroplankton	**5** Coral reefs	**5** The Indo-West Pacific
6 Fish and other marine vertebrates	**6** The tropics versus the Mediterranean: analogues and differences	**6** Underwater nature trails; protection of the marine environment; underwater research

Special courses for underwater guides

Spearfishing is no longer the major attraction for Italian divers: fish-watching and other forms of enjoying marine life are today seen as the best reasons to go diving. As a result, an ever-growing number of amateur divers are looking for unspoilt marine areas where they can go to see the beauties of the sea.

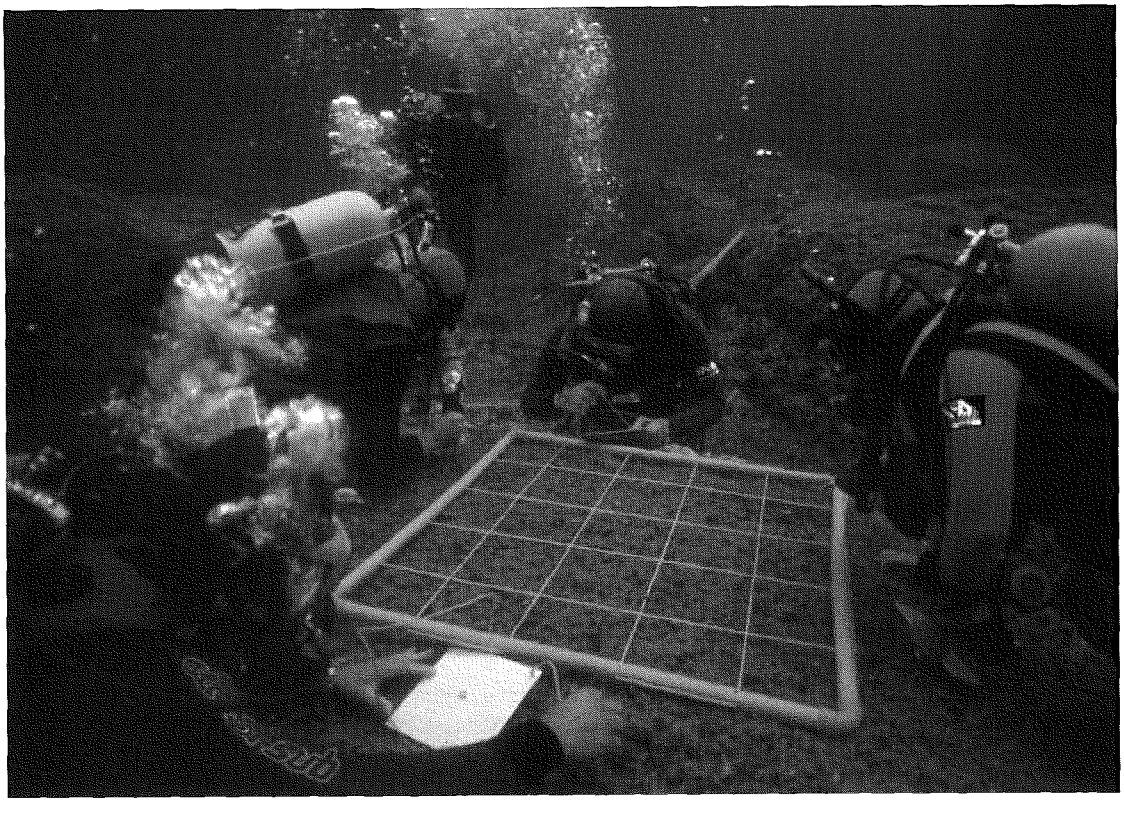
Box 3 Topics covered by the marine biology module of the course for underwater tourism managers, held in 1997

- Basic botany, zoology and ecology
- Classification and identification of the most common marine flora and fauna
- Venomous, poisonous and otherwise dangerous marine organisms
- Major submarine habitats
- The meaning and value of biodiversity
- Principles of marine biogeography
- Protection and conservation of marine ecosystems
- Fundamentals of charting and environmental mapping
- Principles of landscape ecology and integrated coastal management
- Designing underwater itineraries for diving ecotourists ('blue trails')

Thus, even if the establishment of marine protected areas in Italy is happening slowly, the need for underwater 'ecotourism' is strongly felt. This has led to a number of initiatives aimed at training underwater guides willing to work in marine parks or in the growing industry of underwater ecotourism.

One such initiative was recently sponsored by the EC (European Social Funds) and the Italian Ministry of Labour, and implemented by a pool of organizations and individual experts. A course of 350 hours (150 hours theory, 150 hours diving practice, and 50 hours studying underwater areas of natural interest) was aimed at the training of 'underwater tourism managers' – guides who would not only be able to accompany divers on submarine nature trails, but would also know the fundamentals of diving medicine and safety, plus underwater archaeology and general marine biology. Marine biology was allocated 75 hours in all. 30 hours were devoted to theory, aimed at popularizing various aspects of marine biology and related disciplines (Box 3), and there were 45 hours of practical work, to develop and test students' abilities to recognize the main species of marine flora and fauna and the major submarine habitats. Students were provided with an elementary text on marine biology. They also received publications on the submarine environments where they had dived, and learnt how to create a 'blue trail' (i.e. an underwater itinerary of interest for ecotouristism, and of known difficulty, where they could take visiting divers). A range of audiovisual and written support was used, both in teaching and practical exercises.

Figure 2 Students on an ISSD course survey the sessile epibiota within a 1 m² quadrat on a subtidal rocky reef. The students are using diving slates to record species names and abundances, as estimated by visual counts. Later in the classroom, comparison of results will allow evaluation of the variability between observers.



Surveying using quadrats develops practical skills and provides data that can be analyzed later

Conclusions

The role of scientific diving in the advancement of marine research and coastal management is nowadays largely recognized. The major merit of scientific diving is not simply that it allows unique investigations to be made, or otherwise inaccessible ecosystems (e.g. submarine caves) to be reached. Its importance is greater and far more general – it enables humans to get a unbiassed view of the submarine world, by directly experiencing the physical conditions and sharing – even if for too short a time – the real life of the marine biota. It has been written that the introduction of diving in marine biology provided an insight comparable to that provided by the introduction of electron microscopy in cellular biology.

Recognizing that scientific diving has come of age must not mean that we risk overlooking its future development. On the contrary, the need to provide proper training for scientific divers must be stressed. The examples given above, together with similar experiences in other countries, represent progress toward this goal.

Acknowledgements

Thanks are due to the Direction and Control Board of the International School of Scientific Diving (Pisa), to Photosub / Naturalist Diver (Genoa) and to TeSI (Genoa) for fruitful co-operation. The kind help of Giorgio Barsotti (Genoa) and Giusi Grimaudo-Magno (Genoa), in particular, has been essential for the completion of this article.

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See also Training and mobility of scientific divers in Europe: a review and a look ahead, by Marco Weydert, *Ocean Challenge*, Vol. 8, No. 2, pp.15–16.

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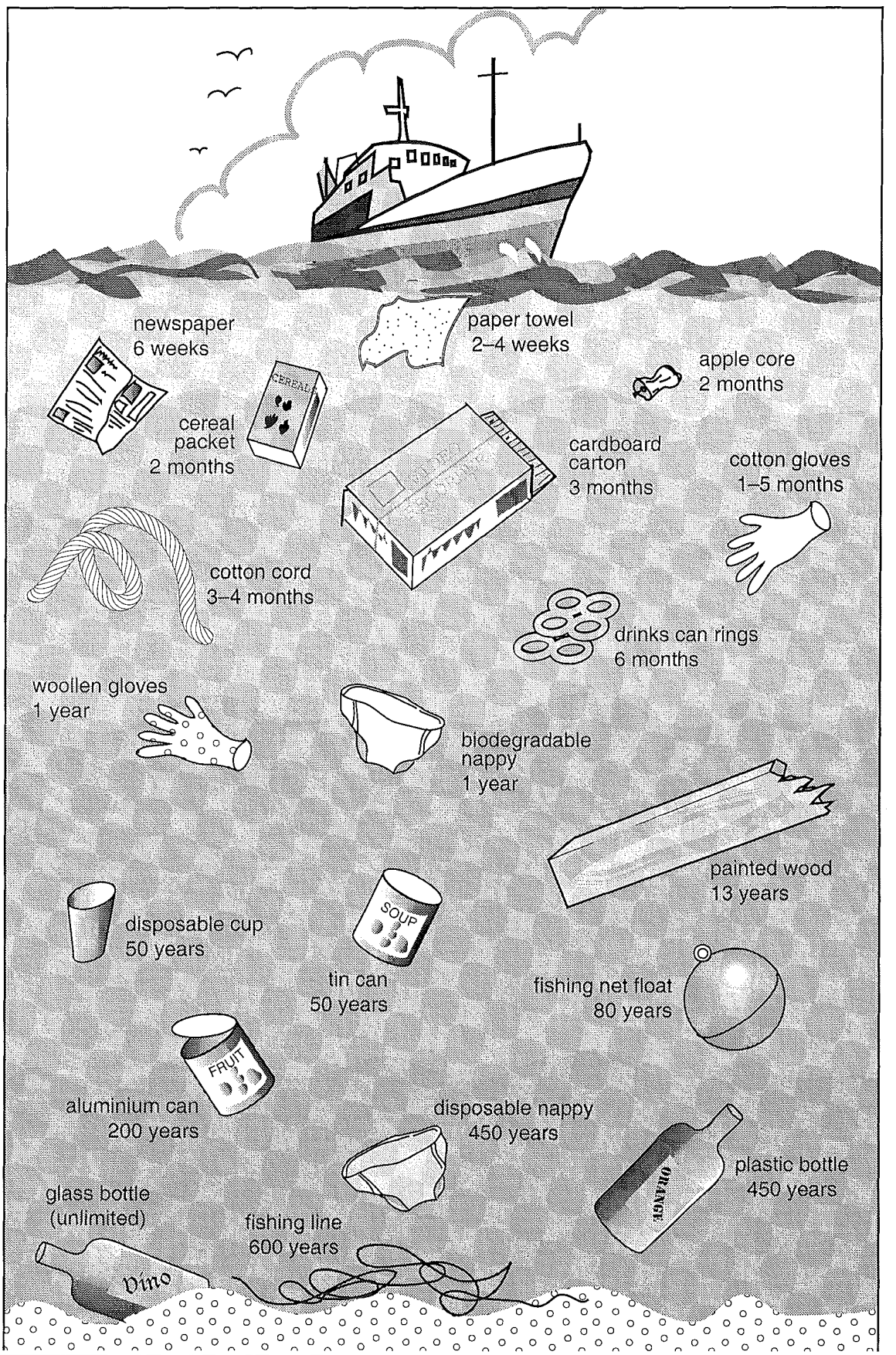
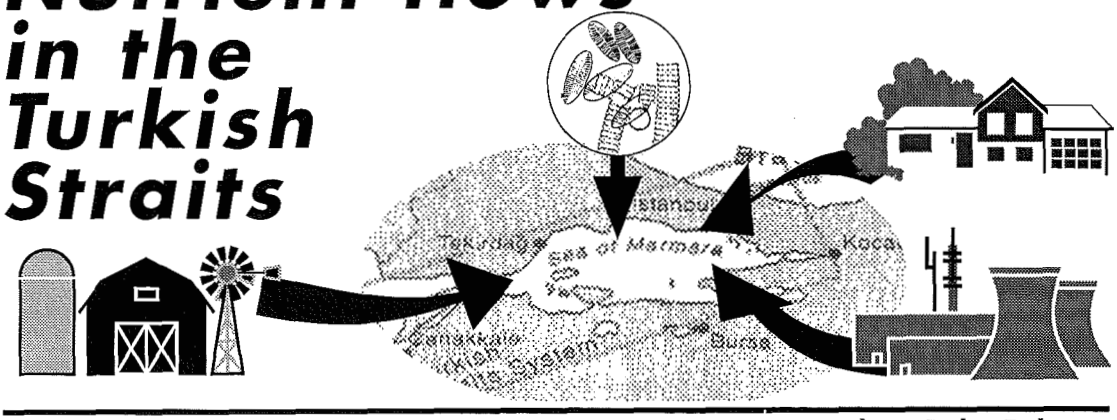
Forgotten ... but not gone

The marine environment may be harsh, but manufactured objects survive a surprisingly long time in the ocean. Here are typical degradation times for objects often thrown or lost overboard.



