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Mrs Edith CRESSON, Commissioner for research, innovation, education, training and youth.
Directorate General XII - Science, Research and Development

RTD Info is a newsletter on research and technological development supported by the European Union. It covers general aspects of Community research such as project results and research policy, as well as practical information including dates of calls for proposals, events, conferences, publications, and so on. RTD Info is aimed not only at current and potential participants in Community research programmes, but also at a wider public of industrialists, decision-makers, students, and others who are interested in developments in European research. Published quarterly, RTD Info is available in English, French and German. Subscription is free. To subscribe, fill in the form below.

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Research programmes: a matter of management

At the Ministerial Colloquium in London on 28 April, I presented the measures proposed by the Commission to guarantee good management of the Fifth Framework Programme and to facilitate access to it, especially for small and medium-sized firms.

I sought to remind those present that this need for improvement has been a constant concern of the Commission for a number of years. Yet, there is no perfect, definitive model for research management. This is especially true at the European level, where the unique features of the framework programme necessarily mean that its implementation will encounter constraints that are unknown at the national level.

The Fifth Framework Programme must enable Europe to innovate more - and better. This must be reflected both in its management methods and in the increased involvement of scientists, industrialists, and users in the way the programmes are implemented. We are, in fact, all involved in a remarkable European experiment - one that teaches us lessons and produces results, but one that requires constant development. My message to Europe's research ministers was that the Fifth Framework Programme opens up new and interesting ways forward for such development.

Edith Cresson

Edith Cresson
Member of the Commission for research, innovation, education, training and youth.

Teleporting Talent Around Europe

The research team which demonstrated quantum teleportation late last year was brought together through the Training and Mobility of Researchers (TMR) Programme. RTD Info met Anton Zeilinger, leader of both research group and TMR network, to see how this and other EC programmes are helping keep European talent in Europe.

The Innsbruck team (left to right): Dik Bouwmeester, Harald Weinfurter, Professor Zeilinger, Jian-wei Pan, Manfred Eibl and Klaus Mattle.

"The Physics of Quantum Information is one of three TMR networks I'm involved in," explains Zeilinger, Professor at the University of Innsbruck's Department of Experimental Physics. "It links together all of Europe's expertise in the field. This is the only way we can keep up with the Americans in a science which will probably totally revolutionise computing early next century."

Nestled deep in the Austrian Alps and better known as an excellent place to ski, Innsbruck seems an unlikely place to startle the world from. But Zeilinger's group did just last December, reporting in the prestigious journal Nature [1] how they teleported a photon across their laboratory at infinite speed and unleashing a torrent of comment and references to Star Trek in newspapers around the world.

"Never seen so many photos of Mr Spock in my life," Zeilinger remarks, surveying a stack of photocopied articles. "The articles focused on the teleportation aspect, of course, but they largely missed the actual innovation of our work."

While their experiment built on purely theoretical quantum physics by Charles H. Bennett and others at IBM's research lab in the early 1990s, it would be a mistake to suppose that this is simply a question of practice catching up with theory. "In Bennet's paper there's a single line where they write that a 'Bell State Measurement' [2] has to be made," explains Zeilinger. "That had in fact never been done until we did it" (see page 5).

Their achievement was more than just a scientific curiosity, however. "If you'd asked me whether there were any applications of this work ten years ago, I'd have just said no," Zeilinger says. "But I would have been wrong. We're only beginning to glimpse the possibilities."

Quantum Technologies

Their work is a crucial step towards an entirely new range of technologies - quantum technologies. Of these, the oldest is quantum cryptography, first suggested in 1985.

Cryptography is the science of encoding messages so that they are unreadable

(1) 'Experimental quantum teleportation' (Nature, Vol 390, 11 December 1997, pp 575).
(2) From the name of the American physicist John Bell (see box p. 5).

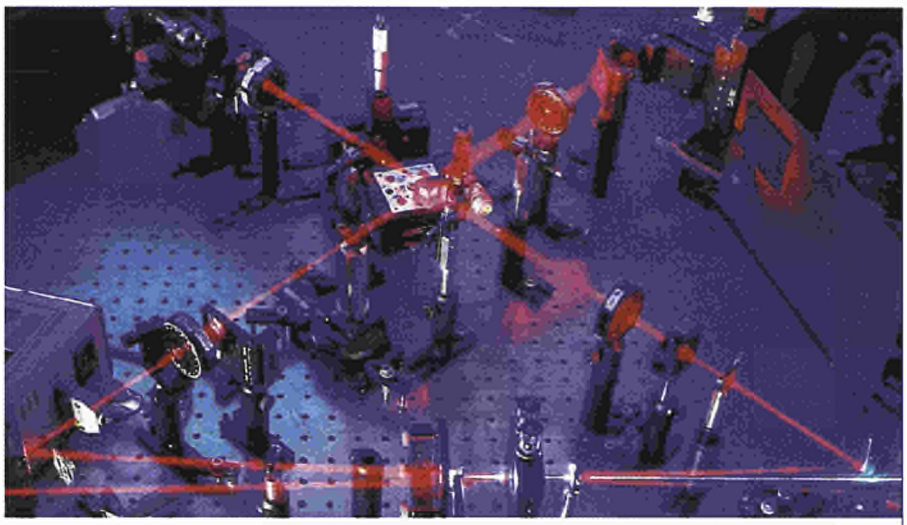
by anyone without the right 'key' to decode it. With the advent of electronic commerce, this is big business.

And only quantum cryptography can provide total security. It exploits the unusual properties of quantum states to enable users to create one-off (and hence utterly unbreakable) cryptography keys. As an added bonus, any eavesdropping can be spotted, as the act of measuring a quantum state changes it.

In comparison, today's systems create keys using very large numbers. They are breakable, although a great deal of computing power is required. How much power, however, is a matter of controversy - some suspect that they are not as secure as is currently thought.

In any case, many expect that quantum computers could crack them easily anyway. This is because quantum computers should be able to do things classical computers cannot. While classical computers are binary - dealing with bits of information, each taking one of two values (0 or 1) - quantum computers deal in 'qubits'. The difference is revolutionary.

"A quantum system can be in a superposition of states," explains Zeilinger. "In a sense, it can be in both the '0' and '1' states at the same time. There is an infinite number of different combinations, or superpositions, of the two. It's already clear that this will allow new types of parallel computing which - for certain problems - will be much faster than today's computers. My own sense is that it will allow a completely new form of computing. We haven't really seen what this means yet, but we will soon."



The laboratory set-up designed by the University of Innsbruck's Department of Experimental Physics to produce entangled photons and achieve the "Bell State Measurement". This world first led directly to another - quantum teleportation.

A European Identity

According to Zeilinger, their success indicates the power of European networking. The first author listed on the Nature paper, for example, is Dik Bouwmeester, a Dutch postdoc trained at the Universities of Leiden and Oxford and brought to Innsbruck thanks to the TMR network. The network also linked the University of Innsbruck to other groups in France, Germany, Italy, Spain, Switzerland and the UK.

"There's always a certain tension in a network like this because everyone wants to publish first - you wouldn't have good scientists if they weren't competitive," Zeilinger observes. "Nevertheless the TMR network helped transfer a lot of knowledge. The Oxford team, for example, provided a lot of experience with entangled states, while we've been following the Paris team's work with atoms with interest.

"But the focus is young people," he continues. "The main event is a yearly workshop for young researchers, but the most important effect is to create a European community in their minds. It has been common practice for young European researchers to go to America rather than another European country for postdoc work. The best often stayed there. This brain drain, in my opinion, has slowed somewhat thanks to the EC programmes."

Industrial Competition

Grants for postdocs to travel, however, may not be enough to take quantum information out of the laboratory. "Both the US National Security Agency and Defence Research Agency are heavily involved in funding quantum information - how much, only they know," Zeilinger points out. "These are the agencies which funded computing science for the three decades after the Second World War, so American research groups don't need to fight for funding. The Los Alamos laboratory could produce an industrial quantum cryptography prototype at any time."

In Europe, no equivalent source of funding exists. "Europe is about the same size as America and we've shown that we have the brainpower, so there's absolutely no reason why we can't win this race," Zeilinger concludes. "But no single European country can match the American government's funding power - it's got to be a European priority." ■

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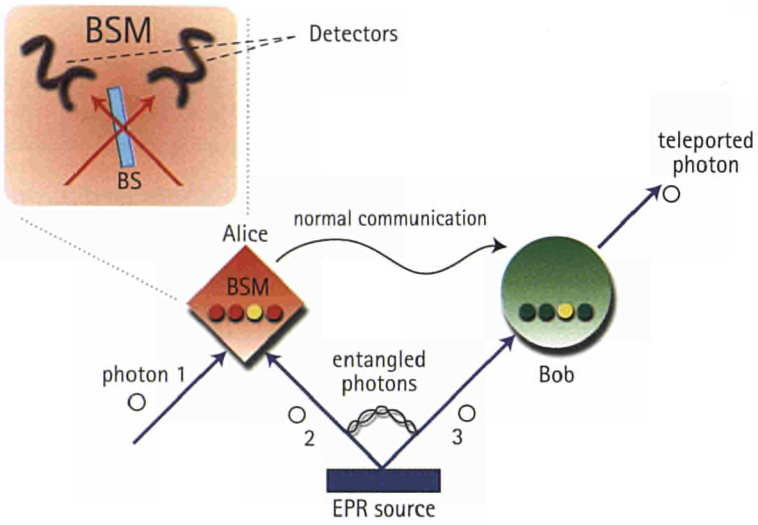


By entangling photon 1 with a photon which is itself part of an entangled pair (photons 2 and 3), Alice can teleport the quantum state of photon 1 to photon 3.
In the Bell State Measurement (BSM, inset), photons 1 and 2 are directed at a beamsplitter (BS), a mirror which reflects 50% of all photons striking it. Detectors are mounted on either side of the beamsplitter. These can register the arrival of a photon, but they cannot identify whether it is photon 1 or 2. The two particles thus lose their identity and exist together in a superposed quantum state. It turns out that if both detectors register a photon simultaneously, it means that the two photons have been entangled orthogonally.

What is Quantum Teleportation?

Quantum teleportation is the result of the many counter-intuitive aspects of quantum mechanics that gave Albert Einstein bad headaches. It relies on the fact that very small particles - the photons, protons, atoms *et al* ruled by the laws of quantum mechanics - can exist in 'indeterminate' quantum states, a mixture (or 'superposition') of all the states in which that particle can be.

This mysterious situation exists until the state of the particle is measured, causing the particle's superposed state to 'collapse' into one of the possible states. The equation describing the particle's superposed quantum state contains the probabilities for each collapsed state.

Photons, for example, can be polarised at any angle. Until a photon's polarisation is actually measured it exists in a superposition of different polarisation angles. It may, for example, be in a quantum state where it is 90% probable that it will collapse into a horizontally polarised particle. When it is measured the particle somehow 'rolls dice' to decide if it is horizontally polarised or not.

Another crucial fact is that particles can be 'entangled' together - their quantum states merge. As John Bell showed, measuring the state of one particle will cause the other particle's state to collapse instantly, even if it is on the other side of the universe.

Put these two phenomena together, and you have the building blocks for teleporting quantum states from one particle to another.

All Tangled Up

In the experiment (see Diagram), the polarisation state of photon 1 was transferred instantaneously across Zeilinger's laboratory to photon 3 via a 'transporter photon' (photon 2).

It is done like this. Let's say someone - quantum physicists seem to always call her Alice - wants to teleport her photon (photon 1) to her colleague Bob. She first creates photons 2 and 3 using a so called 'EPR source', which creates photons which are entangled orthogonally. This means that when the polarisation of one particle is measured, the other particle instantly assumes the opposite polarisation, wherever it may be.

Alice holds on to photon 2 and sends photon 3 to Bob. When Alice wants to teleport photon 1 to Bob, she performs a Bell State Measurement (BSM) on photons 1 and 2. This is the true achievement of the experiment, as it involves taking two completely unrelated photons and entangling them.

The Opposite of the Opposite of White is White

There are four possible ways these particles can be entangled. If they are entangled orthogonally, photon 1's polarisation is opposite to that of photon 2. But photon 2's polarisation is opposite to that of photon 3. So photon 3, which Bob could have taken with him to any place in the universe, immediately adopts the same quantum state as Alice's original particle.

The catch is that Bob does not know this. Alice has to tell him, and that information has to be transmitted normally. Thus quantum teleportation does not violate the limits imposed by the speed of light. "Information seems to move instantaneously at the quantum level of the universe, but to extract that information and use it in our world, we are still governed by Einstein's speed limit," explains Zeilinger. "It makes you think twice about the nature of information."

And the three other possible types of entanglement? Each corresponds to more complex relationships between photons 1 and 3. One, for example, means that the polarisation angles differ by 45°. Given a phone call from Alice, however, Bob can make the necessary transformations.

Translating biology into business

Europe has a lot of expertise in life science. So why are we creating four to seven times less jobs and business opportunities in this field than the US? The first conference of the "Biotechnology and Finance Forum" (1) in May strives to redress this imbalance by mixing people from the "biotechsphere" (researchers, enterprise incubators and biotechnology companies) and from the "financesphere" (venture capital firms, banks, institutional investors and business angels).

While the number of scientific publications in the areas of biology, clinical medicine and biomedical research is approximately the same in Europe and in the United States of America, R&D expenditure and the number of jobs in biotech industry are more than four times higher in the US than in Europe - and in 1997 total sales were nearly seven times higher. These figures reflect Europe's limited capacity to transfer scientific and technical knowledge through to industry and commerce, and to come up with marketable products and processes. The main problem is the obstacles that entrepreneurs face in setting up small research-based biotechnology firms.

The success rate of biotech start-ups depends on three major factors: skills (the right balance between scientific excellence, business management and financial expertise), the environment (a good economic infrastructure, a workable legal framework and appropriate public awareness) and money (sufficient seed and venture capital in the start-up phase).

The ambitious BioTuL team envisages turning over ECU 25 million by the year 2003, and aims to challenge the current market leader in biotechnological measuring instruments, Biacore.

No shortage of money

Venture capital is no less abundant in Europe than in the US. However, real risk investments in biotechnology account only for 2% of the total venture capital employed in Europe, opposed to 28% in the US. Most of Europe's venture capital goes on development and acquisitions rather than on seed investments. Moreover, 90% of European venture capital is invested inside its country of origin.