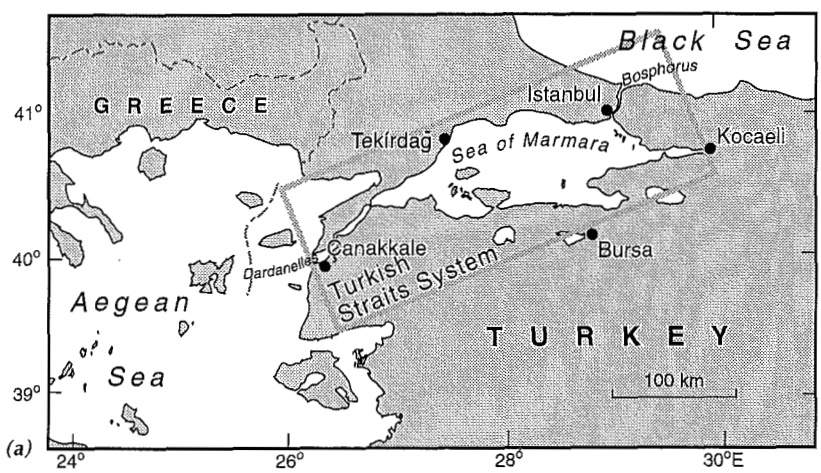
Nutrient flows in the Turkish Straits



S. Çolpan Polat Beken

The Turkish Straits System comprises the Sea of Marmara, which is an intracontinental basin some 11500 km² in area (total volume 3378 km³), plus the Bosphorus (average depth 35 m) which connects it to the Black Sea, and the Dardanelles (average depth about 50 m), which connects it to the Aegean Sea – and thence to the rest of the Mediterranean (Figure 1). The bathymetry of the Marmara basin itself is not simple (Figure 1(b)). There is a wide continental shelf (< 100 m depth) in the south, while in the north there are three depressions over 1000 m deep (maximum depth 1273 m in the central basin), separated by sills at around 700 m.

Because of the large salinity difference between the Aegean and the Black Sea at either end of the Turkish Straits System, there is a permanent two-layer flow through the Sea of Marmara. A thin upper layer of brackish water of Black Sea origin flows westward over a much thicker eastward-moving lower layer of salty water of Mediterranean origin. These two strongly contrasted water masses reside in the Marmara basin for periods that range from as little as 4–5 months for the surface flows, to as long as 6–7 years for the subsurface flows.



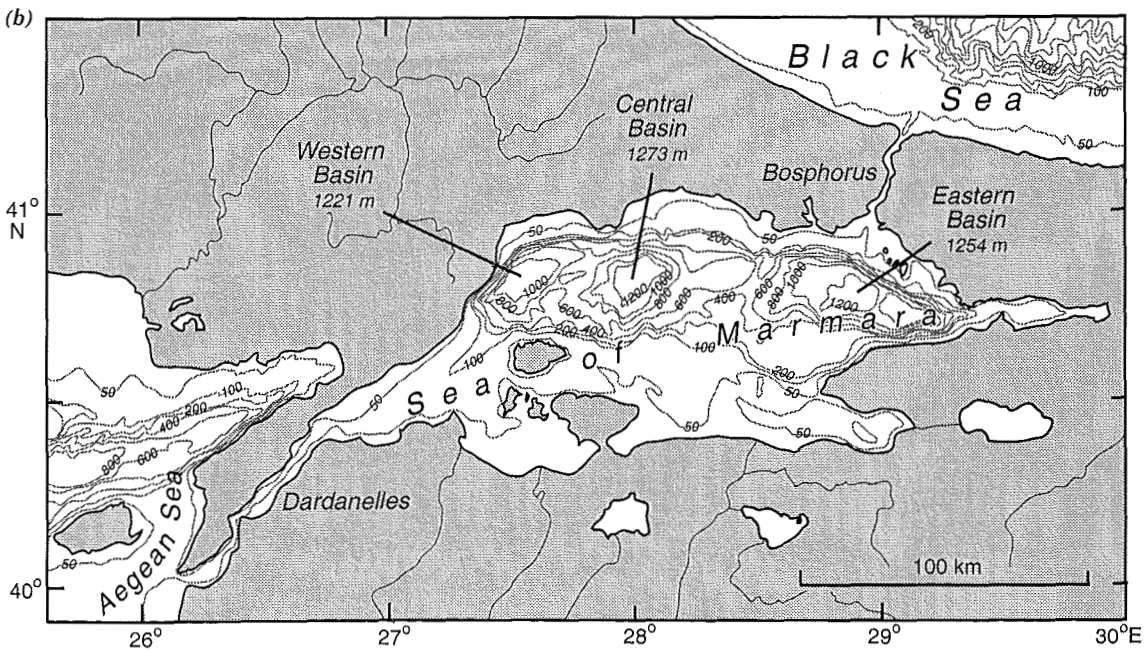


***Figure 1** (a) Location of the Turkish Straits System and (b) the bathymetry of the Sea of Marmara, showing the maximum depths of the main basins.*

The Turkish Straits System consists of two shallow straits and an intra-continental sea with three deep basins

Polluted water from the north-western Black Sea is carried in the cyclonic boundary circulation and enters the Sea of Marmara through the Bosphorus

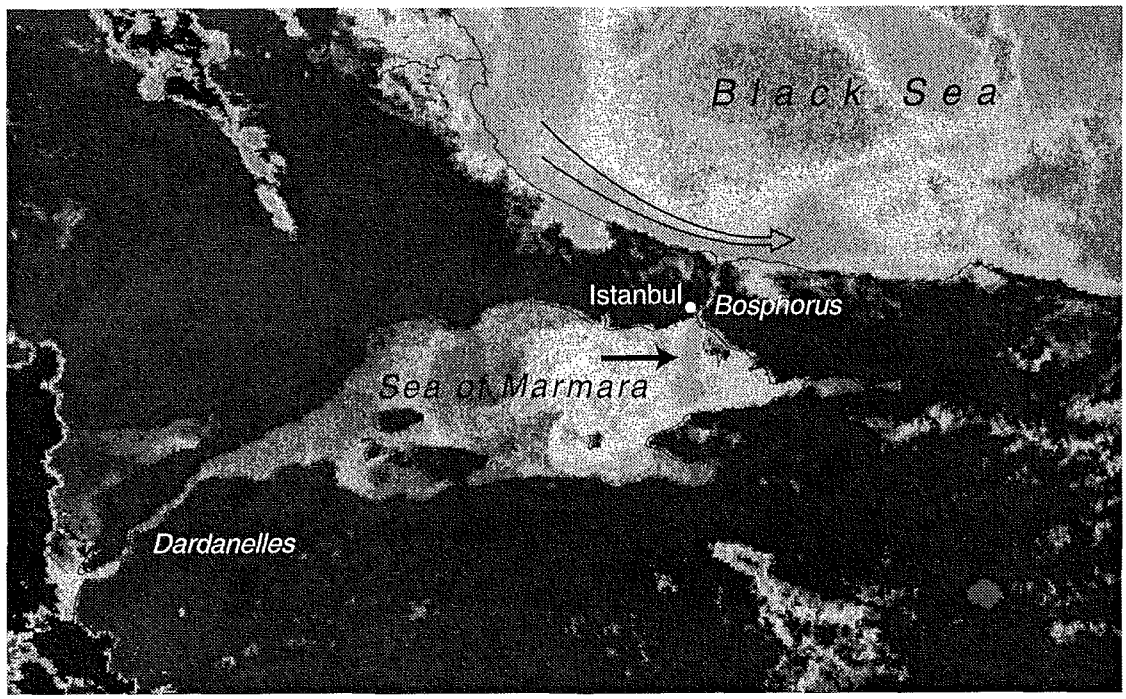


Figure 2 *A typical satellite image showing the inflow of shelf waters from the Black Sea to the Sea of Marmara. Cool eutrophic (and chlorophyll-rich) waters advected through the Bosphorus from the Black Sea form a clearly visible plume (indicated by the black arrow) in the eastern part of the Sea of Marmara.*

The surface layer of the Sea of Marmara is renewed at least twice a year by Black Sea surface waters, especially by the polluted and nutrient-rich north-western shelf waters, which reach as far as the Bosphorus in the cyclonic boundary circulation of the Black Sea and form a plume in the eastern part of the Sea of Marmara (Figure 2). In recent decades the flows through the Turkish Straits System have been subjected to large influxes of land-derived chemicals supplied to the north-western Black Sea by major rivers such as the Danube, and also by domestic and industrial inputs from coastal regions of the Black Sea and of the Sea of Marmara itself. The highly populated Istanbul Metropolitan Area, with its manifold land uses, also contributes to pollution of both the upper and lower waters of the Sea of Marmara.

The purpose of this article is to make first-order estimates of nutrient fluxes through the Turkish Straits System as a whole, in a preliminary attempt to determine how much the Sea of Marmara ecosystem may be threatened by excess nutrients of anthropogenic origin.*

Figure 3 (*opposite*) summarizes the main physical and chemical features of the two-layer stratified system of the Sea of Marmara. At the Black Sea entrance of the Bosphorus, where the depth is >70 m, the upper layer is about 45–50 m thick and has a salinity of 17–18. The average thickness of the upper layer is 25–30 m in the Sea of Marmara, but at the Dardanelles exit it has thinned to 10–15 m (deepening again to 20 m through the straits), and its salinity has increased to 25–26. Underneath the interface, which is characterized by a steep halocline, water of Mediterranean (Aegean) origin flows into the Marmara basin through the Dardanelles, with a salinity of 38.5–39.0 throughout the year. Figure 3 shows that for the nutrient elements, nitrogen (N) and phosphorus (P), the NO_3^- : PO_4^{3-} ratio of the Aegean inflow is 21 : 1, reflecting the phosphorus limitation that characterizes the eastern Mediterranean.† The lower layer salinity has decreased to 35–36 at the Black Sea exit of the Bosphorus Strait because of entrainment and turbulent mixing with the less saline water of the upper layer. Average temperature and salinity in the upper layer vary seasonally (7–24 °C and 22–26 respectively); but the sub-halocline waters of Mediterranean origin possess nearly uniform *T* and *S* of 14.5–15 °C and 38.5–38.6 throughout the year.

Primary production in the Sea of Marmara is limited to the upper layer, and biologically labile nutrients and organic compounds which enter the Marmara surface waters (from both external and internal sources) are exported into the lower layer as biochemically degradable organic matter. The overall effect is an approximate order of magnitude increase in inorganic nutrient concentrations and a concomitant five- to six-fold decrease in dissolved oxygen concentrations of Marmara subsurface waters (Figure 3). These highly modified waters are then exported to the Black Sea via the Bosphorus subsurface outflow.

*Human activities are having other effects too – e.g. ctenophores introduced into the Black Sea (in ships' ballast water) have spread into the Sea of Marmara where their populations are increasing, with as yet unquantified effects on other grazers in the ecosystem.

† See 'The Oceanography of the eastern Mediterranean Sea' by Michael D. Krom, *Ocean Challenge*, Vol.5, No.3, pp.22–8

The Sea of Marmara can be treated as a two-layer box for purposes of calculating annual fluxes of N and P through the basin. We can assume that the system is in a steady state on a yearly time-scale, chiefly because primary production occurs only in the upper layer, and sub-halocline nutrient concentrations tend to change little with either depth or season. However, water fluxes and concentrations of labile nutrients do vary markedly with season in the surface layer, and the bathymetry of the Sea of Marmara (Figure 1(b)) shows the basin to be far from a simple 'box'. Accordingly, the results can be no more than first-order approximations.

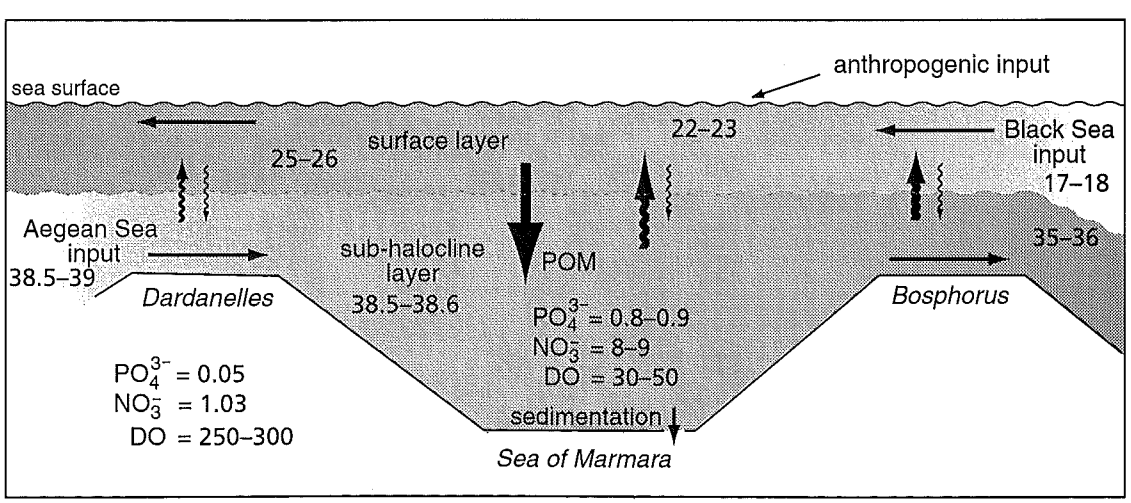
Budget estimates based on such a simple box model nonetheless provide valuable scientific information about the major sources and sinks which dominate the chemical cycles in the upper and lower layers of the basin, as well as about the magnitude of any 'missing' annual fluxes. In particular, nutrient export by particle 'snow' (particulate organic matter, POM), from surface to sub-halocline waters of the basin, can be estimated indirectly from the apparent imbalance between the nutrient fluxes into and out of the upper and lower layers in the Sea of Marmara. Estimates of the flux of biodegradable particles to the sub-halocline water permit us also to calculate the mean annual rate of oxygen consumption by respiration in the lower layer. Similarly, the total annual load of chemical pollutants discharged directly from natural and anthropogenic sources (atmosphere + river + waste water) into Marmara surface waters may be estimated from the nutrient balances established either for the upper layer or for the entire basin. It should be emphasized that all these estimates have been made using the reliable long-term hydrochemical data provided by a national research and seasonal monitoring programme that has been maintained since 1986 by the Turkish Scientific and Technical Research Council.

Figure 3 *Changes in salinity, nutrient chemistry (nitrate and phosphate) and dissolved oxygen (DO) – all concentrations in μM – of the two-layer flows through the Turkish Straits System. Arrows indicate fluxes between upper and lower layers and through the straits; the relative thicknesses of arrows indicate size of flux and wiggly arrows indicate mixing. POM = particulate organic matter. NO_3^- includes some NO_2^- (~1–2% in Marmara deep water, ≥5% in Aegean inflow, but seasonally varying). (The complexity of the variations in thickness of upper and lower layers is not shown.)*

Principles of the budget calculations

If the hydrochemical regimes of the Sea of Marmara and the straits are assumed to be at steady state on a yearly time-scale, the total annual chemical influxes to Marmara upper or lower layers must be compensated for by annual outfluxes from the system. The simple two-layer box displayed in Figure 3 indicates the main sources and sinks of phosphorus and nitrogen, and their principal flux directions, in the upper and lower layers of the Sea of Marmara. The annual average water fluxes and total nutrient concentrations that have been used in flux and mass balance calculations are given in Figure 4 (*overleaf*). The water balance figures are based on long-term salinity data measured monthly or seasonally in the Turkish Straits System. The fluxes of 'total' phosphorus (ΣP) and 'total' nitrogen (ΣN), calculated using the water balance of the system and the measured concentrations, are summarized in Figure 5. Total nutrient concentrations (i.e. particulate plus dissolved organic and inorganic) are used in order to overcome uncertainties in the flux calculations that may arise from the seasonally varying phosphate and nitrate concentrations in the upper layer, and to enable the anthropogenic flux to surface waters to be estimated.

Fluxes of phosphorus and nitrogen into sediments (F_{sed}) were calculated from the relationship between the dry weight percentage of each element in the sediment (0.06% for P and 0.14% for N for the deep basins of the Sea of Marmara), the known porosity and density of the sediment, and an estimated sedimentation rate of 100 cm per 1000 yr. F_{sed} is calculated as 0.45×10^4 t for ΣP and 1.0×10^4 t for ΣN (Figure 5, *overleaf*).



Vertical fluxes within the Turkish Straits System transform the chemistry of upper layer waters flowing from the Black Sea and of lower layer waters flowing from the Mediterranean

Surface flows are rich in organic nutrients whereas inorganic nutrients dominate the subsurface flows

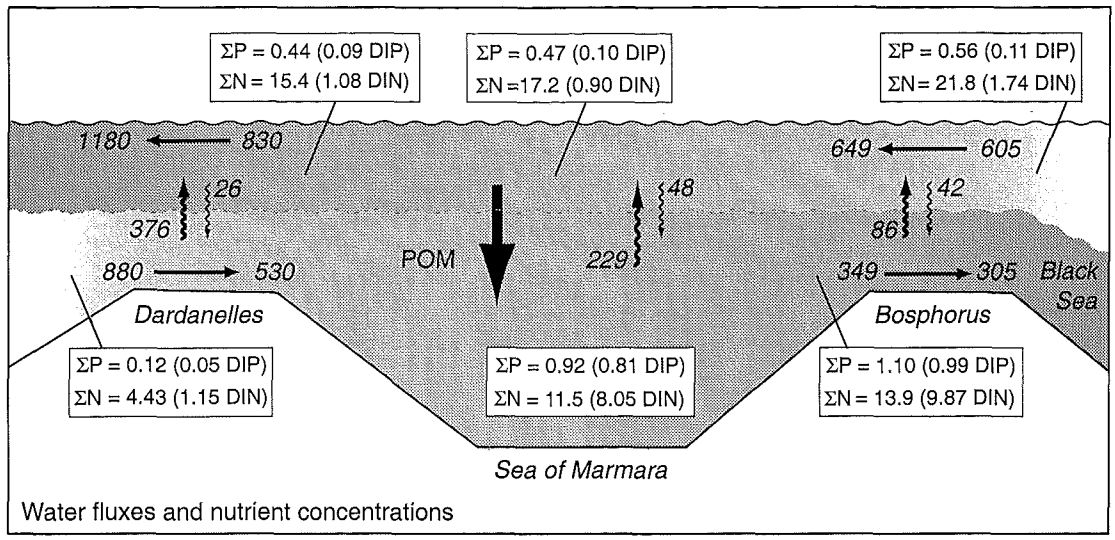


Figure 4 *The annual mean concentrations (μM) of total phosphorus (ΣP) and total nitrogen (ΣN) and water fluxes (in italic, in km^3yr^{-1}) used in the budget calculations. (Concentrations of dissolved inorganic phosphorus (DIP) and nitrogen (DIN = $NO_3^- + NO_2^- + NH_4^+$) are given in brackets.) E – P is positive but small, at 11 – 7 = 4 $km^3 yr^{-1}$, and riverine input is negligible (average ~ 6 $km^3 yr^{-1}$, from 1954–79 hydrographic data).*

Phosphorus fluxes

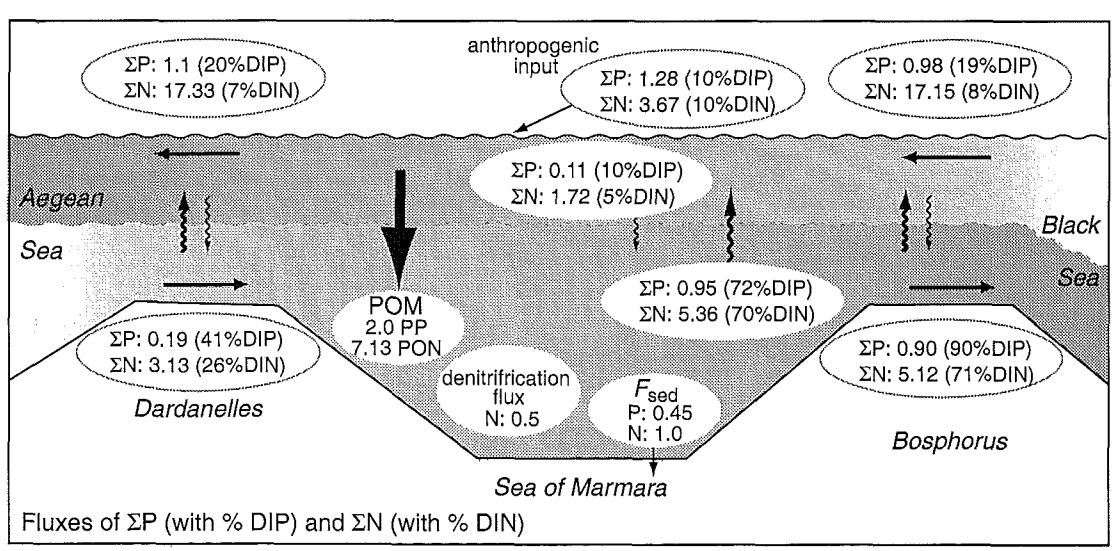
The annual flux of total phosphorus (ΣP) in particulate organic matter (POM) is in the order of 2.0×10^4 tonnes P yr^{-1} (PP, Figure 5), and makes up 87% of the annual ΣP input to the lower layer. By contrast, at least 72% of the phosphorus exported from the sub-halocline water is in the form of dissolved inorganic phosphate (DIP), as PO_4^{3-}.