The recent opening of venture capital markets in the form of the so-called "New Markets" in Frankfurt, Paris, Amsterdam and Brussels (EURO.NM) and of EASDAQ (European Association of Securities Dealers Automated Quotation) in Brussels is part of the remedy. But it must be accompanied by a wider and more intensive interaction between the spheres of biotechnology and finance on a pan-European level. This is the objective of the Biotechnology and Finance Forum (BFF) a dynamic initiative set up last year between the European Commission and the European Association of Securities Dealers (EASD).

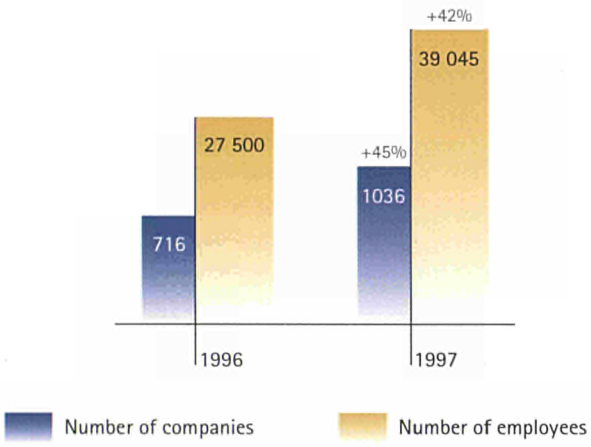
Promoting a symbiotic relationship

The BFF's first conference, held on 12-13 May, was opened by Commissioner Ms Edith Cresson and EASD Chairman Didier Duhem. The following discussion issues were on the agenda: global performance of European biotechnology; success stories of European biotech companies and biotech financial investors; access to capital markets for entrepreneurs; venture capital for biotechnology; promotion of managerial training; emerging technologies and fields of research; opportunities for scientific and industrial collaboration; and promoting dialogue between the biotech and financial spheres.

The "Innovation and Technology Equity Project" (I-TEC), a Community pilot project currently under way to foster investments in start-up capital, and the symbiotic relationship between large companies and small biotech research-based firms were the focus of two presentations. Throughout the event, 36 European biotech companies, at various stages of maturity, made presentations of their history and activities to potential investors.

On 14 May, a Biotechnology Innovation Symposium was held to complement the conference. It compared various national approaches to promoting biotech entrepreneurship, and identified possible strategies to use research funds more efficiently and to encourage synergies. In the first discussion panel, national inno-

European Biotech Sector
An encouraging growth in 1997



Role models and networking

The motif of the First BFF Conference was networking. It was the theme of the event, and was repeatedly mentioned as barriers between scientists, entrepreneurs, investors and policy-makers came down. Young entrepreneurs were able to make contacts with venture capitalists in presentations and also in conversation. The importance of role models was put forward as a good vector to create a generally enthusiastic atmosphere about biotech start-ups and to make the need for venture capital clear to venture capitalists. One speaker juxtaposed biotechnological and financial terms and asked the audience whether they understood all of them. The comparison made it clear that fruitful collaboration starts with understanding your partner's language.

vation programmes like the German BioRegio initiative were presented, while the other two panels focused on specific measures such as regional biotech initiatives and encouraging patenting among researchers.

The workshops identified the factors that drive or impede innovation as being: management skills; the right mix of science and business cultures; market awareness; existence of a critical mass; the relevance of the technology; and public perception. The first key measure identified was an increase in training in business and management of students. A training scheme scaling-up earlier pioneering initiatives of the EC Biotech programme and meetings between young researchers and entrepreneurs were also proposed.

It is crucial to remove the cultural and legal obstacles that prevent scientists from exploiting their research results. As an example, the research environment must increase the incentives to patent: instead of "Publish or perish!" the researchers' slogan should be "Patent, publish and flourish!". ■

(1) A joint initiative of the European Commission and the European Association of Securities Dealers (EASD).

BioTuL GmbH, Munich – off to a good start

Biophysicist Dr Gunnar Brink started his first biotech laboratory in 1993 as a spin-off from Munich Technical University. During the first period of business, financing was achieved through fellowships of doctorate students, funds from the European Recovery Programme, bank loans, and through a preparatory award from the EC Biotech Programme. Three years later he obtained a patent for the concept of a new biosensor and succeeded in getting an EC grant of ECU 1 million from the Biotech Programme which enabled Dr Brink to put together a research proposal. This grant levered ECU 3 million of venture capital and led to the foundation of BioTuL GmbH (Tools and Tunable Lasers for the Biosciences).

The company has now grown to employ 15 people. It markets a surface plasmon resonance biosensor and coated biochips in the nanometer range, and is developing a completely new measuring instrument designed to characterise the bonding behaviour of biomolecules. The ambitious BioTuL team envisages turning over ECU 25 million by the year 2003, and aims to challenge the current market leader in biotechnological measuring instruments, Biacore.

Concerning the company itself, Dr Brink stresses the three pillars of success: creativity, a strictly international orientation and a cost-conscious approach. As regards the business environment, he points out the good economic infrastructure and the excellent scientific infrastructure in the Munich region. This region is one of the three "BioRegios" in Germany, areas that have been selected by the Federal Government as seedbeds for biotech entreprises.

European S&T - the state of play

Europe is currently a major scientific power but, to retain its world position, it must promote long-term economic growth by stepping up investment in research, development, education and training. The vicious circle of less investment - less growth could become a big problem as we move into the 21st century

The Second European Report on S&T Indicators (ERSTI), published by the Commission in April 1998, is a unique and massive collection of data, analyses and opinions on every imaginable aspect of science and technology in Europe compared to the rest of the world in the mid-1990s. In this issue and the following ones, RTD Info will review the five parts of the report (see box).

Entitled European Science and Technology in the World, Part I of the ERSTI report considers the economic performance of all 180 countries in the world in relation to their S&T performance. This approach shows that access to science and technology has emerged as a major factor which separates the 'haves' from the 'have-nots'. It defines a clear "super-group" of 50 countries - composed of nations from all the corners of the globe - that are leading a healthy, almost booming, world economy.

The gap between these leaders and the remaining 130 "S&T weak" nations - where a quarter of the world's population lives - is wide.

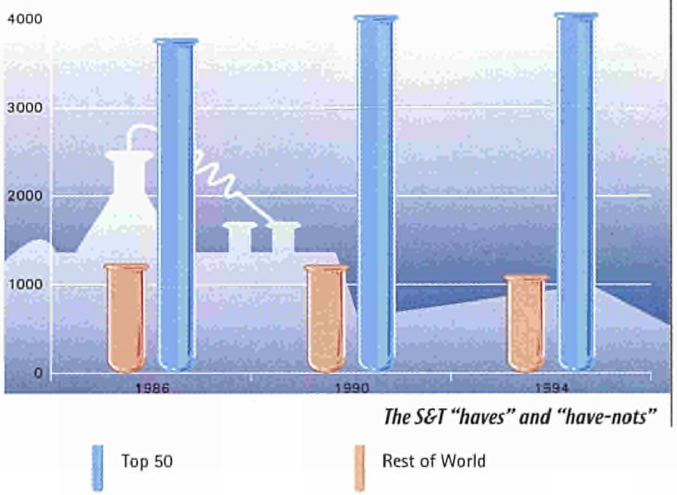
The "top 50": key figures

In 1994, the "top 50" accounted for 98% of world R&D and education spending. They employed 95% of the world's scientists and engineers. These, in turn, were responsible for 98% of all publications in journals mentioned in the Science Citation Index and 99% of all patents issued in the US and Europe.

Returns on this investment were equally impressive: the "top 50" generated 90% of world Gross Domestic Product (GDP), accounting for 92% of world industrial production. They attracted 99% of direct foreign investment and they were the source of more than 96% of international trade in manufactured products, and virtually 100% of high-technology exports. Between 1986 and 1994, the "top 50" consolidated their position: their long-term economic growth was three times greater than that of the other 130 countries in the world. The average economic wealth per head in these 50 countries grew by 1.1% per year in constant ECU. Their income has fallen over the last decade by 1.5% per year. Whilst the rich have got ever richer, the poor have got poorer (Figure 1).

Figure 1

The "top 50" and the rest of the world
Trends in economic wealth per head
(Exchange rate basis, 1990 ECU)



National variations

Within the "top 50", most of the indicators show that individual countries which invest more in scientific research, and exploit technology with greater efficiency, are the best economic performers. Several countries at the lower end of the "top 50" are now making substantial increases in their science investment budgets and are currently undergoing a process of catching-up.

For example, between 1990 and 1996 the developed Asian countries built on knowledge generated in other parts of the world and invested heavily in science and technology. Just before the current financial turmoil, they had achieved economic growth rates of around 10% per year.

Europe's position

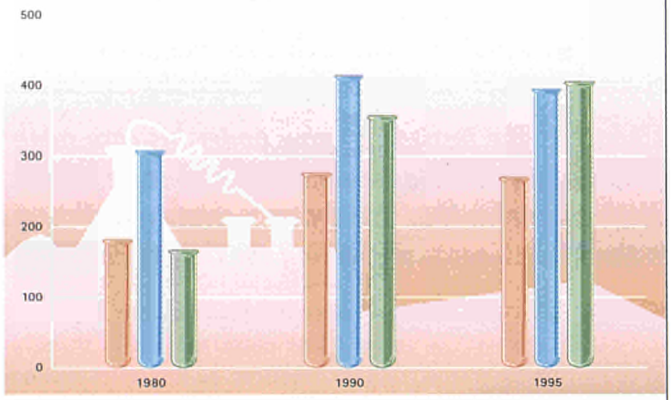
Europe's economic growth over the last decade has been much lower than Asia's but in line with that of the US and Japan. All countries in the European Union are, of course, within the 'top 50' and, collectively, the EU is currently retaining its position as the world's second scientific power, behind the US but ahead of Japan. It has a strong science base, its trade performance has been improving since 1993 and the EU still holds first place in the world as the source and destination of foreign investment.

However, since the economic downturn of the early 1990s, Europe as a whole has cut back on its investment in intangibles such as R&D in science and technology, education and training (Figure 2). This explains, at least in part, the lower economic growth, lower competitiveness and higher unemployment: all factors that are likely to reduce investment still further in the immediate future.

Figure 2

Comparing the research efforts Trends in R&D expenditure per head

(in purchasing power standards - 1990 ECU)



Since the economic downturn of the early 1990s, Europe as a whole has cut back on its level of investment in R&D in science and technology

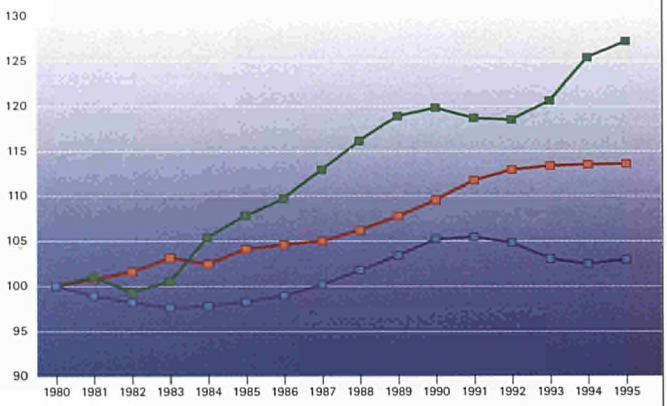
EU | North American Free Trade Area (NAFTA) | Developed Asian Economies (DAE)

Figure 3

The European employment weakness

Employment trends, 1980-1995

(1980 = 100)



There are significant differences between the US, Japan and Europe in terms of their employment performance. The impact of the recession was more acute in Europe than anywhere else.

USA | EU 12 | Japan

A paradox, not a fate

The so-called "European paradox" is still evident: although the EU has a very strong science base and invests well in education, it is generally weak in some aspects of its technological and economic performance compared to other major industrial powers.

The rapid investment that Europe made in R&D in the first half of the 1980s is still paying dividends and accounts for the continual improvement in scientific performance that Europe has shown throughout the period from 1980 to 1995. However, during the second half of the 1980s, Europe's technological performance deteriorated significantly relative to the US and Japan. The rate of growth in exports by European high-tech industry remains below that of its two principal competitors, and Europe still shows a high trade deficit in high-tech products. Sectors with a high degree of R&D activity are still contributing little to overall economic growth, and redundancies in industry are still getting worse, despite economic recovery in other parts of the world.

The problem of social exclusion

Unemployment, job insecurity and social exclusion have become more pervasive problems in Europe during the 1990s (Figure 3). It seems that people who find science and technology inaccessible because of insufficient education and qualifications are profiting less and less from the increase in economic wealth that results from the acceleration in growth of the world economy.

To prevent the problem from becoming worse during the next few years, ERSTI concludes that Europe must invest massively in developing its human capital. R&D and innovation capacity needs to be expanded and science results need to be commercialised much more effectively if Europe is to take the place it deserves among the economic, scientific and technological powers of the 21st century. ■

Next article:
Understanding the European Paradox

ERSTI Contents

Part I - European Science and Technology in the World
Overview of the global economy in the 1990s - Trends of R&D expenditure in the world - Investment in Human Capital - Education and the change in the number of R&D researchers world-wide - Economic performance indicators related to S&T - Technological output indicators - Scientific output indicators
Part II – From R&D to innovation and competitiveness
Part III – European diversity, convergence and cohesion
Part IV – R&D co-operation in Europe
Part V – The European Union as world partner
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Citizens, sustainability, competitiveness

Herbert Allgeier, the JRC's new Director General, has watched the institution now under his care adapt progressively to a far broader role than the one it was initially given. Maybe that role is in some respects too broad. In this interview given to RTD Info, Mr Allgeier explains that the Centre's strategy will be to refocus its work to support European Union policies. Its three watchwords are serving the citizen, enhancing sustainability and underpinning competitiveness.

RTD Info: Why do you think that the time has come to refocus the JRC's strategy?

Herbert Allgeier: I feel it is important to clarify the JRC's mission. Why do we have Commission officials running a research establishment? To answer this question, we have done some hard collective thinking and come forward with the statement that the JRC's mission is to support the conception, implementation and monitoring of EU policies. If that is not our role, then we are not needed.

Herbert Allgeier (centre) during the interview: "Support the conception, implementation and monitoring of EU policies".

Why do EU policy-makers need their own research centre?

We are living in a time when the speed of change is by and large dictated by scientific and technological development. It changes the way we live, the way we work, the way we communicate. Policy-makers have constantly to strike a balance for the benefit of our society as a whole between the interests of the individual, sustainable development and the competitiveness of our industry. They need a source of independent expertise to support them. They cannot rely exclusively on lobbies, or consultants, or even on national laboratories, because different Member States have different interests too. And the Amsterdam Treaty has extended the EU's regulatory competence in many areas - in the environment, energy, consumer protection, international trade and telecoms - making this support all the more necessary. Our strength is that we are a Commission service, we have a dynamic relationship with those who are thinking about the future of Europe. We share their concerns and thinking and we understand the political agenda.

Could you give an example?

In these days more than ever, we have a role right through the life of a policy. In its conception, our mission is to alert decision-makers to challenges and opportunities, and help them to map out policies ahead of time. As regards implementation, let us look at the directive liberalising trade in dangerous chemicals. This requires a procedure, which must be accepted by all Member States, for identifying these chemicals, verifying what industry says, deciding whether additional labelling is necessary and so on. The body that does this must be independent, and its work must be carried out confidentially because of the competitive environment. By undertaking this work, the JRC can help ensure that the internal market works for these products. It's not only a question of the JRC's competence, but also of the credibility of the process.

Serving the citizen is one of the JRC's priorities. Could you explain what this means in practice?

A case in point: we are deeply involved in "mad cow" research. We are developing reference methods, verifying ways of determining whether individual animals are infected, and testing ways of making feedstuffs safely, so that the internal market can function as it should and the consumer is protected. In this way the JRC is able to use its expertise in measurements and testing in the service of EU policy making.

What does this policy-driven approach mean for the JRC's taking part in the Fifth Framework Programme?

Our three objectives - service to the citizen, enhancing sustainability, and underpinning the open market and European competitiveness - give us clear selection criteria for what we do and what we don't do. For every package of work that we do, we have to be clear what problem it is addressing, what policy it is supporting, and who needs the knowledge we are acquiring.

For several years, the JRC also tried to open its activities towards competitive RTD services delivered on the market. Will this openness be maintained?

Competition gives us a motivation, and a scale against which to measure our-

selves. So the concept of competitive actions developed under the Fourth Framework Programme, and the requirement for us to earn 15% of our income from external sources, is helpful. But making money cannot be the objective of an EU-run research establishment. A purely commercial approach would not be consistent with our mission, whereas a reasonable level of competitive activity enables us to check relevance and cost effectiveness and helps to keep us close to other research centres and industry.

In fact, we have suffered some harm as a result of the invitation to take part in certain competitive activities under the Fourth Framework Programme, because research establishments tend to see us as competing for the same pot of money. We now have to convince them that our expertise is complementary to theirs, and that we can add value to joint projects aimed at policy support.

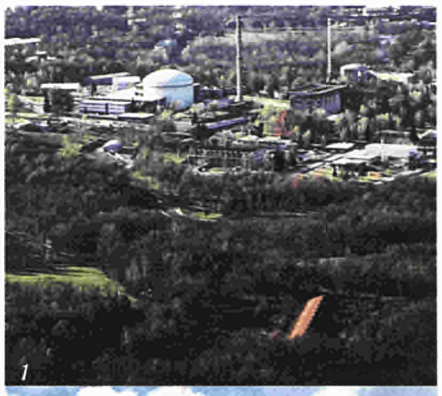
In February, the Council of Ministers proposed a reduction in the JRC's budget to ECU 700 million over five years. Commissioner Cresson said that the JRC couldn't work with that money.

I think that the Council's common position sends the wrong political signal. At a time when we in Europe want to secure high-quality employment, when we are conscious that we live in a knowledge society, it does not make sense to reduce research. In comparison, Japanese law requires a doubling of public investment in research over the next 10 years, and similar trends are occuring in the US. So much for the Framework Programme in general. As for the JRC, the implications of a major budget cut, such as envisaged by the Council, are more serious and even critical. We at the JRC are dealing with costly scientific installations and facilities: ultra clean laboratories, reactors, a microwave signature lab, and so on. At the same time we are facing increased demands in new areas such as consumer protection. As we go through the process of building up customer-contractor relationships requested by the Member States, I think that the demands made of the JRC can only grow, not shrink. And we must be more selective in the work we take on.

One key way in which we can target our resources better is to transfer the cost of routine service activities to other European budgets. We have for instance developed on-site laboratories at Cap la Hague and Sellafield which should be paid for entirely out of other budgets, not the research budget. And the costs of our work on controlling fraud over agricultural set-aside should be borne by the common agricultural policy.

Do you see any other new roles for the JRC?

I see a particular role in promoting technology transfer in areas where market forces do not function, for instance in regional development. Because the solution is not always to imitate the richest region using the same technologies. The JRC should be supporting less favoured regions by providing regional policy-makers with new ideas and our proven understanding of sustainable development for regions. We should be looking not only at technology but also at issues such as legal and fiscal instruments and standardisation. I want to mainstream this approach, piloted by our institute for prospective technological studies at Seville, which I call "technical economic intelligence", and make it the culture of the whole JRC. ■


1


2


3


4

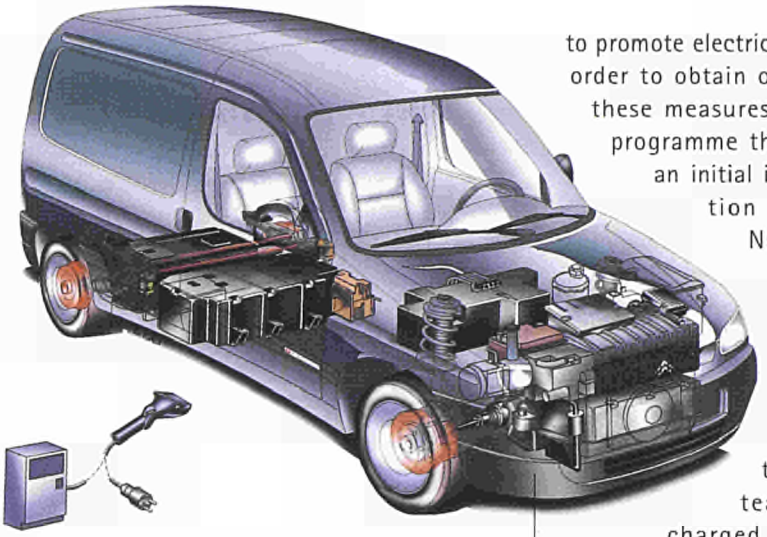

5

The seven JRC Institutes are established at five European sites:
1. Ispra, Italy
(Environment; Space applications; Systems, informatics and safety; Advanced materials)
2. Petten, The Netherlands
(Advanced materials)
3. Geel, Belgium
(Reference materials and measurements)
4. Karlsruhe, Germany
(Transuranium elements)
5. Sevilla, Spain
(Prospective technological studies)

The need for information

The technology of urban electric vehicles has now been perfected, yet potential buyers remain reluctant to make the change. The absence of a common framework for comparing and disseminating information makes it difficult to assess products, performances, prices and the development of energy supply infrastructures. Two European initiatives, supported by the Joule programme, are set to correct this lack of information.

Cars are responsible for more than 50% of hydrocarbon, carbon monoxide and dioxide, and nitrogen oxide (NOx) emissions in urban areas, as well as for the formation of ozone - which over recent years has been reaching warning levels with increasing frequency. They are also the source of a second major nuisance cited by city dwellers as one of the least tolerable factors impairing the quality of life: noise. Yet the alternative for a new age of sustainable urban mobility already exists.



"Clean and safe, but the high price of the batteries still deters potential purchasers".

Clean, silent and conducive to safe and courteous driving, several models of electric vehicles (EVs) are already available on the European market, produced not only by manufacturers of specialist vehicles but also by the major motor companies such as PSA-Peugeot-Citroen, Volkswagen and Fiat. These electric cars have a perfectly acceptable autonomy of 80 to 100 km (the average journey in an urban environment is always under 40 km) and are recognised as being reliable and easy to drive (see box).

Embryonic niche markets

Nevertheless, no more than a derisory 10,855 of Europe's 150 million registered motor vehicles (1997 figures) are electric powered. Most are found in France (3,500), Switzerland (2,500) and Germany (2,200). A large part of these operate within the "captive" fleets of local authorities or private companies. The electric car fleet of a company such as Electricité de France alone consists of 1,000 EVs, or 30% of all electric-powered vehicles in France.

The use of EVs by private car drivers remains at an embryonic stage and the market is showing no signs of picking up. PSA-Peugeot-Citroen, Europe's leading manufacturer of "mass produced" EVs, recorded sales of just 1,400 electric cars in 1996. A figure which it was unable to match in 1997.

Igniting the market

The question is how to ignite a market which is totally at variance with the regulatory measures being taken to combat urban air pollution. The EU has adopted directives which will impose a sharp reduction in harmful vehicle emissions from the beginning of the new millennium. Many countries are preparing for this and stepping up - but in random order - research, testing, demonstrations and pilot experiments to promote electric-powered vehicles. In order to obtain optimal benefit from these measures, under the Joule II programme the EU has supported an initial initiative: Collaboration between CEC and National Programmes on Electric Vehicles in Europe [1]. This brings together about 30 organisations involved in promoting this sector as well as six teams of experts charged with looking at all aspects of the EV issue.

The researchers first gathered the results obtained in a series of some 70 European tests carried out on more than 1,700 vehicles. On the basis of this information, a task force of European experts was able to define standardised test procedures. Other groups studied the market context in which EVs are being launched: the development of infrastructures - in particular the crucial question of recharging batteries; legal, economic and psychological obstacles to EVs and how to correct them; and strategies for winning new market segments, especially in the field of captive public or private fleets.

The researchers working on this programme propose that "the public authorities should provide incentives in an attempt to overcome certain technological and economic barriers in order to persuade manufacturers and consumers that the electric car is the vehicle of the future." The concrete measures proposed include support for battery hire schemes (proportionally the most expensive component of the vehicle), the awarding of purchasing premiums,

A charging point - essential infrastructure for market growth.

reduced VAT and other taxes, lower insurance premiums (given the lower speed), and the imposition of EV quotas in public sector fleets, etc.

Making it easier to choose an EV

Following this initial phase of assessing the situation and introducing genuine European coordination in favour of EVs, European cooperation is set to continue through the new MATADOR project, supported by Joule [2]. "This second stage is aimed at providing decision-makers in the public and private sector with a decision-making tool," explains Bernardus van Spanje of the Netherlands Environment Agency (NOVEM), which runs the European coordination network. "While continuing to develop the database content, we are preparing a genuine expert system able to analyse technical information and to define the technical, energy, environmental and economic performance of electric vehicles compared to traditional cars or cars using other technologies."

Although more advantageous in the long term, battery-powered electric vehicles are in fact just one of a number of alternatives for less polluting vehicles. Light vehicles with smaller engines, alternative fuels (liquefied petroleum gas, natural gas, etc.), hybrid vehicles (electric + internal combustion) and EVs with fuel cells are all potential solutions. The MATADOR project will be looking at all of these with the aim of stimulating the market in the short term and increasing awareness of what EVs have to offer.

A study of the international situation shows that more is involved with the electric car than environmental aspects alone: European competitiveness is also very much at stake. Certain manufacturers, especially in France, are ready to respond to this challenge. Experts from the cooperative network supported by Joule believe that Europe is suffering above all from failing to come out firmly in favour of the electric vehicle, as certain of the largest US states have done, California for example. Similarly, the long-term strategy adopted by the Japanese government and motor industry could make Japan the leader in this sector within just a few years. ■

(1) Project JOU2-CT94-0291
(2) Management Tool for the Assessment of Driveline Technologies and Research, Project PL97-0200

Contact Bernardus van Spanje, NOVEM,
The Netherlands
Tel. : +31 30 239 34 21
Fax : +31 30 231 64 91
Internet :
www.ecn.nl/unit_bs/ev/index.html

What do drivers think ?

A study carried out at the 1996 Brussels motor show showed that, although reluctant at first, most visitors appreciated the virtues of an EV after a test drive. The principal motivation for possibly changing to an EV was concern for the environment, although drivers also liked the fact that these vehicles are so easy to drive. The main source of dissatisfaction was not the speed (limited to 90 km an hour) or the autonomy (under 100 km), both of which were deemed sufficient for urban driving, but the reliability of the batteries and the possibility of electrical problems, coupled with inadequate after-sales service. Although the running costs (servicing + fuel) of an EV are lower than for a traditional vehicle, with a purchase price which is almost double that of another car a major barrier certainly remains - even if certain projections indicate that EVs can be more economical in the longer term.
Also, it is not enough simply to launch electric vehicles on the market. The infrastructures - charging points and the necessary skills at garages and service stations, etc. - must follow.

News in Brief

EUROPEAN RTD POLICY

Fifth Framework Programme: more efficient management - "This meeting shows the importance the Council attaches to ensuring that European research funds are used effectively and to providing our researchers with a user-friendly system that is efficiently run", stated the UK minister John Battle, president of the Research Council, at a special meeting held last April to examine strategies for improving the management of the Fifth RTD Framework Programme. The new management approach proposed includes:

- Regular *benchmarking* in order to compare the Commission's performance with that of other research organisations. In this connection, Edith Cresson presented the conclusions of a recent study of staff and administrative costs, carried out by Andersen Consulting, which shows that the Commission's costs compare favourably with other national and international research organisations.
- Greater involvement by scientists, industrialists, and users in implementing the programmes. A meeting will be held of the Commission's advisory bodies covering academic research (ESTA) and industrial research (IRDAC). External advisory groups will also be set up and charged with submitting public advice on the general direction and research priorities for key programme areas.
- Improved transparency and simplified procedures. (PR - 29/4/98)

http://www.cordis.lu/uk/en/src/report.htm

An integrated RTD policy in the less-favoured regions - "*Cohesion, competitiveness and RTD & Innovation*". The Commission recommends that the EU should focus on these four elements in taking up the essential challenge facing regional policy in the years 2000-2006, namely to create jobs and provide sustainable development in Europe's less-favoured regions. These areas must participate in the dynamic of developing knowledge and competitiveness.