Figure 5 shows the particulate phosphorus (PP) export from the upper layer to be about twice the influx of ΣP from the lower to the upper layer by vertical mixing (0.95×10^4 t yr^{-1}). The large PP export from the surface is supported by this upwelling flux, as well as by inputs from the Black Sea (0.98×10^4 t yr^{-1}) and from anthropogenic sources via rivers, waste waters, and the atmosphere (1.28×10^4 t yr^{-1}). The anthropogenic input may be slightly overestimated, because it is assumed to make up the balance between the natural fluxes into and out of the basin; and phosphorus input from sediments into the subsurface waters of the Sea of Marmara is not known, and therefore cannot be considered in the calculations.

When the most labile fractions of the ΣP fluxes (i.e. those utilizable by phytoplankton) are considered, the contributions to the Sea of Marmara POM flux from the Black Sea and from the lower layer waters of the Marmara Sea each amount to about 45% of the total (i.e. 0.9×10^4 t yr^{-1} each). The remaining 10% is provided by anthropogenic inputs, which are mostly of less labile (more refractory) phosphorus compounds, such as phosphonates (complex organic phosphorus compounds containing alkyl (C_nH_{2n+1}) groups).

Figure 5 *Annual phosphorus and nitrogen fluxes ($x10^4$ tonnes yr^{-1}) through the system, and mass balances of N and P in the Sea of Marmara, calculated using concentrations and water fluxes in Figure 4 (e.g. relative atomic mass of P is 31, so Black Sea surface ΣP input = (605 – 42) $km^3yr^{-1}\times$ 0.56 μM × 31 = 0.98 × 10^4 t yr^{-1}; or ΣP input from upward mixing = (229 × 0.92 μM × 31) + (86 × 1.10 μM × 31) = 0.95 × 10^4 t yr^{-1}). (Contributions of DIP and DIN (in %) to the totals are given in brackets.)*

The Black Sea gets back nearly as much as it gives to the Mediterranean in terms of phosphorus. However, it continuously feeds the surface waters of the Sea of Marmara, and hence the Mediterranean, with nitrogen



Nitrogen fluxes

The annual input of total nitrogen (ΣN) in particulate organic matter (POM) from the surface to the sub-halocline waters is estimated to be 7.13×10^4 tonnes N (PON, Figure 5). PON settled from the surface layer makes up two-thirds of the input of particulate and dissolved organic nitrogen (PON + DON) species to the Marmara sub-halocline water. The remaining third is introduced via the Aegean Sea inflow (3.13×10^4 t N yr^{-1}, with DON : PON ≈ 10 : 1) and by downward mixing from the upper layer. Together these inputs of PON + DON make up about 92% of the ΣN flux to the lower layer. Only about 8% of the ΣN input to the lower layer is in the form of dissolved inorganic nitrogen (DIN), part introduced from the Aegean (0.8×10^4 t N yr^{-1}), part mixed down from the surface layer (0.09×10^4 t N yr^{-1}). By contrast, the DIN export from the system (as $NO_3^- + NO_2^- + NH_4^+$), via the Bosphorus, constitutes only 70% of the ΣN outflux (compared with about 90% of the ΣP outflux as PO_4^{3-}); and we established earlier that the estimated sink for nitrogen via sedimentation (F_{sed}, Figure 5) takes up 1.0×10^4 t N yr^{-1}.

Calculations made for labile fractions of the ΣN fluxes suggest that the contribution of DIN from the Black Sea to the Sea of Marmara PON flux is nearly 20% of the total (1.4×10^4 t N yr^{-1}), while the contribution of DIN by upward mixing from lower layer waters, both of the Sea of Marmara and of the Bosphorus, is about 53% (3.8×10^4 t yr^{-1}). Another 5% is from anthropogenic sources, and includes an important fraction of ammonia/ammonium (NH_3/NH_4^+) where domestic wastes dominate the inputs. The remaining 22% is in the form of PON + DON contributed from the Black Sea.

Although the denitrification flux might be expected to be a critical term in the Marmara lower layer nitrogen balance, it appears to be only locally significant. Waters of the coastal margins (especially the wide continental shelf in the south, Figure 1) and of the semi-enclosed bays of the Sea of Marmara, which are heavily polluted and where water exchange is limited, are recognized as favourable denitrification sites, especially during summer–autumn months. However, we have determined the N : P ratio in surface water particulate matter to be about 9.5, which is similar to the N : P ratio in subsurface dissolved inorganic species (10 : 1, Figure 3). This suggests that nitrogen loss via denitrification is not significant at the basin scale. Overall NO_3^- consumption via denitrification in sediment and overlying waters was computed to be 0.5×10^4 t N yr^{-1} (Figure 5).

Redfield ratios and seasonal variations

Inorganic N : P ratios (i.e. $NO_3^- (+NO_2^-) : PO_4^{3-}$ or DIN : DIP in Figure 4) in the sub-halocline waters of the Sea of Marmara (about 9.5 : 1) are considerably lower than the normal 16 : 1 Redfield ratio of seawater in the open ocean. The reasons for this are not yet known, but the ratios are not constant. They change as water in the upper and lower layers flows in opposite directions between the Black Sea and the Aegean. Thus, Black Sea water flowing in at the Bosphorus has an average inorganic N : P ratio of 15.8 : 1, which decreases to 9.0 : 1 within the Sea of Marmara, before rising again to 12.0 : 1 in the Dardanelles surface outflow (Figure 4). This is in marked contrast to (and may partly compensate for) the 21 : 1 N : P ratio of the subsurface Dardanelles inflow from the Aegean, which then falls dramatically to 10 : 1 in the sub-halocline layer of the Sea of Marmara (Figure 3), and retains that value in the water exported to the Black Sea in the Bosophorus lower layer (Figure 4).

Moreover, within the Sea of Marmara itself, analyses of seston (which is dominated by biogenic particulate matter) show that the molar N : P ratio of particulate matter in the surface layer varies with seasonal fluctuations in biological production. Periods of high production occur between February and April, when nutrient supplies are plentiful and diatoms dominate the phytoplankton. At such times the N : P ratio in particulate matter (~ 9.5 : 1) is similar to that in the sub-halocline water. During periods of low production (May–December), on the other hand, when the surface layer is relatively warm and infertile and small phytoplankton species predominate, making use of regenerated nutrients in surface waters, the N : P ratio in particulate matter is much lower, at ~ 6 : 1.

Biological production in the Sea of Marmara thus appears to be N-limited throughout the year, even though the chemistry and biology of the region have been drastically modified in recent decades. This is particularly remarkable when the ΣN and ΣP concentrations (Figure 4) and fluxes (Figure 5) in the Marmara upper layer are compared. A great deal more nitrogen than phosphorus is supplied from the Black Sea to the Marmara upper layer (and thence to the Aegean), but the proportion of DIN in this throughflow is very small. This means that the bulk of the nitrogen supplied from the Black Sea is in the form of DON (see above) and especially PON, i.e. phytoplankton and detritus advected through the Bosphorus. Within the Sea of Marmara itself, however, the large concentration of ΣN in the upper layer (17.2 μM) consists predominantly (80%) of DON. Much of this represents algal degradation products advected in from the Black Sea, along with DON of riverine origin from the north-western shelf of the Black Sea, also representing the degradation products of phytoplankton.

Apparent oxygen utilization

Analyses of over 600 samples from the Sea of Marmara lower layer show that concentrations of inorganic nutrients (PO_4^{3-} and $NO_3^- + NO_2^-$) increase linearly with decreasing dissolved oxygen concentrations. Molar ratios derived from the regression lines yield values (at ~ 90% confidence limits) of 178 : 1 for $O_2 : PO_4^{3-}$ and 19.7 : 1 for $O_2 : (NO_3^- + NO_2^-)$, implying a molar

N : P ratio of 9 : 1, close to the ratio determined from direct analysis both of dissolved nutrient concentrations (Figure 3) and of the particulate organic matter (see above).

The annual rate of oxygen consumption in the sub-halocline water was estimated using these regression analyses of apparent oxygen utilization (AOU) versus nutrient concentration in the lower layer (which are based on long-term data from 1990 to 1996). The oxygen : phosphate ratio was used, along with the calculated amount of PP (plus a small quantity of dissolved organic phosphorus, DOP) that is annually oxidized to DIP in the sub-halocline water, to calculate a value of 0.91 mg O_2 l^{-1} yr^{-1}. This value depends on the reliability of the ΣP balance, but is unlikely to be more than 10% in error, since the ΣP concentration in the outflowing waters from the deep basin – and in the deep basin itself – shows little seasonal variations.

The oxygen : nitrate ratio in the sub-halocline waters of the system was used in the same way to estimate the annual rate of oxygen consumption. The excess of annual outflux over influx of DIN enables us to use the steady state assumption (i.e. that ΣN influx = ΣN outflux) to calculate the annual rate of oxygen utilization in the Marmara sub-halocline water. The resulting value of 0.99 mg O_2 l^{-1} yr^{-1} is very similar to that calculated for oxidation of organic to inorganic phosphorus in the deep water.

Conclusions

The mass balance approach based on a two-layer box model for the Sea of Marmara provides information about the horizontal exchanges of nutrients between the Black Sea and the Aegean, as well as about vertical exchanges of nutrients within the Marmara basin. Of the particulate nutrients that are exported from the thin upper layer of the Sea of Marmara to its more saline lower layer (2.0×10^4 and 7.1×10^4 tonnes of ΣP and ΣN per year), about 45% and 70% (i.e. 0.9 and 5.1×10^4 t respectively) eventually reach the Black Sea via the Bosphorus, mainly in the form of dissolved inorganic nitrogen and reactive phosphate. Much of the rest is entrained by vertical mixing into the Marmara surface waters of Black Sea origin, further polluted by land-based nutrient inputs, and reaches the Aegean basin of the Mediterranean via the Dardanelles surface flow. The annual nutrient load exported from the Marmara basin to the Aegean Sea via the Dardanalles is probably the major nutrient source for the Aegean ecosystem.

The chemical properties of the Aegean inflow to the Marmara lower layer are modified markedly during their stay in the deep basin of the Sea of Marmara through the remineralization of particulate organic matter sinking from the surface to sub-halocline waters; this strongly depletes dissolved oxygen concentrations and significantly lowers the N : P ratio. A significant fraction of ΣP and a minor fraction of ΣN are deposited in the sediment layer of the Marmara basin, and a little nitrogen is also 'lost' through denitrification (Figure 5).

Inflows from the Black Sea, together with anthropogenic inputs from within the Marmara region, supply about 80% of the total nitrogen (ΣN) and about 70% of the total phosphorus (ΣP) to the Sea of Marmara surface layer. The rest is supplied from lower layer waters by upwelling, mixing and entrainment into the surface layer. The Marmara ecosystem may thus be threatened by excess nutrients from external sources, although there is as yet no firm evidence of this, despite the large changes that have affected the ecosystem in the last few decades as a consequence of human activities.

The calculated values in this article may be over- or underestimates. However, we have an obligation to attempt to quantify the relative impact of external (anthropogenic) inputs of nutrients both from the Black Sea and from around the Sea of Marmara itself. Further research is needed to understand the microbial processes taking place, especially at the halocline and in the deep waters, and to explain the low N : P ratios that characterize the Turkish Straits System.