The Commission Communication [1] stresses that training, research and innovation must increasingly permeate through to the manufacturing fabric of regions in difficulty. These three priorities must therefore be central to the joint interventions of the Structural Funds and the RTD Framework Programme. One of the key objectives of European support will be to help regional players to initiate and develop integrated research and innovation strategies adapted to their know-how and resources.

(1) COM(98)275

Contact : H. Logue

Fax : +33 2 29 60 56 60

Programme addresses on EUROPA and CORDIS

the "EUROPA-12" and "CORDIS" Internet addresses given for the various programmes referred to in the following three pages should all be prefixed as follows:

For EUROPA-12: http://europa.eu.int/comm/dg12/

For CORDIS: http://www.cordis.lu/

Reference to DG XII press releases

Information bearing the reference PR + DATE is also available as a press release on EUROPA-12: press.html

Fax: +32-2-295.82.20.

Publications

Publications listed where the EUR number is followed by an asterisk * are subject to charges and can be ordered from the OOPEC - Fax: +352-48.85.73. Other publications can be obtained from the programmes concerned.

EU at Expo'98

The European Union's Pavilion at Expo 98 in Lisbon is expecting some one million visitors by 30/09/98. Located at the base of the three-storey Vasco de Gama panoramic tower, in a boat-shaped building projecting 60 metres into the River Tagus, every aspect of the EU's marine activities are on display - marine research, developing sustainable fisheries, new shipbuilding technologies, advanced communication at sea, and maritime safety. In the Inventing Tomorrow thematic space, visitors can discover marine RTD - through audio-visual interactive technologies - in the areas of climate change forecasting, energy, coastal preservation, combating marine pollution, exploration of the ocean abysses, the design of new high-speed ships and more. A number of scientific events will be held throughout the Expo, either in the Pavilion itself or at other locations in Lisbon (see our "Diary" Information in the RTD Programmes news).

Internet: http://europa.eu.int/expo98/en/inventing.html

Women and science: The results of the European conference - "To forego the intellectual potential of half the population is simply absurd," Edith Cresson told 400 women (and a few men) who attended the "Women and Science" conference organised by the Commission and European Parliament in Brussels on 28 and 29 April.

The Commission proposed that a "Women and Science" observatory and European network should be established. The aim of these two initiatives will be to:

- establish precise statistics on the position of women scientists;
- continually assess the presence of women on European research projects;
- increase awareness of equal opportunities among scientists and politicians at the Commission and in the Member States. (PR - 29/4/98)

See also "Against an apartheid of the sexes", a reader's response to the article published in RTD Info 18.

"Mad cow" disease: 22 new European research projects are launched - Assessing the risks of transmission to man, identifying the role and structure of the "prion", and implementing new approaches to treatment are just some of the

subjects covered by the 22 new research projects on bovine spongiform encephalopathy (BSE). The projects, which the European Commission has just adopted following an initial joint call for proposals launched by the BIOMED, BIOTECH and FAIR programmes, have a total budget of nearly ECU 21.9 million. (PR- 24/2/98).

Diary

■ *'Research, Technology, Innovation: their role in Economic Development. Regional Partnership as Catalysts'* - 30/6-1/7/98 - Cardiff (UK) - Hugh Jones - Fax: +44 1970 622063 - Internet: http://www.aber.ac.uk/~mvj/conference/

■ *4th annual conference of the European Association of Research Managers and Administrators (EARMA)* - 3-4/7/98 - Dublin. On the programme: university/industry relations and optimising the research potential, with special emphasis on the future policy and direction of European research. E-mail: EARMA@incentive-conf.ie

■ *The culture of science and technology - Europe and the planet* - 1-3/10/98 - Lisbon. Conference organised by the European Association for the Study of Science and Technology (EASST), with the support of the European Commission (DG XII) and the Fundaçao Portuguesa para a Ciência e Tecnologia. This interdisciplinary meeting will cover subjects such as: the involvement of experts and the public in decision-making; science, law and ethics; the reality and significance of the virtual society; space, environment and mobility; the history and theory of science and technology. E-mail: EASST98@iscte.pt

Information Technologies (ESPRIT)

Fax: +32-2-296.83.88
E-mail: esprit@dg3.cec.be
CORDIS: esprit/home.html

Diary

■ *HPN 98 - 8th conference on the management of high performance networks* - 21-25/9/98 - Vienna - Organisation: International Federation of Information Processors (IFIP)

Industrial Materials and Technologies (Brite-EuRam)

Fax: +32-2-296.67.57
+32-2-295.80.46
E-mail:
imt-helpdesk@dg12.cec.be
EUROPA: br-eur1.html
CORDIS: brite-euram/home.html

Diary

■ *Electric Vehicle Symposium* - 31/9-3/10/98 - Brussels

Publication

■ *"Europe's research at the service of its people - main conclusions of the Conference on Industrial Technologies, Toulouse, 27-30 October 1997"* - CG56-98-P01-EN-C.

Standards, Measurements and Testing (SMT)

Fax: +32-2-295.80.72
E-mail:
smt-helpdesk@dg12.cec.be
EUROPA-12: bcr1.html
CORDIS: smt/home.html

Results of the last call for proposals - 71 new projects have been selected (46 research projects, 14 thematic networks and 11 accompanying measures). The contracts are being negotiated.

Training

■ *Quality Assurance for Chemical analysis (QUACHA)- September- November 98* - In five Member States (Spain, France, Greece, Italy, Portugal), the SMT programme is organising training for scientific managers at laboratories situated in outlying regions in order to allow them to be included in a harmonised approach to current EU practices. A manual summarising these training sessions will also be published in the 5 languages of the countries participating in this initiative. Information: see *Measurements and Testing Newsletter* (vol.6, N1), June 98 issue.

Publication

■ *Microbiological Analysis of Food and Water - Guidelines for Quality Assurance* - Lightfoot N.G. and Maier E.A. Eds., Elsevier, Amsterdam, ISBN: 0-444-82911-3 (1998)

Environment & Climate

Fax: +32-2-295.20.97
E-mail:
environ-infodesk@dg12.cec.be
EUROPA-12: envir1.html

Earth observation by satellite - The last call for proposals, which closed in October 97, produced 24 proposals for research projects, 7 of which have been selected and will receive total financing of ECU 13.6 million. The projects relate to forest fire monitoring, management of the plant and agricultural environment, and the study of chemical phenomena in the atmosphere in relation to climate change. (PR - 13/3/98)

Diary

■ *INTECOL 98: New tasks for ecologists after Rio '92* - 19-25/7/98 - Florence (I). 7th

Against apartheid of the sexes

The Women in science, women and science article (RTD Info 18) prompted a response from a British scientist, Ms Julia Stegemann, of the Imperial College of Science, Technology and Medicine (London).

"I would like to protest against the emphasis of the article, as introduced by the statements that "*women ... bring a specific approach and sensitivity ... A more active involvement of women in research will not only add to the available skills, but also broaden the content*", and continued with statements such as "*The feminist view ... is that women approach the world - and thus the object of their research - in a manner which is both emotional and intellectual ...*".

It is a source of continual amazement to me that reputable publications such as yours consider it acceptable to perpetuate a view of women as being "equal but different", which is essentially the same as apartheid, based on sex rather than race. It is no more fair to categorise women in general with positive adjectives such as sensitive, emotional, broad-minded and socially skilled (and by obvious extension, men in general as insensitive, unemotional, narrow-minded and socially inept), than to say that women are illogical, irrational, hypersensitive, have poor maths skills, or any other of the negative characterisations which have traditionally been misapplied.

I am sure we all know both men and women to whom any of these descriptions could be applied. Whether we would apply them to equal numbers of males and females of our acquaintance is a subjective question, and if the numbers were unequal could we say definitively whether biological or social factors were responsible? Even if it were possible to conduct research to show scientifically that, on average, women are (for example) more sensitive than men, and that this has an innate biological basis, what purpose would be served? Observation of the world around us shows that the range of human characteristics and behaviours is wide. To allow equal opportunities for everyone, we must be free from prejudices, and take individuals as we find them.

** This letter provides an opportunity to open up the pages of RTD Info to our readers who are invited to submit their opinions, reactions, questions, suggestions, etc. to the editors.*

International Congress on Ecology, organised by the International Ecology Association (INTECOL).
Internet: www.tamnet.it/intecol98/index.htm

■ *Earth observation - The applications of observations of the oceans and coastlines* - 2-3/7/98 - Lisbon - Seminars organised by the Earth Observation Centre, managed by the JRC. On the programme: the state of the seas - oceans and climate - monitoring ice fields - the proliferation of algae - pollution by hydrocarbons - coastal areas.
Internet: www.ceo.org/

■ *2nd International Conference on Climate and Water* - 28/8-5/9/98 - Espoo (FI).

■ *European symposium on sustainable regional development* - 28-30/10/98 - Graz (A).

■ *Environmental change: valuation methods and sustainability indicators* - 28/8/-5/9/98 - Sienna (I).

Publication

■ Impact of Endocrine Disrupters on Human Health and Wildlife - Report on the European seminar held in December 1996 - EUR 17549

Marine Science and Technologies (MAST)

Fax: +32-2-296.30.24
E-mail: mast-info@dg12.cec.be
EUROPA-12: marine1.html
CORDIS: mast/home.html

Diary

■ *2nd annual ELOISE (European Land Ocean Interaction Studies) Conference* - 30/9-3/10/98 - Huelva (E) - (see also publication below).

■ *OCEANS '98 Conference* - 28/9-1/1098 - Nice (F)

■ *European Climate Science Conference* - 19-23/10/98 - Vienna - Assessment of research carried out under the 120 European projects supported by the E&C programme.

■ *Symposium Marine Benthic Dynamics: Environmental and Fisheries Impact*, 5-7/10/98 - Iraklion (Crete)

■ *6th International Paleoceanography Conference* - 23-28/8/98, Lisbon

■ *3rd Workshop of the Mediterranean Targeted Project* - 15-17/10/98, Rhodes (GR)

Publications

■ *Project synopses (Volume 2) - Coastal Ecosystems (ELOISE)** - EUR 17785 EN; ISBN 92-828-2312-1

■ *Air-Sea Exchange: Processes and modelling* - EUR 17660 EN; ISBN 92-828-2577-9

Biotechnology (BIOTECH)

Fax: +32-2-299.18.60
E-mail: life-biotech@dg12.cec.be
EUROPA-12: biot1.html
CORDIS: biotech/home.html

Publication

■ *Ethical, legal and social aspects of life sciences in FP-4C* - Catalogue of ELSA projects.

■ *Biotechnology (1992-1994) - Final Report* - Final results of 133 projects which received global funding of ECU 158 million during this period.

■ *Biotechnology (1994-98) - Progress Report* - A review of 60 projects launched under the Biotech 2 programme.

Agriculture and Fishing (FAIR)

Fax: +32-2-296.43.22
E-mail: life-fair@dg12.cec.be
EUROPA-12: agro1.html
CORDIS: fair/home.html

Diary

■ *European research towards safer and better food (3rd Nutrition Symposium)* - 12-20810/98 - Karlsruhe (D)

Non-nuclear Energy (JOULE)

Fax: +32-2-296.68.82
E-mail: helpline-energy@dg12.cec.be
EUROPA-12: joule1.html
CORDIS: joule/home.html

Diary

■ *Third European wave energy conference* - 30/9-2/10/98 - Patras (GR)
The latest scientific RTD developments are to be presented. This provides the participants at the conference with the opportunity of taking part in an exchange of experience and of making critical remarks.

Publication

■ *Financial assistance by the European Communities to the energy sector from 1995 to 1997* - COM(1998) 244 - ISBN 92-78-35275-6 - This recent communication by the European Commission, which reports on developments in EU policy in the energy sector since 1995, shows that more than a third of European funding (ECU 1.9 billion out of 4.7 billion) is allocated to the JOULE and THERMIE programme's research and demonstration projects. The communication also analyses interventions in favour of the energy sector under the Structural Funds, international cooperation and the European Investment Bank.

■ *Joule: 20 examples of projects* - EUR 18020 - ISBN 92-828-2314-8

Nuclear Fusion

Fax: +32-2- 296.42.52
EUROPA: fusion1.html

Diary

■ *International conference on*

A new look for "Euroabstracts" - "Euroabstracts", the review of publications on Community R&D published every other month by the European Commission's Innovation programme, is one of the Commission's oldest magazines, first published more than 30 years ago. In April it got a new look, in terms of form and content. The change was prompted by the fact that the traditional abstracts of all the EU-generated research publications are now more quickly and easily available on the CORDIS Website. The re-launched magazine will therefore focus on a more in-depth analysis of a number of key publications concentrated in strategic areas of the EU's research policy.
The June issue gives extensive coverage to the publication of the 2nd report on S&T indicators in Europe.

Contact : Fax : +352-4301-32084
E-mail : RTD-helpdesk@lux.dg13.cec.be
Cordis : euroabstracts/en/home.html

Cordis Rapidus, home delivery

Are you interested in certain items of information on European RTD? CORDIS *RAPIDUS* is a free and easy-to-use service available on the Cordis server, the on-line database of EU programmes and initiatives in the field of RTD.
When making any search on the Internet site **www.cordis.lu**, all the criteria selected can be memorised by clicking on the "*Store Search*" option. The *RAPIDUS* service will then send you a personal e-mail as soon as any additional information corresponding to your "search profile" becomes available.

E-mail: helpdesk@cordis.lu

fusion energy - 18-24/10/98 - Yokohoma - Japan

International Cooperation (INCO)

Fax Helpdesk: +32-2-296.59.36
E-mail: inco-desk@dg12.cec.be
EUROPA-12: intco1.html
CORDIS: inco/home.html

Central and Eastern Europe - 204 new S&T cooperation projects - Improving the quality of life and of the environment, seeking new production processes applicable to Central and Eastern European countries, analysing socio-economic questions such as drug use. These are just some of the subjects of 204 new projects selected following the call for proposals which closed in October 1997. The budget for this new research period is ECU 46 million. (PR - 7/4/98)

Diary

■ *The potential of Research and Technological Development in Structural Support Schemes for the Enlargement of the European Union* - 13-15/9/98 - Budapest - Dr. Nandor Eber - E-mail: eber@power.szfki.kfki.hu

■ *Interdisciplinary ACP-EU Fisheries Research Workshops - Expo'98 Lisbon* - "Trophic relations in the oceans and economic productivity" (1-3/7/98) - "Integrated coastal zone management" (13-17/7/98) - "Sustainable use of biodiversity" 3-5/9/98

Targeted Socio-Economic Research (TSER)

Fax: +32-2-296.21.37
E-mail: tser-secr@dg12.cec.be
EUROPA-12: tser1.html
CORDIS: tser/home.html

Diary

■ *2nd International Conference on Technology Policy and Innovation* - 03-05/8/98 - Lisbon

■ *EASST'98 - European Association for the Study of Science and Technology - General Conference* - 1-3/10/98 - Lisbon

ETAN

Publication

■ *The ageing population and technologies: challenges and opportunities* - Report and minutes of the ETAN (European Technology Assessment Network) seminar of 7/5/98.

Training and Mobility of Researchers (TMR)

Fax: +32-2-296.32.70
E-mail: tmr-info@dg12.cec.be
EUROPA-12: tmr1.html
CORDIS: tmr/home.html

Diary

10th European Union Contest for Young Scientists - 21-26/9/98 - Porto (P) - To detect talents, reinforce vocations and intensify scientific culture throughout Europe. These are the objectives of this annual international competition, open to young people aged 15 to 20, which allows winners of the national competitions held in 30 European countries to defend their projects - in a wide range of scientific fields - before a panel of top-level scientists, in an atmosphere which is both rigorous and relaxed.

■ *Conferences on European research (EURESCO)* - The European Science Foundation (ESF) has published a programme updated to October 1998 on meetings devoted to a wide range of scientific fields (physics, chemistry, materials, biology, biomedicine, environment and earth sciences, human sciences). These are organised with the support of the "Euroconferences" under the TMR programme. The conference is open to researchers worldwide. Young scientists, especially those from Europe's less-favoured regions, are eligible for grants to allow them to attend.
Internet: www.esf.org/euresco/

Ongoing/Upcoming calls for proposals

(from 1 July 1998)

Programmes (and contacts)	Publication	Deadlines	Areas (and specific contacts)
STANDARDS, MEASUREMENTS & TESTING *CONTACT :* Wiktor Raldow Fax : +32-2-295.80.72	15.6.95	30.7.98	Open call for support & accompanying measures.
BIOTECHNOLOGy E-mail : life-biotech@dg12.cec.be	17.12.96	15.9.98	Advanced practical workshops. *CONTACT :* Alessio Vassarotti - Fax : +32-2-299.18.60

Marie Curie Research Training Grants

Post-graduate, post-doctoral and return grants for researchers
INFORMATION ON INTERNET: http://www.cordis.lu/tmr/home.html

STANDARDS, MEASUREMENTS & TESTING	15.12.95	1.9.98	*Wiktor Raldow - Fax : +32-2-295.80.72*
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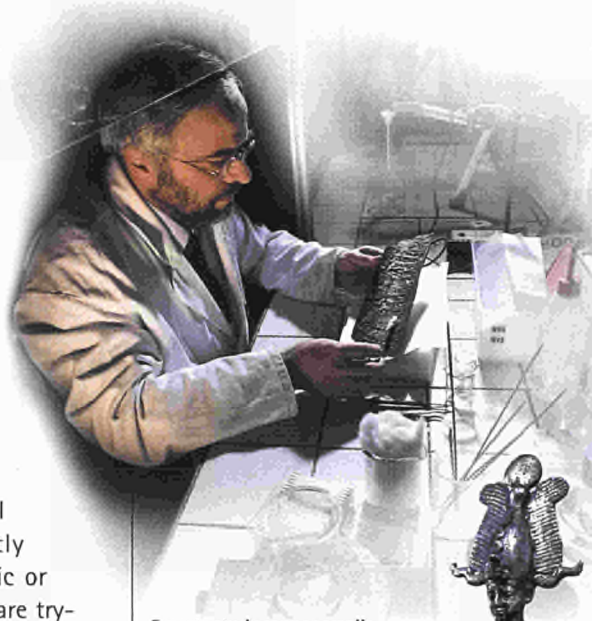
The secrets of alloys

Archaeologists too are interested in reference materials. By analysing thousands of objects from the Bronze Age, Iron Age and Roman times we can determine the composition of the alloys used by these civilisations. The samples developed on the basis of this information can then make it possible to increase our knowledge of these ancient objects and improve the methods used to conserve them.

How, in the major civilisations of the past which practised metal-working techniques, did the craftsmen prepare their alloys? This technical question yields historical answers which tell us a great deal about the know-how of lost civilisations and the transfer of skills within and between these societies. "The proportions of the various components vary widely, according to the production methods used - depending on whether the metal was simply cast or subsequently forged - and the desired aesthetic or mechanical result. Archaeologists are trying to determine the empirical know-how of these antique metal-workers," explains Philippe Brunella, a researcher at the European Archaeological Park of Bliesbruck-Reinheim (France/Germany).

The experts have long been fascinated by this question. Starting in the 1960s, spectrometry and microscopic observations provided them with the beginnings of an answer. But these analyses are incomplete and not very systematic. "The methods used are not clear, the nature of the samples - such as whether or not it is a modified material - is not specified, and the archaeological context is not given. This is why scientists felt the need to obtain certified reference materials," explains Michel Wuttmann, a researcher at the Institut Français d'Archéologie Orientale du Caire (IFAO).



Experts study copper scrolls from the Dead Sea at the EDF-Valectra laboratory. ©X.Renauld - EDF-Valectra

A bronze and lead statue of Osiris (around 450 AD) discovered in Ayn-Manâwir. This was studied during the first phase of the IMMACO project.

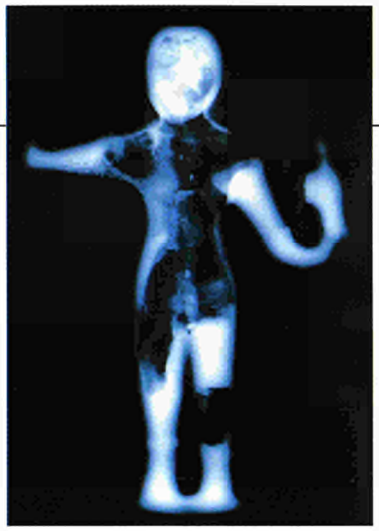
Analysing the analyses

The IFAO is coordinating the IMMACO (Improvement of Means of Measurement on Archaeological Copper-Alloys for Characterization and Conservation) project, supported by the Standards, Measurements and Testing programme, on which seven partners from four European countries are working [1]. Their aim is to establish reference standards which are representative of all the objects handed down from history's major metal-working civilisations.

But what must be certified? "It was necessary to determine both the number of materials and their composition in order to cover all the alloys produced between the time when metal-working first appeared and the end of Roman times." (Michel Wuttmann). This first phase of the project (1996-1999) is being conducted by the IFAO and researchers from the EDF-Valectra laboratory [2]. "A vast bibliographical study allowed us to examine all the analyses made on copper-based metal objects from three periods - the Bronze Age, the Iron Age, and Roman times - and four countries - France, Germany, Greece and Italy. The research led to the selection of 3596 results of recent chemical or physio-chemical analyses. This statistical study allowed us to draw up, for each of the countries, tables giving the compositions of alloys for the purposes of standardisation," explains Noël Lacoudre, manager of the EDF-Valectra laboratory. It was this laboratory which carried out a "physical" analysis of 15 objects from the Gallo-Roman site of Bliesbruck-Reinheim. "These were items which it was acceptable to sacrifice. There were cut up in order analyse the metal composition and corrosion products" (Philippe Brunella).

From Europe to Egypt

The IFAO also carried out other analyses of Egyptian objects from the Old and New Kingdoms. These analyses increased the geographical and historical range covered, and thus the potential users of the certified materials. "Metal-working techniques spread widely during the Bronze Age, in particular in the eastern Mediterranean, and a great many Egyptian objects are to be found in European museums. Archaeological research into these civilisations is also a field in which European institutions have been involved since the very beginning," (Michel Wuttman). The analysis of these objects supported the choice of five copper alloys made by the Valectra laboratory and pro-



Figurine decorating a bronze brazier found at the Mafraq site (Jordan) - 8th century. X-ray and object after restoration. ©X.Renauld - EDF-Valectra

posed for certification.

On the basis of this information, a team from the Institute of Reference Measures and Materials (IRMM) at the Joint Research Centre in Geel (Belgium) was charged with manufacturing samples which would subsequently serve as certified materials. Chris Ingelbrecht, project manager at the IRMM, explains that the "principal difficulty lay in the fact that these alloys no longer exist today. For example, arsenic, a dangerous substance, is no longer used, so we developed an innovative system to reintroduce elements and reconstitute these materials."

Measuring, conserving and restoring

In addition to certifying reference materials, the IMMACO project also compiled a genuine guide to "good analytical practices". This tool will permit systematic composition analyses which can also be carried out at archaeological sites using portable instruments. "Archaeologists will thus be able to gather a very large number of more reliable measurements. This will give us correct statistics on alloy composition and at that point we will be speaking the same language," (Philippe Brunella).

Another far from insignificant result of the painstaking work of standardisation will be to provide conservation and restoration experts with new precision tools. Certain chemical or electrochemical methods used to repair the effects of corrosion are disputed due to the lack of control over the reactions produced on the surface of the object.

"Part of the project is devoted to the production of patina on reference materials, based on the study of the patina found on archaeological objects. Different methods can be tested which would be impossible to carry out on the original items," explains Noël Lacoudre. "This processing will answer a number of questions concerning conservation, in particular the problem of the migration of various elements from the metal to the periphery. The IMMACO project not only permits an increased knowledge in the field of archaeology, but also aims to improve the conservation of an important heritage." ■

(1) Laboratoire de restauration de l'Institut Français d'Archéologie Orientale - Le Caire (France), Laboratoire EDF-VALECTRA (France), Laboratoire d'Etudes de la Corrosion de l'Ecole Nationale Supérieure de Chimie de Paris (France), Universitaire Instelling Antwerpen - MITAC (Belgium), Technische Universität Wien (Austria), Institute for Reference Materials and Measurements of the Joint Research Centre of the European Community (Geel/Belgium) and, as an associated partner, the SEK - Europäischer Kulturpark Bliesbruck-Reinheim (Germany).
(2) Belonging to Electricité de France (EDF), this laboratory is specialised in the conservation and preservation of ancient metal objects and is a frequent patron of scientific and technical projects

The metal "road"

Copper was worked a long time before gold. The earliest objects, produced by cold-hammering techniques, were found in Anatolia, in western Iran, and date back to the 9th millennium BC, but it is another 2,000 years before we see the beginning of metallurgical techniques which require ovens reaching a temperature of over 1000°C. In around 6,500 BC, centres appeared in Anatolia and Mesopotamia. In around 4,500 BC, copper objects were produced in the Balkans, the technique later spreading west through the Mediterranean and along the Danube valley.

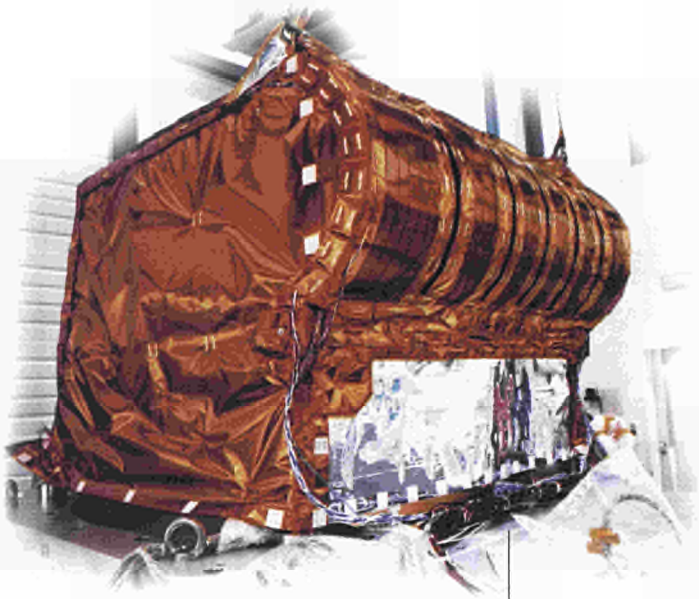
The progress in metal-working techniques came from the development of alloys. When another component is added to copper, the metal becomes more resistant and is also easier to shape or to melt at a lower temperature. Arsenic was the first ingredient to be added. This was later replaced by tin, to produce bronze. The Bronze Age thus began in France in the year 2000 BC. Bronze allowed high quality weapons to be produced and the craftsmen were employed in the service of warriors. In the first millennium BC, when it seemed to be difficult to obtain copper and tin, lead was used to produce alloys. This led to the Iron Age, which appeared in Europe around 1 200 BC and reached its apogee during the Hallstatt civilisation (Austria) in around 700 BC before spreading to Central and Western Europe.

It is this iron civilisation which was conquered by the Romans. Iron became the metal used in making weapons and tools, while bronze continued to be used for more refined objects and jewellery.

Vegetation, a "green" eye for SPOT

As the first system specifically designed to observe the Earth's vegetation cover, VEGETATION opens up new opportunities to study, protect, and manage the vegetal biosphere. Benefiting from substantial EU funding, the VEGETATION sensor was launched aboard the SPOT 4 satellite with the mission to send back "standard products" in line with users' demand. The programme reaffirms the importance of European space expertise.

The SPOT 4 satellite was launched on 24 March 1998 in Kourou, French Guyana, with the *Vegetation* sensor on board. A week later, *Vegetation* was sending back its first images. Previously, US satellites [1] with observation systems designed for meteorologists had been the only ones to provide a global view of the Earth's forests and crops. With the implementation of the *Vegetation* programme, Europeans have developed an instrument specifically designed to monitor the Earth's plant life by making full use of the many possibilities offered by the orbiting SPOT platform.