Further reading

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Acknowledgements

The author would like to thank the Research Fund Secretariat of Istanbul University for supporting her participation at the First Symposium of European Marine Societies in 1998, where she discovered *Ocean Challenge*.

S. Çolpan Polat Beken is currently working in the Institute of Marine Sciences and Management of Istanbul University as a chemical oceanographer. Her main research interests are nutrient dynamics in a various marine environments – intra-continental seas, shelf seas, coastal waters and lagoons.

Mind your language!

I've just been reading Vol. 9, No. 3, 1999, News and Views. Basically I find this material very good but I did have some trouble with two of the pieces.

One was 'Ecotourism, Stressed Whales and Acoustic Smog'. Some aspects of it jarred. Why 'It is *claimed* that Russian ... dolphins ... were trained to kill ... divers'? It is public knowledge that the US did train dolphins for precisely this purpose, and used them during the Vietnam War. Also, that dolphins are predators is not a reason especially to beware of them. After all, dogs are voracious predators too. On the other hand, don't dismiss the dangers of messing about with gray whales, a species of whalebone whale which lives by nibbling benthos – Yankee whalers didn't call them 'devil fish' for nothing!

This piece interested me particularly, because earlier this year I chaired an international workshop on whale-watching in Italy, and one very controversial topic among the 'experts' was the 'swim with' programmes.

The other piece that struck me was 'Global Warming and Ecosystem Drift'. I entirely agree that nonsense is being written about 'devastation' rather than simply 'displacement' (and, of course, we have no idea whether the waters of the north-east Atlantic are going to be warmer or colder as a result of the greenhouse effect). Also, I agree that direct human effects are likely to be far more important than these hypothetical indirect ones. But how come you take a swipe at '... groups such as WWF'? Did WWF really suggest that gradual shifts of marine animals could 'devastate' fish stocks? I haven't seen this, and I work on and off as consultant to WWF International on fisheries matters. But more irritatingly, who/what is meant by 'groups such as'? It looks like a backhanded generalized smear – but at whom? FoE? Greenpeace? IUCN? UNEP?

No, I think that if a finger is to be pointed, then as a matter of ethics and fairness it should be pointed at precisely identified people or organizations, preferably with quotations, or at least references. Maybe I'm picky, but some of this comes over as prejudiced.

Anyway, you continue to produce a very good read. I much appreciated Martin Angel's review, with David Pugh, of the IYO. Congratulations, and keep up the good work.

Sidney Holt
Crickhowell
Powys

John Wright replies:

Both the News & Views pieces you mention were mine. The reason for the 'claimed' was that I simply did not know for sure whether the stories about dolphins being trained to kill divers were true, as my sources were not sufficiently explicit. The comparison between dolphins and dogs is apposite – I for one am always wary when approaching a strange dog!

I wasn't intentionally smearing or taking a swipe at WWF, or indeed at anyone else. The 'phrase '... groups such as ...' arose because I was unsure whether WWF's was the only voice. I was merely hedging my bets – and in light of your comments, it occurs to me to wonder whether WWF was misquoted. I shall try to be more careful in future.

In fact, as Editors, we do try our best to attribute statements/comments/opinions/theories correctly, and we also try hard not to let our prejudices show! But we don't always get it right, and it is very good to learn that our readers are keeping us up to the mark.

Thank you also for your complimentary closing comments – they are much appreciated.

Plan to Relocate POL

Within the next two to three years, the Proudman Oceanographic Laboratory (POL) may be moving to the University of Liverpool campus, bringing together at a single site POL scientists and University groups with similar research interests. It is felt that a new combined centre would raise the profile of Oceanographic Sciences in the north-west to a level that neither POL nor the University could achieve on its own, creating a stimulating environment and attracting more overseas visitors, young researchers and students.

The move still remains conditional upon the approval of funding by the University and NERC, but a statement of intent was signed in March and further more detailed discussions are planned. POL would remain within the Centre for Coastal and Marine Sciences (CCMS) under the control of NERC

Despite the exciting new plans, many POL staff must surely be sad at the thought of leaving their unique and historic site, with its dramatic views over Liverpool Bay (see the account by Eric Jones in *Ocean Challenge*, Vol. 9, No.1). And if the move goes ahead it will be necessary to find an appropriate use for the buildings, including the Observatory, a use which recognizes their heritage value. Those readers who have not yet visited Bidston Observatory should take advantage of the Open Days on 28, 29 June and 2 July.

Other news ...

- Mike Fasham of the Southampton Oceanography Centre was elected a Fellow of the Royal Society in May.
- The Deutsche Gesellschaft für Meeresforschung (the German counterpart of the Challenger Society) is twenty years old this May. Congratulations to the DGM and their journal, the *DGM Mitteilungen*.
- UNCW's *Prince Madog* is to be replaced in April 2001 by a new research vessel, which will be twice the size but will bear the same name. She will be able to carry up to 20 students to sea for up to 10 days.

Book Reviews

Catalogue des appareils d'océanographie en collection au Musée océanographique de Monaco by Christian Carpine (published between 1987 and 1999 as Vols of the *Bulletins de l'Institute océanographique, Fondation Albert 1er, Prince de Monaco; see Table below*).

For over twelve years Christian Carpine has been examining, researching, photographing and cataloguing a magnificent collection of equipment which had been accumulating at the Musée océanographique in Monaco since it opened in 1910. In all, there are about 500 instruments and sets of apparatus used for gathering oceanographic data. Many of the items were made for and used by Prince Albert during his voyages in the Mediterranean and North Atlantic in his four research yachts *Hirondelle I, Princesse Alice I, Princesse Alice II* and *Hirondelle II*, between 1873 and the First World War. Others were donated by the inventors and some were made especially to complete the collection when originals were no longer to be found.

The results of Carpine's work are now available in eight numbered catalogues in seven parts of the *Bulletin de l'Institut océanographique, Fondation Albert 1er, Prince de Monaco*, between 1987 and 1999. Each catalogue is set out in chronological order, and every item has a page to itself. A brief history of the instrument is followed by a description of its purpose and how it operates; there is a photograph on the facing page.

The texts are in French with the exception of a Preface by Anita McConnell, who refers to the completion of the galleries at the Musée in 1913 where 'an entire hall was devoted to the apparatus which oceanographers use to measure the oceans, collect the specimens, and carry out various analyses.' She points out that interest in this subject has grown apace since the first International Congress for the History of Oceanography was held in Monaco in 1966. Six such Congresses have now taken place, with the seventh due at Kaliningrad in 2003.

Each of Carpine's catalogues is prefaced by an erudite Introduction covering the history of collecting the specific data concerned.

Catalogue No. 1 concerns photometers. About 1880 a gelatino-bromide coated plate replaced the Secchi disc to measure light penetration in the sea. By 1910, 'messengers' – which were sent down the wire to expose and then recover the plate – were being used. In 1911 Bertel produced his spectrograph in a bronze watertight container, with which successful dips were made down to 600 m off Monaco.

Catalogue No. 2 lists devices for measuring currents. The French scientist Georges Aimé (1810–46) was first in the field, with a device which was proved by the Danish Admiral Irminger in the Atlantic to be capable of recording the magnetic direction of current flow to an accuracy of about 10°.

The remarkable upsurge of interest in oceanography in Scandinavia, subsequent to Fridtjof Nansen's return from the *Fram* expedition to the Arctic, led to the formation of the International Council for the Exploration of the Sea (ICES) in 1902 and the establishment of its laboratory at Kristiania in Norway.

Wilfrid Ekman, working at the Kristiania laboratory in 1903, invented a very successful current-measuring device which could be lowered from the deck of a vessel. The propeller was directed into the current by a vane, and its revolutions were recorded on a dial to provide a speed measurement; at regular intervals the propeller rotations released small bronze balls which were directed into one of 36 divisions in the compass box by a trough-shaped magnetic needle. On recovery, inspection of the whereabouts of the balls enabled the main direction of the current to be assessed. Prince Albert obtained three of these excellent machines as soon as they became available. Many were still in use in the mid-20th century.

Professor Otto Pettersson invented his 'Universal' apparatus in 1904; this was capable not only of measuring currents but also of obtaining water samples, temperatures, and even plankton hauls. This instrument finds a place in Part 3 of the catalogue. However, Carpine notes that each of the several functions could only be performed one at a time. That it was 'tried out' in the harbour at Monaco in May 1904 and then stowed in its case together with its accessories, leaves one to wonder whether the 'Universal' was perhaps *too* sophisticated.

Prince Albert's interests included long distance surface currents in the North Atlantic. He had constructed a large number of small pear-shaped copper buoys, ballasted to give a low wind profile. These 'flotteurs', as they were called, could be opened to expose a printed card which the finder on some lonely beach could post to the nearest naval authority to inform them of the time and place of recovery.

Catalogue No. 3 concerns biological sampling. At the end of the 19th century, Professor Carl Cori of Trieste Zoological Station invented a bathypelagic net for capturing fish (or, depending on the mesh, plankton), a model of which reached Prince Albert. Lieutenant de vaisseau Henry Bourée, onboard the yachts, and Dr Jules Richard (Director of the Musée and collaborator of the Prince), both worked to develop these nets so that they could be used either for vertical dips or towing at slow speed.

Capturing fish or plankton formed a vital part of the Prince's work, and his team went on to provide bottom trawls and massive sea-bed cages

Vol. of Bulletin	*Date*	*No. of Bulletin*	*Content*
Vol. 73	1987	1437	1. Photomètres; 2. Mesureurs de courant
Vol. 74	1991	1438	3. Appareils de prélèvement biologique
Vol. 75	1993	1440	4. Bouteilles de prélèvement d'eau
Vol. 75	1996	1441	5. Instruments de sondage
Vol. 76	1997	1442	6. Thermomètres
Vol. 76	1998	1443	7. Instruments divers, matériel de pont, instruments de laboratoire
Vol. 76	1999	1444	8. Suppléments, matériel de démonstration, meteorologie. Additions et index cumulatifs

which were baited to capture bottom fauna. Such 'nasses', as these were called, required careful handling when a sea was running, as several photographs reveal.

Catalogue No. 4 is devoted to seawater sampling at depth. From the 17th century onward, efforts had been made in Europe to obtain water samples from specific depths using various methods to seal sampling bottles or cylinders with valves which were closed by the action of hauling up.

Milnes of Edinburgh had devised a more suitable system for the *Challenger Expedition* (1872–76). It consisted of a cylinder with open stopcocks at either end connected by a metal rod; both were closed instantly on arrival of a messenger, trapping a water sample. John Buchanan, who used this apparatus on *Challenger,* brought several of them with him when he joined Prince Albert in *Princesse Alice.* Here he devised an attachment to the bottle into which a reversing thermometer could be fitted and which was reversed as the stopcocks were closed by the messenger.

Dr Richard invented a reversing bottle fitted within a framework (developed by the Italian Hydrographer Admiral Magnaghi), to which a reversing thermometer could be attached. This was the apparatus used most frequently onboard Prince Albert's vessels down to depths of at least 2000 m. There are six examples in the collection, in two of which the reversing is instigated by messenger; whilst in the other four a propeller is used which is locked during the descent and until the haul up begins; after a number of revolutions of the propeller, the bottle is permitted to capsize and trap the water sample. To ensure this method worked correctly it was usual to lower the bottle about 100 m below the depth at which the sample was required.