The Vegetation instrument being tested at Aérospatiale

European involvement

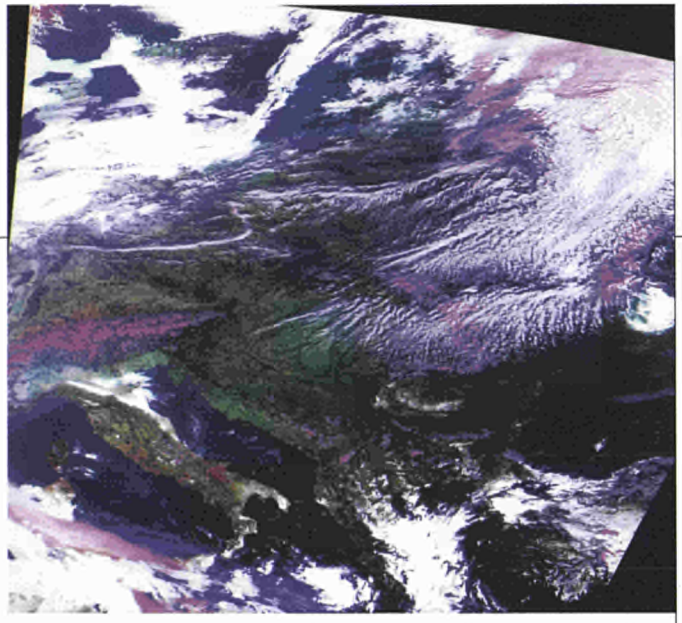
Five partners worked on the *Vegetation* project: the Centre National d'Etudes Spatiales (CNES) in France - the project leader - the Services Fédéraux des Affaires Scientifiques, Techniques et Culturelles (SSTC) in Belgium, the Agenzia Spatiale Italiana (ASI) in Italy, the Swedish National Space Board (SNSB) and the European Commission. "*Vegetation* is part of the Commission's drive to lend new impetus to the Earth observation market by developing operational applications which meet users' needs," explains Michel Schouppe, the scientific officer responsible in DGXII. "Such a programme needed a financial investment, research effort and pooling of infrastructures and industrial know-how to a degree which would have been impossible without European support."

The 46% (ECU 51 million) Commission financing for *Vegetation* demonstrates Europe's commitment to Earth observation - which received funding of ECU 275 million between 1995 and 1998 - and its desire to develop its role as a catalyst in this field further. *Vegetation* reinforces the European expertise developed during projects such as *Fuego* and *Megafires* (fire detection and risk zone studies in the Mediterranean region), FIRS and TREES (cartography of coniferous and tropical forests) and MARS (operational monitoring of European crops and the decline of harvests), with the support of the Space Applications Institute (SAI) at the Commission's Joint Research Centre at Ispra.

User participation

Vegetation was specifically designed to provide "image products" (see box) which satisfy the demands of the many organisations involved in the sustainable management of the Earth's plant life. Their needs were relayed through an International User Committee including representatives of international organisations - such as the FAO - and global programmes - such as the International Geosphere Biosphere Programme.

"The *Vegetation* specifications were drawn up on the basis of the needs of fundamental research teams working on the functioning of major ecosystems, environmental change and the impact of human activities, and much more pragmatic applications, such as controlling forest fires or forecasting agricultural production," explains Gilbert Saint, head of the *Vegetation* mission at the CNES. "Although they are all studying the same biophysical phenomena, the scientists can generally use less-operational data than are required by bodies interested in the status or forecasting of stocks. Also, as such data are intended for global users, the specifications had to conform as much as possible to existing international image archives."



31.3.98. The first - historic - image obtained using data supplied by Vegetation.

A *Preparatory programme for the use of Vegetation products* has been set up, following a call for proposals, in order to improve the processing algorithms for the *Vegetation* data, define innovative products, identify potential fields of application and stimulate the interest of the widest possible community of users.

The ground component

The *Vegetation* system includes an important *ground component* for the reception and preparation of products: the *Vegetation* programming centre in Toulouse (F), the receiving station in Kiruna (S) and the image processing centre (CTIV) in Mol (B). "This centralised ground component brings major benefits. It permits the systematic archiving and processing of the entire global cover. A daily synthesis is produced in Mol, which serves as a basis for a 10-day synthesis," explains Michel Verbauwhede, member of the SSTC space division in Belgium.

The CTIV is able to process and deliver to users in under three days the products ordered by subscription. A European consortium formed by Nuova Telespazio (I), Satellitbild (S), CLEO (B) and SPOTImage (F) is responsible for the worldwide marketing of the *Vegetation* data. "Access to the data overviews is also very rapid," points out Gilbert Saint. "Whereas in the United States the USGS gathers data received by about 40 stations for processing purposes - which is going to take some time because in 1998 the summaries of data acquired in 1996 are only just becoming available."

The information provided by *Vegetation* also guarantees European autonomy. "For the Commission, *Vegetation* represents an independent information source which can support its sectoral policies - whether in assisting agricultural production and reform, forest management, environmental monitoring, regional development, preparing the data necessary for drawing up international agreements, or implementing international emergency food aid," explains Michel Schouppe.

The added value of the Vegetation products

Spatial resolution - The present state of detector technology, with the detectors arranged in a line on a small bar, makes it possible to reduce the geometric distortions observable at the edges of the image considerably and to maintain the spatial resolution of 1.15 km (resolution variations ranging from 1 km to more than 6 km are observable in AVHRR images). The localisation of each pixel is very precise - 300 metres dispersion in the course of one year. The analysis of a series of measurements of a given geographical point, taken over a specific period of time, is therefore based on reliable spatial data.

Four spectral bands - In addition to the two traditional spectral bands of red and near infrared (which give indications of photosynthetic activity), medium infrared and blue are now included.

The radiometric resolution has been adapted in order to measure variations linked to ground use - and not only the major contrasts which meteorologists need. Medium infrared, which is sensitive to the water content of soils and plants, is able to detect humidity and cover structure. The blue was mainly added in order to obtain better atmospheric corrections - and secondarily for certain oceanic applications. This band also provides opportunities for soil cartography and the monitoring of desertification.

The linking of resolutions - *Vegetation* works at two levels. Its low-resolution data (each pixel represents 1x1km^2) can be combined with those of other high-resolution SPOT 4 instruments (HRVIR - High Resolution Visible Infrared) which are able to observe details of 10 to 20 cm. This linking of low- and high-resolution images taken simultaneously from the same platform permits a finer analysis. "A zoom effect with the high resolution and the same spectral bands makes it possible to describe better virtually every *Vegetation* pixel. We can therefore understand why such a measurement changes over time depending on the diversity of the soil use," explains Gilbert Saint. Conversely, *Vegetation* makes it possible to make up for the low frequency of the high resolution which only permits a few images a year - between three and five in Europe.

VEGETATION 2

Following a call for proposals by the European Commission, a *Vegetation 2* research project is now being launched in order to improve the products and services offered to users and to bring technological innovations to the mark 2 version. "SPOT-type satellites have a life of about five years. The next version of *Vegetation* will be the opportunity to respond to a constantly changing demand," continues Michel Schouppe. "Different areas of the economy are at present being polled in order to identify their exact satellite information needs and thus in future supply data which are increasingly relevant to the new types of user."

Worth noting is the fact is that the European Commission's financial contribution to *Vegetation 2* - which will be developed with financial participation of industry - will be much reduced. This reflects industry's growing interest in very high-level scientific and technological investments in an up-and-coming field offering the prospect of a fast-growing market for applications. ■

(1) Of the AVHRR (Advanced Very High-Resolution Radiometer) type fitted to NOAA (National Oceanic and Atmospheric Administration) satellites.

Tailor-made products

Vegetation supplies its data in two forms: primary products (VGT-P) and synthesised products (VGT-S). The former relate to a measurement taken when the instrument passes a certain point. The latter select, within a given period (one day or 10 days), the best measurement from those available at a given geographical point.

"The method currently used for synthesised products results from tests using traditional AVHRR data," explains Gilbert Saint. "We are waiting to receive sufficient Vegetation data to validate new methods using blue and medium-infrared bands in particular."

The 10-day overview seems sufficient to determine the development of vegetation. But in order to obtain a quality measurement every 10 days, it is necessary to continue to gather data every day.

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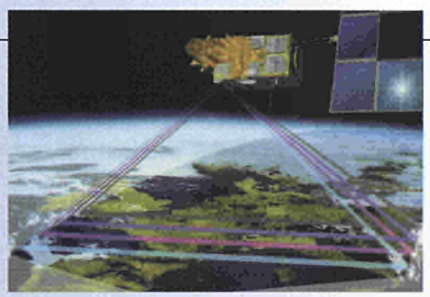
The planet day by day

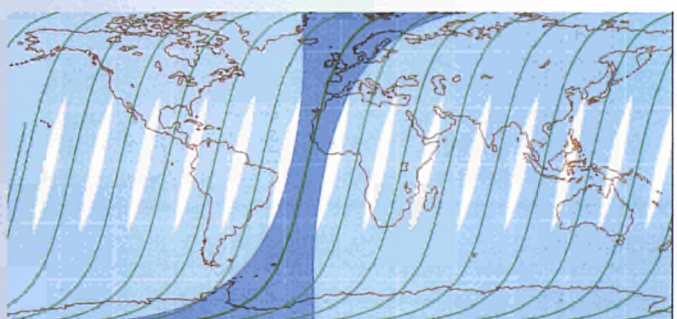
The traditional high-resolution images transmitted by SPOT satellites scan a strip of ground 60 km wide. This relatively narrow and necessarily intermittent scanning of the Earth's surface only permits pictures obtained at quite widely spaced time intervals. But the observation of the evolutionary cycle of vegetation at any given site is only of any meaning if it is repeated with sufficient frequency. This is exactly what the four low-resolution cameras which function as Vegetation's eyes are able to do.

They can photograph an area 2,250 km wide in the course of SPOT's 14 daily orbits [1], a field of view which allows them to obtain excellent-quality data on any point on the Earth's surface on an almost daily basis. In the space of 24 hours, Vegetation is able to transmit pictures of 90% of the world's equatorial zones, the remaining 10% being scanned the next day without fail. For latitudes above 30°, the frequency of passage over a given area increases progressively. At the Kiruna receiving station in Sweden, for example, data is transmitted five or six times daily, each time the satellite passes overhead.

(1) This scanning shifts slightly every day, with SPOT 4 returning above any given point every 26 days, after 369 orbits.



Four cameras, scanning the ground to a width of 2,250 km, can send back images of 90% of equatorial zones in 24 hours.



The whole of the Earth's surface is covered by means of SPOT's 14 daily orbits.

Oceans in a changing world

The Earth is a dynamic planet and the relationships between its oceans, atmosphere and land masses are incredibly complex. Disentangling them is not just interesting science; it might well be crucial to our future survival.

The oceans, which cover 70% of the Earth's surface, are a central component of the environment. Water circulation patterns in and between the different oceans strongly influence the climate of many parts of the world. Northern Europe, for example, is at the same latitude as Alaska, but it has a much milder climate because of the Gulf Stream that brings warm tropical water from the Gulf of Mexico.

All the oceans of the world are linked and events in one ocean can have widespread effects in other oceans, on the land and in the atmosphere. Today, we know that some water circulation patterns are changing, but we have two problems. Not only is it virtually impossible to separate the changes due to natural phenomena from changes caused by human activities, it is also difficult to say what the eventual consequences might be. Models that predict how the global environment might change in the future do give a lot of good information - many are now incredibly sophisticated. However, any model is only ever as good as the data fed into it. European researchers recognise that to improve our models, we need to learn a lot more about how water moves in the oceans.

In deep water

The European research project ESOP2 is focusing on circulation patterns that form the very deep, cold water in the Greenland Sea. Deep water formation in this area is important for the climate of Europe because it encourages the northward flow of the Gulf Stream Drift. The process of deep water formation in the Greenland Sea is also relevant to the global environment since it takes carbon from the atmosphere into the deep ocean, preventing it from contributing to the greenhouse effect.

Despite its importance, the physical processes involved in deep water formation are not well understood. ESOP2 gathers scientists from many different fields and is using a range of methods to learn more. In one of the project's most exciting experiments, scientists released an inert tracer into the centre of the Greenland Sea at a depth of 300 metres. The results obtained by following the fate of the tracer were better than anyone hoped for: two previously unknown mechanisms of water circulation were discovered.

Investigators were surprised to find that strong currents rapidly transported the tracer-labelled water from the 300 m level down to a depth of more than 3 km, causing storms on the seabed. In addition to this large-scale movement of water, the team also discovered a localised chimney effect - thin currents, which take water from the surface straight down to the bottom. One chimney, detected in May 1997, takes surface water down to a depth of 2 km.

Lessons from the past

Studying the past is also important for predicting the future. Measurements over the last 100 years tell us that the global environment is changing: we have released large amounts of carbon dioxide and other gases into the atmosphere and these seem to be causing a slight global warming. However, although average temperatures might rise, some parts of the world could become very much hotter whilst others could actually cool.

To predict the future, we need to know the past. Researchers are studying ice and sediment cores to chart previous climate changes and gain important information to understand the global environmental variations that we are seeing today.

Several projects supported by the EU are using a common approach to find out more about what might happen to the climate in Europe. Teams of researchers are studying ice and sediment cores to study the natural variations in climate that occurred during Earth's turbulent past. Similar periods of warming have already been identified and the teams are using this data to improve current models that predict climate change. In one EU-funded project, Jean-Claude Duplessy and his colleagues have been investigating events that took place more than a hundred thousand years ago.

During the warm period just before the last ice age, some of the ice sheets in the Atlantic broke up and formed icebergs that floated south and melted when they met warm water. The large amounts of freshwater released into the ocean blocked the normal water circulation patterns and stopped currents like the Gulf Stream bringing warm water northwards. This led to a strong cooling effect over Northern Europe which lasted for 1-2 thousand years and which was then followed by a rapid warming.

This warming, however, was only temporary and within a few hundred years there was another period of cooling, although not large enough to cause a real ice age. This time the change to a colder climate cannot be explained by melting icebergs. What seems to have been more important is that, at the time (115-127 thousand years ago), the North Pole was tilted further away from the Sun than it is today and so less heat was able to enter the top of the atmosphere in the Northern Hemisphere. This resulted in less heat at the higher latitudes and cooler, less salty water in the North Atlantic, which again prevented the Gulf Stream reaching Northern Europe.

Jean-Claude Duplessy stresses the relevance of these ancient events to our current situation: "The increase in CO_2 in the atmosphere due to human industrial activity in this century is causing more rain in the high latitudes of the North Atlantic and again increasing the influx of freshwater. This could force back the Gulf Stream further south again."

The oceans and the atmosphere

The oceans play an important role in the cycling of carbon between the atmosphere, the physical environment and living organisms. Three large European projects - ESCOBA, CARUSO and ASGAMAGE - are investigating these complex processes using experimental techniques and specially developed computer models.

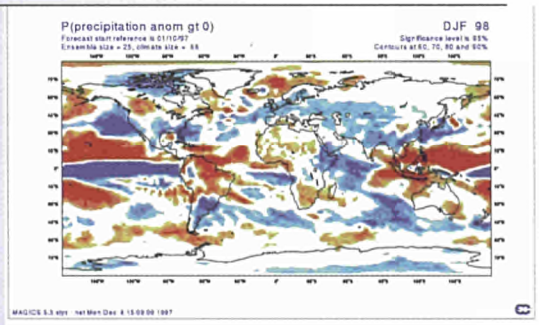
Carbon dioxide from the atmosphere dissolves in water and is transported around the globe by currents in the deep oceans. Plankton which can photosynthesise (make organic matter by combining carbon dioxide and water and using energy from sunlight) use some of this carbon. If they are plentiful, the ocean becomes a net sink for carbon, taking it out of the atmosphere and locking it up in organic debris that eventually become trapped in sediments on the seabed.

If the CO_2 in the atmosphere goes up, as it has during the last 200 years, it pushes more CO_2 into the oceans. Unfortunately, this increase does not mean more growth of living organisms because the carbon they need is already present in great excess. So more carbon in the atmosphere generally means more carbon in the sea. At present, we do not know in detail how this is linked to ocean circulation patterns but ESCOBA has already developed several new computer models that should help us to do this in the future.

One of the biggest deficiencies in our knowledge of the ocean's role in the carbon cycle is our inability to accurately calculate the rate at which CO_2 is exchanged between the air and the sea. This means that we cannot tell how much of the carbon dioxide produced by human activity goes into the ocean or if there is any chance that the oceans might save us from global warming by soaking up excess CO_2. Scientists working within the ASGAMAGE project are trying to come up with answers to these questions by developing and testing new methods of measuring how CO_2 passes between the atmosphere and the oceans.

Forecasting El Niño

What is El Niño? At the Equator, water in the western Pacific Ocean is warm. By contrast, its eastern part near the American continent is colder because it is continually replaced by upwellings of deep, cool water. Every two to seven years, strong westward-blowing trade winds subside, and warm water slowly drifts into the eastern ocean. This significant change can provoke drastic changes in climate that affect many parts of the world causing serious damage to economies and loss of human life. Since 1997, the current El Niño (the worst this century) has caused disastrous flooding in Africa and all along the Pacific coast of the American continent and has led to severe droughts and bush fires in Indonesia and Brazil. Europe has escaped the more violent consequences of El Nino, but many parts of it have experienced unusual weather conditions.



PROVOST: Predicting the effects of the 1997/98 El Niño - The blue or yellow/orange areas indicate parts of the world for which wetter or dryer weather than usual was forecast by ECMWF. The deeper the colour, the more severe the effect. The wet winter over Europe, the floods in China, South America and along the Pacific Coast of the US and the drought in Indonesia are all clearly predicted.

Building on many years of painstaking observations of El Niño events, European researchers, partly supported within the PROVOST project, have recently developed a reliable atmosphere-ocean modelling system. This is designed to provide regional, global and seasonal climate forecasts which could be of immense socio-economic value. If, for example, governments could rely on seasonal forecasts, they could increase fuel stocks before a cold winter. Similarly, farmers could select the crops that would grow best in the conditions expected. And, although the project has a European focus, its predictions and benefits are global. So if the model forecasted an El Niño event that would cause failure of the sugar cane harvest in the tropics, European farmers could increase the sugar-beet production to compensate.

The new European model uses data from a range of different sources - land-based observations, satellite data and ocean surface and sub-surface data from ships and buoys. It is proving to be accurate so far, but forecasting is easier when the El Niño (warm) or La Niña (cold) events are strong. The team is now working hard to improve the models to enable them to forecast the effects under a wider range of conditions.

The CARUSO European measurement campaign has shown that the Antarctic Ocean is a better carbon sink than the waters of the Northern Hemisphere. This unexpected finding is thought to be due to the high density of mineral nutrients, particularly iron, in the Southern Ocean. Plankton need iron to use carbon dioxide in the process of photosynthesis.

At the edge of the ocean

A better sink in the South

The Southern Ocean is a larger carbon sink than the Northern Ocean. This is actually unexpected for two reasons. Firstly, the Antarctic has a very long winter with long nights and it also suffers very rough seas. Not only is light generally limited, plankton that can make use of it when they are floating on the surface are intermittently plunged to the depths where they get no light at all. Secondly, very cold and deep water tends to well up to the surface, releasing dissolved carbon dioxide into the atmosphere as it warms up.

The key seems to be that the water coming up from the deep Southern Ocean is not only high in carbon but also in major mineral nutrients such as nitrogen, phosphorus and silicon. Hein de Baar, one of the leading scientists in CARUSO, and his colleagues were the first to show that horizontal currents coming from nearby continental margins enrich the surface water with iron: "Apart from light, iron could be the major limiting factor for photosynthesis. Its role is vital because one iron atom is at the heart of every single molecule of chlorophyll, the green pigment which enables the plankton to photosynthesise."

The fact that iron levels, not light, limit photosynthesis in the Southern Ocean in the summer months has led to the suggestion that adding more iron might enable larger plankton blooms to take more carbon out of the atmosphere. Some attempts at iron fertilisation have been made in various parts of the Pacific near to the Equator, with mixed results. In one experiment, a brief plankton bloom occurred but then the iron quickly disappeared. Hein de Baar and the rest of the CARUSO team are nevertheless considering some further iron-enrichment experiments. "Chemically-labelled iron will be added to the sea so that we can trace exactly where it goes."

Our interaction with the oceans is at its greatest along the world's 595 814 km of coastline: more than half the world's population - over 2.7 billion people - live within 100 km of the coast. The coastal zones are dynamic areas and most are of great economic and environmental importance. We use them for fishing, aquaculture, mineral extraction, industrial development, energy generation, tourism and recreation and for waste disposal.

It should come as no surprise that managing coastlines is very difficult. In Europe the Integrated Coastal Zone Management Programme is pioneering a holistic approach which treats each coastal zone as a complete functional entity. The fields of research are many and complex: at the moment we do not fully understand the natural physical, chemical, geological and biological processes that combine to form the many varied coastal environments. Particularly difficult is linking disturbances in coastal systems to their causes since events in the open sea and activities on the land all affect the coastal environment.

The programme has chosen thirty coastal zones for special study. Sites were picked to represent the range of ecological, economic and social situations found in European coastal zones.

Tracing coastal history

Many other projects outside this integrated programme are also concerned with coastal areas. One is using the 'learning from the past' approach - tracing the development of tidal flats and salt marshes in different parts of Europe using sediment cores. As sedimentation is a slow process in such areas, the cores reveal changes that have occurred over short-term time scales (between one and 100 years) as well as over long-term time scales (centuries to millennia).

The natural patterns of flooding and storms that have been detected by analysing the cores provide ☞

Impact of coastal erosion at Fao, Portugal.

important information for coastal management, especially in areas which are threatened by erosion. And, as Thomas de Groot, the project co-ordinator reports, one discovery was rather unexpected: "There are clear indications that human activities have been damaging the natural environment since long before the industrial revolution. Human use of land since Roman times and especially since the Middle Ages has influenced local erosion of the natural environment, particularly in coastal dune areas. We need to take this into account in our studies because local impacts, whether natural or human, overprint the signs of most large-scale climate changes in sediment cores. "

The balance of living organisms

Marine ecosystems in coastal areas can be strongly disturbed by human activity. One of the most serious problems is coastal eutrophication, an excess of nutrients in the water that can provoke uncontrolled growth of micro-organisms.

Regular blooms of a small organism called Phaeocystis plague a long stretch of European coast along the North Sea. Normally, this is a fairly harmless single-celled plankton, present in relatively small numbers. However, when it has an excess of nutrients Phaeocystis runs out of control, forming blooms which dominate the balance of organisms in the entire coastal ecosystem. And, when the bloom reaches a critical size, single cells clump together to form large gelatinous blobs that float on the surface of the water, releasing large amounts of protein as they die during the late spring.

An excess of nutrients has resulted in this Phaeocystis bloom. Similar blooms are ruining many beaches on the North Sea coast.

The turbulence of the waves whips up the protein producing an effect similar to beating great volumes of egg white: lots of meringue. Although the froth is not toxic, it completely ruins the beach and areas badly affected by Phaeocystis blooms have experienced a large decrease in revenue from tourism.

Researchers working within the ESCAPE project have shown that, on a global scale Phaeocystis-dominated phytoplankton blooms also have a serious impact on the environment since they are major sources of the volatile organic sulphur compound dimethylsulphide (DMS). DMS is the main natural sulphur gas emitted to the atmosphere and is thought to play a significant role in acid rain formation and in climate change. Clearly, something should be done to prevent Phaeocystis blooms and research is continuing to try and work out a cost-effective strategy. ■

The treasure of marine life

We are completely dependent on the richness of the Earth's varied ecosystems for food, energy and raw materials. Understanding why biodiversity is important and studying the complex relationships that make ocean ecosystems tick are important goals for European research.

Conserving biodiversity is a high priority, but we do not know that much about it. No one can yet explain, for example, why some environments support a much wider range of living organisms than others. To make conservation efforts more effective, we need to study the richness of life that exists in different ecosystems and to learn how this diversity is generated, maintained or lost. Ocean ecosystems, like those elsewhere on Earth, are incredibly complicated and so most studies of marine biodiversity concentrate on one organism, using it as a case study. These projects increase our knowledge of the biology of the chosen species and they also develop techniques and strategies that are useful for studying other organisms.

The subtle balance between micro-organisms

The living organisms in any ecosystem gain energy through the food chain. At the bottom of the chain, micro-organisms make their own food: other, larger organisms eat them and are, in turn, eaten themselves. So, if the population of micro-organisms in an ecosystem changes suddenly following a dramatic shift in water quality, the whole ecosystem can be thrown into chaos.

This is exactly what happens in a marine ecosystem that experiences eutrophication. Eutrophication is an excess of nutrients in water-based ecosystems, generated by human activity. Intensive farming plays some part but the influx of sewage and refuse from large urban developments is the cause of the most serious eutrophication that occurs in coastal waters.

The levels of inorganic nutrients such as ammonia, nitrate and phosphate determine the numbers of micro-organisms that can grow in any aquatic system. Eutrophic (nutrient-rich) waters can support many more micro-organisms than oligotrophic (nutrient-poor) waters. When waters that are usually poor in nutrients are suddenly deluged by a large quantity of effluent, various micro-organisms explode and cyanobacteria, bacteria and algae can all 'bloom'. Various species fight for, and achieve, dominance as the conditions vary wildly. As the blooms fade, decay of the dead organisms that caused them increases the nutrient content of the water still further, deepening the problem.

The EU-funded project CHABADA is investigating how eutrophication in the normally nutrient-poor waters of the Mediterranean affects bacterial populations. The team involved in the project have sampled the bacteria present in the water before and after simulating the effects of nutrient pollution. To date, about 600 strains have been isolated and about 60% of these have been cultured for further study. Using molecular techniques, the team has shown that two groups of bacteria are dominant in eutrophic waters, irrespective of the cause of the eutrophication. Later phases of the project will find out more about them.

Another project, NUTOX, is studying how an imbalance of nutrients along the coastal areas of the Baltic Sea and the Atlantic Ocean can allow harmful phytoplankton species to dominate and release toxins that can damage communities normally present in the ecosystem.

The secret sex-life of seaweed

Another key primary producer in marine ecosystems is the seaweed, which grows on the coastal shelf. Seaweeds are used by humans for food and in other products such as garden fertiliser and the gel called 'agar'. This is used as a food additive and also as the thickening agent in the gel used to culture bacteria in laboratories and hospitals worldwide.

The BIOGAP project is studying seaweed populations using techniques that are a mixture of ecology and genetics. Researchers aim to find out more about seaweed biology and to assess how well populations cope with harvesting.

Periwinkles living at different levels of rocky intertidal habitats have been chosen by scientists from the AMBIOS project to produce a comprehensive picture of how biodiversity develops in such a dynamic environment.

The BIOGAP project is studying three different seaweed populations using techniques that are a mixture of ecology and genetics to find out more about their biology and to assess how well they stand up to harvesting. Chris Gliddon of BIOGAP explains, "Sea weeds with a range sexual habits were chosen so that our studies would be as widely applicable as possible." One reproduces in the same way as single-celled algae, one reproduces in the same way as a higher plant and the third one is a sort of mixture of the two; for part of its life cycle it looks like a seaweed but it produces small, plankton like organisms that float off to colonise other areas of coast.

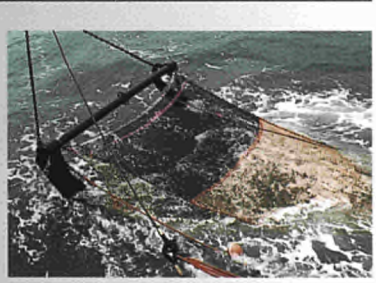
Kingdom of the periwinkle

To many of us, the periwinkle might not seem the most exciting of marine organisms. But it was chosen by scientists from the project AMBIOS because it is an ideal subject for a biodiversity study. The rocky intertidal habitat in which the periwinkle lives has a pronounced environmental gradient. The lower levels of the habitat are usually completely submerged, even at low tide, whilst the upper levels are always above the water. Conditions in the middle levels change as the tide goes in and out. This provides several completely different and, at the same time, continually changing physical environments within the same ecosystem.