Catalogue No. 5 lists sounding machines. I reviewed this in *Ocean Challenge* Vol. 7 (see end for full ref.), where examples of the photographs may be seen.

Catalogue No. 6 deals with thermometers, starting with a self-registering maximum and minimum thermometer, using both mercury and alcohol, invented by James Six in England in 1782 and designed for use at sea in 1794. Such thermometers protected from deep sea pressure were constructed by Negretti & Zambra, and Miller–Casella, in London in 1857 and 1869 respectively. Although Aimé had been working on a thermometer which fixed its reading on reversal, it was Negretti & Zambra who continued to work on the problem and put their perfected model on sale in 1912. Meanwhile Victor Chabaud of Paris had been supplying the Prince with usable reversing thermometers for ten years.

The Scandinavians certainly took advantage of the introduction of good reversing thermometers. In 1912 Fridtjof Nansen's reversing water bottles, to which were fitted holders for reversing thermometers, were launched on the oceanographic world by Bergen-Nautik of Bergen. There are few oceanographers who have not been photographed operating Nansen's bottles from the chains of a research vessel.

Catalogue No. 7 starts by listing instruments for measuring internal waves and long period changes in tidal levels, with which Georges Aimé was busy around the Port of Algiers in 1838. Then follow about half-a-dozen 'piézomètres' for measuring the compressibility of seawater in relation to its salinity and temperature down to depths of 4500 m or more. Deck winches, accumulators, swivels, Nansen's counting pulley and his net-closing device are followed by a series of complex messengers; these are headed, of course, by a giant lead one used by Aimé in 1843 and presented to the Musée in 1914 by Adolphe Trèves, who in his youth had worked with Aimé.

During the long gestation period of the eight catalogues, a number of additional references came to light and these have been listed towards the end of Catalogue No. 8 by Jacqueline Carpine-Lancre. She finally adds three most useful indexes, covering the eight catalogues – 'Inventors and Constructors', 'Ships Mentioned' and the 'Instruments and Equipments' listed.

Having worked through the catalogues page by page I have come to realize that an incomparable collection of oceanographic instruments is held at the Musée. If it is to survive it will require ongoing conservation in a world where the science of oceanography, and hence its history, will become ever more significant.

The seven Bulletins which contain the catalogues should surely grace 10 centimetres of shelf space in any major oceanographic library, at least until such time as the catalogues are available on CD-ROM.

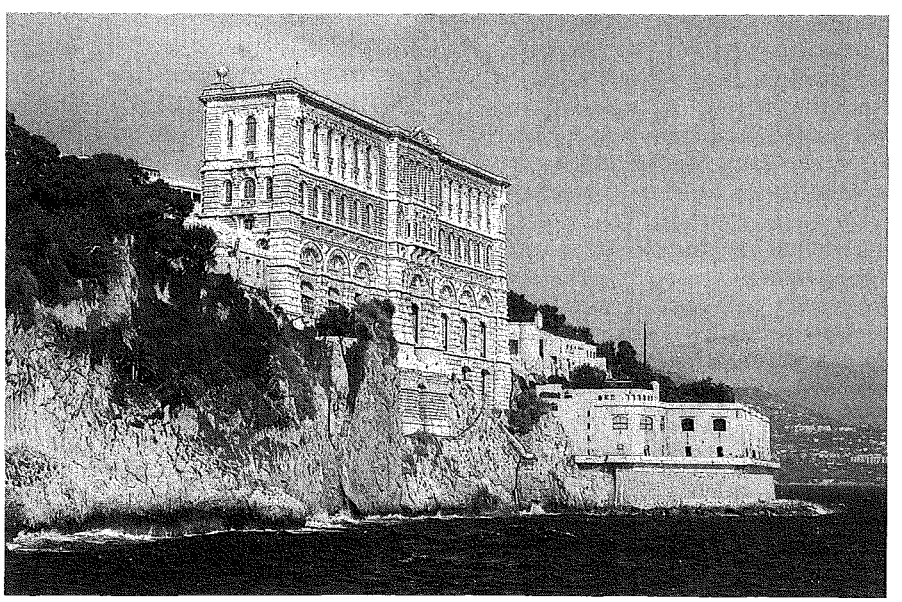
G.S. Ritchie
Collieston, Scotland

The catalogues may be ordered from: Musée océanographique (Service de publications), Avenue Saint-Martin, MC 98000 Monaco;
Email: mcmobiblio@meditnet.com

Depending on length, they are priced between 150 and 250 francs (1100 francs for the complete set).

Catalogue 5, *Instruments de sondage,* was reviewed in *Ocean Challenge,* Vol. 7, No. 1, 1997, p.47, which also contains more information about Prince Albert of Monaco; see also *Ocean Challenge,* Vol. 4, Nos 1/2, 1993, p. 62.

The beautiful setting of the Musée océanographique at Monaco
(By courtesy of Y. Berard)



You saw the TV Series – Now Read the Book

Earth Story: The Shaping of Our World by Simon Lamb and David Sington (1998). BBC Books, 240pp. £19.99 (hard cover, ISBN 0-563-38799-8).

What a magnificent TV series that was, so wide-ranging that even practising Earth scientists could have encountered things they hadn't known about. It was fascinating news to me, for example, that large parts of Greece are gradually sliding into the Mediterranean along giant faults, as a result of the rapid rise of the Himalayas and the Tibetan Plateau a few million years ago.

Having been a small-time presenter of TV science programmes myself, I felt an empathy with Aubrey Manning, whose enthusiasm and clarity of exposition were admirable. All the same, my own experiences led me to feel that sometimes he wasn't well served by the script. There were moments when I thought 'But he's already said/shown that', there were others when my reaction was 'Yes, but what about ... ... ?'

But I am quibbling, also digressing. This is about the book, which is in its own way every bit as good as the TV series. It doesn't purport to follow the programme sequence (though there were 8 chapters and there were 8 programmes), and I didn't recognize any of the illustrations from the TV. David Sington, producer of the TV series and one of the authors, was presented with the American Science Journalists' Award (a plaque plus cheque for $2000) – the first broadcaster and first non-American to win this award. The other author (Simon Lamb) is a geologist, which seems appropriate since it is chiefly the geological sciences that have provided our understanding of geological time and of the inner workings of Planet Earth.

The history of geology is summarised in Chapter 1 ('The Time Travellers'), and Chapters 2 to 6 are in my view somewhat overtly geological – but that's hardly surprising, considering the background of the authors and that the title of the book is *Earth Story*. Although Chapter 2 is called 'The Deep', it's not really about the sea, but about how sea-floor spreading was elucidated and hydrothermal vents subsequently discovered.

Life doesn't get much of a mention in these first six chapters, except in the context of topics like fossils, hydrothermal vent communities, and silicate weathering and limestone formation (the Urey reaction responsible for drawing down most of the early Earth's atmospheric CO_2). Photosynthesis is not actually mentioned until Chapter 7 ('The Living Planet') which more than makes up for the apparent glossing over of Life in earlier chapters. It's 'all you ever wanted to know' about the evolution of Life on Earth, from bugs to hominids, plus mass extinctions *en route*, beautifully outlined in just 30 pages.

I found Chapter 5 ('The Flow of the Continents') especially interesting, not least because it rang a nostalgic bell for me, in its mention of the geologist Harold Wellman, the first to recognize New Zealand's Alpine Fault, counterpart of North America's San Andreas Fault on the other side of the Pacific (I spent time in New Zealand in an earlier incarnation). This chapter is very 'new mantle dynamics', expounding the theory of mountain and plateau uplift through loss of mantle 'roots', and subsequent lateral spreading of uplifted masses under their own weight (cf. *Ocean Challenge*, Vol. 9, No. 3, p.16) – which is why bits of Greece are sliding into the Mediterranean, see above.

Uplift of the Himalayan/Tibetan region has been strongly correlated with climatic cooling, and this chapter leads into Chapter 6 ('The Ice Age'), in which thermohaline circulation, Milankovich cycles and ice-core records of greenhouse gases figure prominently. Earlier ice ages are also mentioned in Chapter 7, in relation to mass extinctions. The one that particularly caught my eye was the late Precambrian Ice Age, associated with mass extinction of the acritarchs (large single-celled eukaryotes that had become abundant in the oceans), which may have cleared the way for the Cambrian 'explosion' of diversity recorded in the bizarre fossil assemblages of the Burgess Shale. (The causes of that ice age are currently the subject of some debate, see p.6.)

The final chapter of the book ('A World Apart') is a look at the Earth's place in the Solar System and in the cosmos as a whole. The authors suggest that Life may be common and widespread in the Universe but that, in any one location, it may not last for the billions of years needed even to allow multicellular organisms to evolve, let alone intelligent life-forms. Indeed, they suggest (though not until the last page of the book!) that Life has lasted so long on Earth only because of the way it has interacted with the essentially abiotic physicochemical processes of solar radiation, oceanic and atmospheric circulation, mantle convection and so on. Somewhat to my surprise, however, I could find no mention in the book of how burial of organic carbon has contributed hugely to drawing down the Earth's original store of atmospheric carbon dioxide, and has been solely responsible for replacing it with oxygen. That is a significant omission, especially now that humans are busy replacing the oxygen with carbon dioxide again, through deforestation and the profligate use of fossil fuels.

Nonetheless, in their discussion of how Life itself can keep planets habitable (given sufficiently favourable starting conditions, especially the presence of liquid water), the authors have eschewed overtones of the mysticism often associated with Gaian philosophies. The Universe is impersonal and morally neutral, driven by stochastic determinism, i.e. effects follow causes that are random and unpredictable – like aircraft accidents and meteorite impacts. I'm not suggesting that the authors share this cosmological view, merely that there is nothing in the book to conflict with it. Nor do the authors speculate about whether we are alone in the cosmos or not, which reminds me of something Stephen Hawking said not long ago: 'If ET is out there, why hasn't (s)he phoned?'

But I digress yet again. This book is a lovely read, it won't become out-of-date for ages, the pictures are gorgeous, and all in all it's ideal for anyone interested in the Earth System or wanting to interest somebody else in it. There's a short Glossary which isn't really essential because the book doesn't require much prior scientific knowledge, so it doesn't matter that some of the terms are a bit technical – the context is so clear that it's hardly possible not to understand the story.

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Read the Books – Beware the Web?

Oh, I do get so *angry* with these so-called 'web-enhanced' books. Consider the two I have. Both are exemplary so far as the printed word is concerned, both general introductory texts, albeit with a strong American slant, but none the worse for that. It is their 'web connections' that I find so exasperating. But before I vent my spleen, bear with me while I look at the books themselves.

The first is:

Introduction to Ocean Sciences by Douglas A. Segar (1998). Wadsworth (International Thomson) Publishing Co. 497pp. (+ 99 extras). £24.99 (hard cover, ISBN 0-314-09705-8).

Here is another standard American-style multidisciplinary, largely equation-free, beautifully and lavishly illustrated, and (for the most part) clearly presented compendium of the basic principles for a foundation course in marine science. I have to confess to friendly feelings towards the author, for three reasons. The first is that he refers to our own Open University oceanography texts in his end-of-chapter lists of Suggested Reading. The second is that among the objectives listed in the Preface is the explicitly stated aim 'To impart an understanding of the interdisciplinary nature of ocean sciences ... and how they are connected to our lives.' (Reminds me of the objectives of *Ocean Challenge*!) He even opens this up to the student reader in one of his Critical Thinking Questions (p.93): '... most university curricula now require students to concentrate on one of the subdisciplines of science ... physical science students often learn little about biological sciences [and *vice versa*].' He then invites students to explore this state of affairs and offer opinions. How would *you* deal with this issue? Segar doesn't provide any answers to his questions (see below), but in this case we do know where he stands.

Indulge me in a brief digression, dear reader. The other day I heard on the radio someone who purports to be a scientist claiming that 'boundaries between scientific disciplines are coming down, there is more interdisciplinary cooperation nowadays'. Hah! Oh yes, I know it is fashionable for scientists in different fields to cooperate on research projects to attract more funding – but actual instances of real cross-discipline understanding are still very rare. When I asked some examiners whether they ever vetted (let alone marked) each other's questions, I got a dusty answer: 'If we could do each other's questions, what would be the point of having specialist lecturers?' Hah, again!

Sorry. Back to the review. My third reason for warming to this guy Segar is that he seems to understand the 'sustainability dilemma' faced by the world. In another of his Critical Thinking Questions (p.314) he actually says that serious reduction in greenhouse gas emissions (through reduced fossil-fuel use) would be economically harmful, and would in any case (1) do no more than slow the rate of warming, and (2) probably not happen anyway, because of the developing nations' need to 'catch up' with the rest of us.

He relates each of his chapters to one or more Critical Concepts, which are explained and summarized in glossaries at the end of the book. Examples include 'Biodiversity', 'Chaos', 'Coriolis force', 'Isostasy', 'Photosynthesis and nutrients', 'Density/stratification' and 'Salinity/temperature/density relationships' and so on. Geostrophic flow is done without any maths, which means that calculation of current speeds is not possible; and I'm not sure I go along with the statement that '... alkalinity is expressed as pH', but that's a can of worms probably best left unopened at this level! On the other hand, this is the first book I've seen of its kind that gets near to a decent explanation of the difference between diurnal and semi-diurnal equilibrium tides. There's also a short section on 'Law of the Sea', of which I thoroughly approve. Critical Thinking Questions are sprinkled throughout each chapter, and all the 'Chapter Summaries' are followed by revision/consolidation-type Study Questions. Most disappointingly, the book contains no answers for any of the questions.

My second book is:

Earth Science by Steven I. Dutch, James S. Monroe and Joseph M. Moran (1998). Wadsworth (International Thomson) Publishing Co. 536 pp. (+ 35 extras). £24.99. (flexicover, ISBN 0-314-20111-4).

The scope of this book is a great deal wider than Segar's, wider indeed than other books of this type that I've seen. It covers the Earth, oceans, atmosphere and Universe, and it aims to 'emphasise the Earth systems and their interconnected-ness ...'. The idea is great. The more interdisciplinarity we have, the better (see digression above). The first half (11 chapters) is essentially basic geology/petrology/mineralogy/hydrology/geophysics (including plate tectonics)/stratigraphy. Then there are two chapters on the oceans, five on the atmosphere, and the last three are about the Solar System and Universe.

In brief we have here another standard American-style compendium of the basic principles relevant to a science foundation course, this time about the Earth and its place in the Universe. Like my other book it is largely equation-free, beautifully and lavishly illustrated, and (for the most part) clearly presented.

And yet, and yet ... there is a curiously abiological feel to this book. The words bacteria, evolution, microorganisms, oxygen and vegetation, don't appear in the index. I felt that the role of Life itself in keeping the Earth habitable is mentioned rather in passing, even though there is a chapter on soils and another on the History of Life.

All the same, anyone wanting a good basic overview of the setting and workings of Planet Earth could do a lot worse than get this book. The price is reasonable, after all, and there are answers to some of the questions at least. There are two kinds of questions at the end of each chapter: Review Questions (revision/consolidation) and Points to Ponder (more philosophical). The peculiar thing is that the authors provide answers *only for odd-numbered Review Questions*, and none for the rest. And some answers are a bit odd. Is the explanation of why there are two high and two low tides each day really that: 'One bulge is raised by the Moon's gravity, the other by rotation around the Earth–Moon center of mass.'? I have trouble getting my head round that!

So much for the books. Now to their web connections. I am a lot less patient and forgiving than my kindly colleague Sue Greig, who has reviewed another book from this stable (see next review). I fancy she feels the same as I do, but she is more polite.

Students can get into the web links for these books via http://www.wadsworth.com/geo or thomsonlearning.com I just hope they don't expect too much. They get no help with any of the questions, despite a statement in Segar's Preface that this is where the answers lie. Instead they get other questions, mostly of a rather

simple-minded multiple-choice type, which they can answer on-line. There is also access to 'Flash Cards' and 'InfoTrac' material, but these were either not available or I couldn't get into them. The real time-killers are the links to other websites which, to quote Sue Greig, 'are highly technical sources of data' that require proper tutorial guidance to prevent students becoming overwhelmed by unfamiliar jargon and detailed information, including often arcane numerical data. I felt that a lot of this material wasn't altogether relevant to the subject matter of the chapter to which it was supposedly linked. Even if it *were* relevant (and the Dutch *et al.* book has website addresses at the end of each chapter), I suspect, with Sue, that much self-discipline is required to avoid being side-tracked – and time is a commodity in short supply for both teachers and students.

I experienced some difficulty in getting into the web links for these two books, but I thought that was probably the result of my clumsiness and inexperience at web-surfing. So I went back to the book by Paul R. Pinet which I reviewed for Volume 8 (No. 3, p.56). I got into the web links for that very easily. And lo, my people, it came to pass that the icons did correspond with that which had been writtten upon the tablets (well, in the book actually), mysteries were unfolded and resolved, terms defined and questions (mostly) answered.

The real trouble with all these books is the enormous baggage of supplementary material that goes along with them, in the form of Study Guides, Instructor's Manual, Workbooks, CD-ROM, sets of transparencies, and so on. Everyone's time is limited, and the publishers don't help. All they do is send you the book to review, they never send you any of the supplements. In the distant past when I had more time (ah memories, memories), I sent off for such supplements, but I wasn't much impressed when they came (e.g. Vol. 7, No. 2, p.42). Perhaps things are better now.

Stop Press The last time I tried the wadsworth.com/geo connection I suddenly noticed that I'd been welcomed to the Brooks/Cole Earth Science Resource Center. Takeovers are as rife in publishing as they are in other branches of commerce – perhaps more so. Never mind, all will be well so long as they put their forwarding addresses on the web.

John Wright
The Open University

Oceanography by Tom Garrison (1999), 3rd Edition. Wadsworth (International Thomson) Publishing Co., 552pp. £28.99 (hard cover, ISBN 0-534-3091-5).

I reviewed the first edition of this book in 1993 (*Ocean Challenge*, Vol. 4, No. 3) and felt happy recommending it as an interesting introductory read for the oceanography students I teach in the Open University, and as a useful addition to a sixth form library and also to a local library. It would be a little unfair to say *plus ça change* as there are some definite improvements. However, the overall structure of the book remains the same. I still like the use of vignettes to set the scene at the beginning of chapters. More colour is used than previously and many illustrations and photographs have been re-tinted in an acceptable way. Answers to the End of Chapter Study Questions are still not in the book but available to purchase separately (ISBN 0-534-53085-0). I still feel that it would be better to have them in the book, although that would probably make it too unwieldy, given its size without them.

The book has increased by a small amount from 540 to 552 pages. This is partly due to the inclusion of recent satellite imagery illustrating sea-surface temperatures, bottom topography, wave heights and wind speed (to name a few), including *TOPEX–Poseidon* data. In addition, five prominent marine scientists have contributed short accounts of their own recent research. These include Denise Smythe-Wright on 'CFCs' and Cindy Van Dover on 'Shrimps at mid-ocean ridges'. The section on 'Tides' has been improved by rewriting with additional diagrams, whilst more is included on biogeochemical cycles. The reading lists at the end of each chapter have been updated to 1998 and are still very helpful.

The author notes that more mathematics is included, but I did not see much evidence of this. However, he does still reiterate the importance of math (*sic.*) for students who wish to pursue their studies further and/or a career in marine science. Indeed, there is a short new section at the end of the book giving information and addresses for finding out more about studying the marine sciences, marine science as a career, and organizations which promote oceanography.

Perhaps the most noticeable difference is the selling point of internet access. The book has its own dedicated website with hyperlinks at http://www.g3oceanography.com

In the text, there are large numbers of icons indicating interesting websites which complement the discussion. The publishers also advertise their own website at http://www.wadsworth.com/geo which has information on careers, reviews of current articles and more links to science-related sites. Despite the plentiful icons, on further inspection many of the chapters did not have website links, presumably because there are no suitable ones available yet. The idea of searching these websites appears in the first instance to be a good one. However many of them are highly technical sources of data. If relatively inexperienced students are to use these resources profitably they need some sort of guidance or planned assignment based around them. The plethora of links means that much self-discipline is needed to avoid being side-tracked (a danger for most of us on the web, I imagine). The website also contains 'Flash Cards' which I unfortunately could not access due to lack of appropriate software. Fairly straightforward multiple-choice questions were also available. The answers could be submitted to the website for checking.

Also available for one academic term is the free unlimited use of the 'InfoTrac College Edition'. Purchase of the book provides you with a password giving you access to an online library of full-text articles from a wide range of periodicals going back about four years. Links are also made between the text of *Oceanography* and the online articles. This sounds a splendid idea, but one academic term seems rather short if you are taking an introductory marine science course over a longer time span, particularly if library access to journals is a problem.

As John Wright wrote about a similar book, armed with the website address and the original version, you would have comparable information to that in the later 'web-enhanced' edition. In this case, much of the satellite imagery contained in the new edition of *Oceanography* is also easily accessible on the web, particularly at sites such as *Topex–Poseidon* and the Ocean Color site.

It is probably a sad reflection on the status of Marine Science in schools in the UK that there are no accessible introductory level books on Oceanography. The National Curriculum makes few references to the oceans, and A-level modules on the oceans are rare. At least marine science is taught in a substantial number of high schools in the USA, largely through

the inspiring efforts of the American Meteorological Society and the US Naval Academy, who jointly sponsor the Maury Project, which trains teachers of all levels in key aspects of marine science. Perhaps we should not be critical of texts such as this when very little has emerged in the UK.

Sue Greig
Forest Row

From Monsoons to Microbes: Understanding the Ocean's Role in Human Health (1999). Report by the Committte on the Ocean's Role in Human Health, Ocean Studies Board, Commission on Geosciences, Environment and Resources, US National Research Council, 132pp. National Academy Press (hard cover, ISBN 0-309-06569-0).

In 1998, in recognition of the Year of the Oceans, the US National Research Council held a workshop on the Ocean's Role in Human Health, and this book, which is partly based on the workshop sessions, is one of the outcomes. It is, of course, written from a US perspective, but the first part, on Hazards to Human Health from the Oceans, should be of interest to all those with responsibility for human health and safety in coastal areas, and the second – Value of Marine Biodiversity to Biomedicine – would probably be interesting to any scientist who was not already familiar with the topic. A non-Earth scientist involved in health administration might find some parts of the book difficult, as would an oceanographer with little experience of biology, but both would be given a new perspective on health and the natural environment.

Part I has three chapters, on, respectively, 'Climate, weather, coastal hazards and public health', 'Infectious diseases' and 'Harmful algal blooms'. The first of these covers the effects of tsunamis, hurricanes and (especially) storm surges, and emphasizes that although the severity of such disasters is commonly measured in terms of the immediate mortality – perhaps 500 000 dead, in the case of the 1970 Bay of Bengal cyclone – other less obvious results are equally destructive. These include large numbers of hospitals put out of action, setback in development, and loss of individual income. Later sections deal with health problems associated with estuaries and with climatic variability (essentially El Niño and the North Atlantic Oscillation). These are mainly discussions of the various phenomena themselves, with limited coverage of implications for health, but the chapter ends with practical sections on the importance of having a prepared health service, and on the new technologies that could enable a state to put its emergency plans into action (i.e. monitoring techniques in physical oceanography and meteorology) and to detect chemical and biological hazards.

The first part of the chapter on 'Infectious Diseases' is about those diseases caused by bacteria, viruses, nematodes and fungi that live in water. The introduction is not optimistic: the incidence of water-borne disease is increasing worldwide, promoted both by natural phenomena (e.g. El Niño) and by human activities, including sewage disposal. Furthermore, while the genetics, chemical structure and mode of action of (say) the cholera toxin are well understood, experts still do not agree about how epidemics start. The second part of this chapter concerns 'vector-borne diseases' (malaria, rift valley fever and dengue fever), and includes a brief discussion of the attempts being made to evaluate the implications for human health of the 1997–98 El Niño event.

Chapter 3 is about 'Harmful algal blooms': blooms which affect humans through contaminated seawater or seafood, or – in the case of algal toxins carried on aerosols – even inhalation. Worldwide, such blooms seem to be increasing in frequency and intensity, and there is concern that this is a consequence of a decline in the marine environment.

The second part of the book, on the Value of Biodiversity to Biomedicine, was all new to me, and very interesting, especially the first chapter on 'Marine-derived pharmaceuticals and related bioactive agents'. As explained in the Exective Summary, plants, animals and microbes have provided either the source or the inspiration for more than half the pharmaceuticals currently on the market. Since the discovery of penicillin in the 1920s, the emphasis has been on terrestrial organisms (mainly soil-based), but despite continued research effort there has been a decreasing return in terms of molecular diversity and hence new drug compounds. Now, apparently, more than 90% of 'active' molecules identified turn out to be molecules that have already been discovered. However, most of the Earth's microbial diversity is found in the ocean, and many classes of micro-organisms are found *only* in the sea, so the potential for the discovery of new pharmaceuticals must be enormous.

As far as multicellular organisms are concerned, sponges have so far provided the greatest variety of chemical compounds with therapeutic potential, being the source of more than 30% of the 5000 chemical compounds from marine organisms. Useful bioactive molecules are also known to be produced by bryozoans, ascidians, molluscs, cnidarians and algae. Of necessity, this topic (like others in the book) is only briefly covered, but there is a reasonable supply of references for the reader who wishes to find out more. One of the important conclusions reached at the end of this chapter is that there is a need for new interdisciplinary research and education programmes, as few researchers have expertise in both medicine and marine science.

The last chapter is on 'Marine organisms as models for biomedical research'– in essence, how certain organisms provide useful, but simple, analogues for mammalian (specifically human) body functions. For example, understanding of how the human retina functions began with studies of the eye of the horseshoe crab, which has about 1000 photoreceptors (the human retina has more than 10^8).

This is all fascinating, but as a non-biologist, I found the discussion of animals as simply resources for medicine rather disturbing. The fact that the section titles refer to the 'roles' of the various animals in clarifying understanding of certain physiological processes only serves to highlight how very human-centred much of our science has become.

The book may be obtained from the National Academy Press.* Although it has an attractive cover, it seems to have lacked the input of a designer and so looks like the report that it is. With a little thought about layout, the appearance might have been improved and the page-length reduced (a large number of pages are devoted to lists relating to the committees and the workshops, or are blank). It is also frustrating that the colour plates are grouped together in the centre of the book, which limits their usefulness. These aspects seem worth commenting on as this slim volume is not cheap, and it would be a shame if it were not read by as many people as possible.

Angela Colling
The Open University

*National Academy Press, 2101 Constitution Ave., NW, Lockbox 285, Washington DC 20055; see also the publisher's website: http://www.nap.edu Price: $34.95 (£23) or $27.95 (£19) if purchased over the Web.

Forthcoming Events

Events in 2000

Expo 2000: Expo at the Sea 1 June until the end of September, Wilhelmshaven, northern Germany (the main exhibition will be in Hanover). There will be a range of activities, including an education server, 'Diving in the Internet', with teaching sequences on water, wind and sun, plus techniques; also worldwide links to images related to the sea, coastlines and harbours. The Senckenbergische Naturforschende Gesellschaft will have its own exhibition in Wilhelmshaven: 'Hydrothermal Vents in the Deep Sea'. *For more information, see the website:* http://www.expo-am-meer.de

Proudman Oceanography Laboratory Open Day 28, 29 June, 2 July, Bidston Observatory. *For more information*: Tel: +44(0)151-653-8633; Fax: +44(0)151-652-2754; website: http://www.ccms.ac.uk

Managing Eutrophication of Estuaries and Nearshore Waters: a Challenge for the New Millenium (31st Annual Symposium of the Estuarine and Coastal Sciences Association). 3–7 July, University of the Basque Country, Bilbao. *For more information contact* ECSA 31, Emma Orive, Departamento de Biología Vegetal y Ecología, Universidad del País Vasco, Apartado 644, 48080 Bilbao, Spain. Tel: 946012570; Fax: 944648500; Email: ecsabilbao@lg.ehu.es Website: http://www.ehu.es/ecsabilbao

The Southern Ocean: Climatic Changes and the Cycle of Carbon (International JGOFS Symposium). 9–13 July, Quartz Congress Centre, Brest, France. 'Brest 2000' a huge gathering of old sailing ships will start immediately after the symposium. *Contact* Paul Treguer, UMR CNRS 6539, Institute Universitaire Européen de la Mer, Technopole Brest-Iroise, 29280 Plouzané, France; Tel./Fax: (+33-2)-98-49-86-64/45; Email: Paul Treguer@univ-brest.fr

Biology of Polar Fish, 24 July, Cambridge. Organized by the Fisheries Society of the British Isles. Email: pace_proj@compuserve.com

Meteorology at the Millenium: Its Relationship to other Sciences and Technology, and to Society 10–14 July, St John's College, Cambrdge. *For more information contact* The Royal Meteorological Society, 104 Oxford Rd, Reading RG1 7LL, UK. Email: execsec@royal-met-soc.org.uk

Science and Conservation of Deep Sea Corals (1st International Symposium on Deep Sea Corals). 30 July–2 August, Dalhousie University, Halifax, Nova Scotia, Canada. The symposium will cover all aspects of deep-sea coral biology, ecology, and conservation; also, climatic reconstruction using corals and technologies available to map corals. It is open to scientists, managers, ocean users and all those with an interest in deep sea corals. *Contact*; Symposium Secretariat: Susan Gass, Ecology Action Centre, 1568 Argyle St, Suite 31, Halifax, Nova Scotia, B3J 2B3; Tel. +1-902-429-2202; Fax: +1-902-422-6410; Email: coral@is.dal.ca

EurOCEAN 2000: European Conference on Marine Science and Ocean Technology 29 August–2 September, Hamburg, Germany. *Contact* SCIC.B.1, European Commission Conferences Organization Unit, Rue de la Loi, B-1049, Brussels, Belgium; Email: ana.marques@cec.eu.int Website: http://europa.eu.int/comm/dg12/envsc/eurocean.html

UK Marine Science 2000, 10–15 September, University of East Anglia, Norwich. *(See full page ad on p.9.)*

Workshop on Human Dimensions in the Coastal Zone 10–22 September, Bonn, Germany. *For more information:* Fax: +49 228 739 054, Email: shaw.ihdp@uni-bonn.de Website: http://www.uni-bonn.de/ihdp/IHDW2000.htm

Underwater Optics (A topical meeting within Optics 2000, at the Applied Optics and Opto-Electronics Conference). 17–21 September, University of Loughborough. Website: http://www.iop.org/IOP/Confs/AOD

9th International Coral Reef Symposium, 23–27 October Bali, Indonesia. October. The conference website is: http://www.nova.edu/ocean/9icrs.html To be held at the Roylindo Convention International Hotel, Wisata International. *For more information:* Tel. (62-21)314-0982; Fax: (62-21)334-470/32-15; Email: mktg@roylindo.co.id

New Directions in Marine Science 2000: An Interdisciplinary Forum 25–7 October, Dunstaffnage Marine Laboratory, Oban (joint with SAMS/University of the Highlands & Islands Project) for research students. *Convenor* Paul Crozier; all correspondence and enquiries to: forum@wpo.nerc.ac.uk

5th German Climate Meeting 2–6 October, Hamburg, Germany. *Contact* Walter Lenz, University of Hamburg, Tel. +49-(0)40-42838-4523; Email: walter.lenz@dkrz.de

10th International Scientific Wadden Sea Symposium, 31 October–3 November, Groningen, The Netherlands. Conference website http://cwss.www.de/news/symposia/Groningen.html Email C.J.M.van.Berkel@Invn.agro.nl *Contact* Mr Kees van Berkel, Policy, Dept North, PO Box 30032, NL 9700 RM Groningen; Tel. +31-(0)50-5992315;

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 (for address see inside back cover).

OCEAN Challenge

The Magazine of the Challenger Society for Marine Science

SOME INFORMATION ABOUT THE CHALLENGER SOCIETY

The Society's objectives are:

To advance the study of Marine Science through research and education.

To disseminate knowledge of Marine Science with a view to encouraging a wider interest in the study of the seas and an awareness of the need for their proper management.

To contribute to public debate on the development of Marine Science.

The Society aims to achieve these objectives through a range of activities:

Holding regular scientific meetings covering all aspects of Marine Science.

Supporting specialist groups to provide a forum for discussion.

Publication of a range of documents dealing with aspects of Marine Science and the programme of meetings of the Society.

Membership provides the following benefits:

An opportunity to attend, at reduced rates, the biennial five-day UK Marine Science Conference and a range of other scientific meetings supported by the Society.

Regular bulletins providing details of Society activities, news of conferences, meetings and seminars (in addition to those in *Ocean Challenge* itself).

MEMBERSHIP SUBSCRIPTIONS

The subscription for 2000 costs £30 (£12.00 for students in the UK only). If you would like to join the Society or obtain further information, contact the Executive Secretary, Challenger Society for Marine Science, Room 251/20, Southampton Oceanography Centre, Waterfront Campus, Empress Dock, Southampton SO14 3ZH, UK.
Fax: 023-80-596149; Email: jxj@soc.soton.ac.uk

ADVICE TO AUTHORS

Articles for *Ocean Challenge* can be on any aspect of oceanography. They should be written in an accessible style with a minimum of jargon and avoiding the use of references. If at all possible, they should be well illustrated (please supply clear artwork roughs or good-contrast black and white glossy prints). Copy may be sent electronically.

For further information, please contact the Editor:
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