Such an environment creates the selection pressure necessary to generate a high level of biodiversity and this is seen in the periwinkle at two different levels. Firstly, periwinkles classified together within the same species still show plenty of variation in characteristics such as shell shape, shell colour and, believe it or not, penis shape. Secondly, new variants of the periwinkle are arising all the time, leading eventually to the development of new, separate species.

AMBIOS is using a range of different scientific methods to investigate periwinkle diversity at both levels and to produce a comprehensive picture of how biodiversity develops in such a dynamic environment. Results to date are looking good; many of the sampling tasks have been completed and genetic analysis of the different species and sub-types obtained is well underway. One species has even been identified as a potentially useful 'sentinel' species for detecting effects of heavy-metal pollution in coastal ecosystems. ■

Blue Europe



There has been a common European policy on fishing and aquaculture since 1983. But the management of this "Blue Europe", which is of such vital importance to our coastal regions, requires us to face up to a number of challenges.

Conserving fish stocks means taking steps to counter the very real threat of over-fishing, while at the same time limiting the effects of fishing on marine ecosystems. Since the beginning of the last decade, researchers supported by the European Union have worked hard to provide a sound basis for the management of Europe's fish stocks and to determine the interdependency between them and the ecosystems they belong to.

A lot of research work has also gone into promoting aquaculture, an activity with good growth potential in several EU countries, but one subject to health, environmental, and climatic constraints. Scientific knowledge in this area must therefore be built up rapidly.

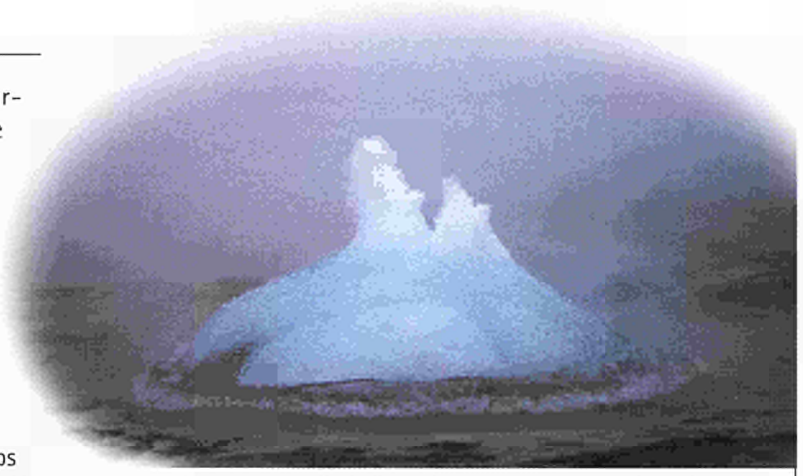
Many European projects are also working on technologies to improve the quality and efficiency - and thus profitability - of sea-produce processing industries. Finally, in addition to all this research in the fields of biology and technology, the EU is also supporting a socio-economic study of certain fishing industries that could help revitalise the sector.

Exploring the depths

The chasms and trenches of the great oceans are mostly unexplored territory. Research is only just beginning to uncover some of the secrets that lurk in their mysterious abyssal depths.

Hot stuff

Deep-sea hydrothermal (hot water) vents have generated much research interest recently. They were discovered in 1977 and are now known to occur in many places on the ocean floor. A vent opens where the Earth's crust is unstable. As cracks form, seawater seeps down into the hot rock and is then expelled again as the temperature inside the vent causes it to boil. The temperature around such a crack can be as high as 420°C. Small particles and hot water enriched with minerals from the rock spew out of the vent, making the surrounding water highly toxic.



Extreme deep-sea hydrothermal environments are caused by underwater vents that open in the Earth's crust. Researchers worldwide have been very surprised to find that these hot and highly toxic waters are teeming with very odd forms of life. Some of the micro-organisms present could be sources of valuable biochemicals.

Researchers worldwide have therefore been very surprised to find that these hot and poisonous environments are teeming with life - very odd life. 300 new species have been found in hydrothermal vents since 1977. The ecosystems are based around bacteria, which use hydrogen sulphide and the heat from the vent to build complex food molecules. These bacteria are the energy source for all other organisms living nearby.

Some vent organisms just eat bacteria to get their energy, but there are also wierd vent worms that have a more unconventional approach. They have no gut or digestive system. Instead they are filled with living bacteria which pack their tissues (every gram of worm contains 10 billion bacteria) and supply them with all the food they need. In return, the worm's blood supplies the huge bacterial colony with all the hydrogen sulphide it needs.

The European project AMORES is being co-ordinated by scientists who are intrigued by this strange environment. Not only are the studies very valuable because they increase our knowledge of the natural world, but there might also be an important practical consideration. The bacteria that can thrive around a hydrothermal vent could be used to solve pollution problems closer to home since the conditions created near to a hydrothermal vent - no oxygen, high levels of hydrogen sulphide and high concentrations of heavy metals – are the very conditions that are often found in the polluted coastal waters of Europe.

AMORES is studying four contrasting hydrothermal fields in the Atlantic Ocean to find out how heat and matter are dispersed into the Atlantic. It is using large surface ships combined with smaller submersibles for deep-sea investigations to collect information about the physical and chemical processes that occur around hydrothermal vents and to identify potentially useful bacterial species.

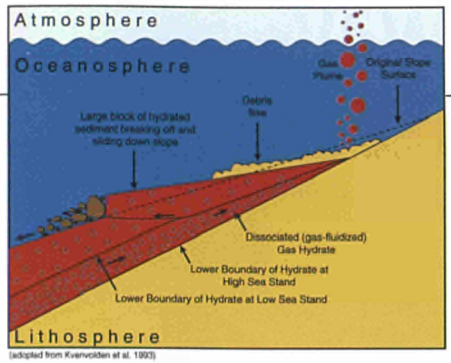
A sub-ocean pharmacy?

Other European researchers are investigating micro-organisms that live in deep-sea vents and marine hot springs as potential sources of valuable biochemicals. Thermophilic bacteria produce compounds and enzymes with unique properties since they must remain active at the high temperatures at which the organism lives. Screening marine micro-organisms known first for their environmental potential has found some interesting biological molecules including unusual enzymes, antibiotics, anti-algal compounds, anti-cancer substances and secreted sugars.

Cold stuff: underwater avalanches

The physical nature of the seabed is also of great interest, particularly the large-scale sedimentation processes that occur at the margins between coastal areas and the deep sea. One area of study in the ENAM project is the European North Atlantic margin between the Norwegian margin and the Celtic Sea. Scientists from ENAM 2 are studying sedimentation patterns from the shelf edge, down through the continental slope and finally into the deep-sea trench of the North Atlantic.

This area is known to oil companies for its potential as a rich field of oil and natural gas and many intend, in the future, to build rigs here. But there is a problem. In the deepest trenches of the ocean, the



(adapted from Kvenvolden et al. 1993)

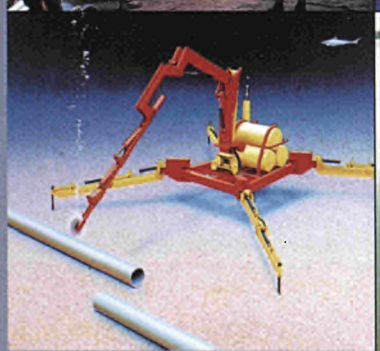
The depths of the North Atlantic are rich in as yet unexploited oil but the sea floor is prone to instabilities under some physical conditions. In the ENAM2 project, European researchers are studying underwater "avalanches" that cause sediments to slide down the continental shelf and could make oil exploitation unsafe.

water is very cold and gas hydrates (ice-like crystals) form just above the sea floor. Oceanic gas hydrates are now recognised as a major, little understood hazard that can threaten the stability of rigs in deep water oil fields. The stability of gas hydrates depends on the temperature and pressure conditions on the seabed. The recent increase in global temperature has caused changes in sea levels that have increased the instability of gas hydrates, making the whole of the ocean floor much more liable to shifting and sliding. Large underwater 'avalanches' called 'mass wasting events' are increasingly common (see figure). In a single event, an enormous volume of sediment can slide, like an underwater avalanche, from the top of the margin into the deepest part of the trench.

Jürgen Mienert, co-ordinator of ENAM II says, "Our work is providing new insights into the different sedimentary processes that shape the sea bed of the North Atlantic margin. We hope to be able to understand better the variations that occur at the shelf edge and on the continental slope and to develop computer models to help us work out which areas are the most stable. This part of the project is obviously generating a lot of interest in the oil industry." ■

Deep-sea technology

Exploring the waters of the deep oceans and the features on and below the seabed cannot be done without highly specialised equipment. New technology is needed to enable researchers to study the often dangerous environment of the seabed. Many projects supported by the European Commission MAST programme (Marine Science and Technology) are developing technology in this area, as are a large number of EUREKA projects, co-ordinated under the EUROMAR umbrella. Here are just four examples.



ALIPOR Project - This automatic lander can sink to the sea floor under its own weight and then conduct experiments, gather data and return to the surface when finished.

The EUROMAR project ROMAN has developed a heavy duty deep-sea robot that can carry out heavy jobs at great depths, taking over tasks that are too dangerous for human divers.

SIRENE is a remote-controlled-carrier, which can position underwater laboratories with extreme precision at depths of up to 6000 metres using advanced tele-acoustic communication.

AMADEUS is a research programme to improve the dexterity and sensory ability of remote-controlled underwater manipulation systems. This final prototype should be able to sample organisms, sediment and rocks with extreme accuracy.

The maritime superhighway

Global trade and travel continues to increase and traffic on the oceans is busier than ever. Europe's newest marine transport technology is developing the marine superhighway as an environmentally-friendly and efficient part of the world's transport system.

A new generation of high speed ships

Today there is a general need to transport passengers, cars and cargo by sea using methods that are safe, fast and cost-effective. European research is developing new types of ship to fulfil this demand. The newest high-speed vessels are Surface Effect Ships, i.e. that lift up away from the water, as well pushing their way through it. Until very recently, the only SES were small and medium size hydrofoils or hydroplanes used for military and passenger transport but a potentially large future market for much larger SES has prompted new European projects to develop them.

Scaling up SES is actually quite difficult. Many of the final stages of design and development need to be done using a prototype, and building full scale working prototypes of large vessels is usually prohibitively expensive. For SES, this problem has been circumvented by SESLAB: a ship-sized SES prototype that is flexible enough to be used as a tool to test a whole family of SES ships.

In the study, a modified full scale ship has been built to act as an experimental model that can be used at all stages in the design process to obtain the necessary data and experience to overcome every technical or design problem imaginable. SESLAB will be used to design a range of large SES. The target family covers a wide range of sizes and performances, which reflect the present and future trend in medium and large SES vessels. SESLAB can simulate a length range between 65 and 160 metres, a displacement range between 500 and 5000 tons and a speed range between 40 and 70 knots (75 to 130 km/h). Each size of ship can be assessed for performance (power/speed), manoeuvrability and to see how well it stands up to sailing in rough seas. No other prototypes will be necessary before final building goes ahead.

The ARCDEV expedition will demonstrate that it is safe to transport oil products from the Siberian Arctic regions to the western European market through a Short Sea Shipping corridor opened by two Russian icebreakers. The Finnish oil product carrier M/T "Uikku" will test new technology that has been developed to load liquid oil products at -30°C.

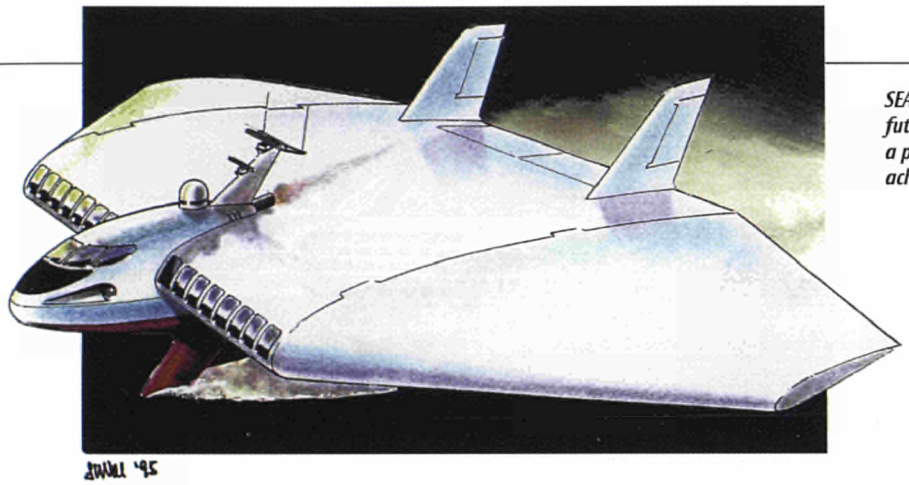
With top speeds of 40-70 knots, SES are fast, but they are likely not to be the fastest vessels on the high seas. Another European project. SEABUS-HYDAER is developing a completely new concept in marine transport: a hybrid between a plane and a ship. Although Seabus never leaves the water, most of its lift power is provided by the wings. This gives it the capacity to travel very fast. Ferries currently in use have top speed of about 40 knots; Seabus beats this hands down, achieving around 120 knots (220 km/h) whilst using 20% less fuel.

A sea corridor between Russia and Europe

Some parts of the world are still difficult to reach. The area around the Ob River in Siberia - the site of 25% of the world's oil products - is one of them. Moving the oil products out by sea has always been considered a bad idea because of the appalling weather conditions that are typical of a Siberian winter. Instead, trade has depended on a pipeline system, which runs through the permafrost area of Russia. In such an inhospitable environment, maintaining the system is next to impossible and a significant part of the transported material is lost through leaking pipes.

Russia is now working with countries from the European Union to look for a more effective and environmentally acceptable solution. The research project ARCDEV is investigating how safe and cost effective it would be to transport these important oil products through a Short Sea Shipping corridor from the Arctic regions of Russia to the western European market, bringing the Ob River within range of European strategic trade interests all year round.

The project is based around a fully operational voyage to the Siberian oil reserves area in the worst of the winter conditions. The ARCDEV expedition, which is supported by the Ministries of Transport in Finland and Russia, involves



SEABUS-HYDAER is developing a completely new and futuristic concept in marine transport - a hybrid between a plane and a ship. This revolutionary new vessel will achieve a top speed of around 120 knots (220 km/h).

many industries and research institutes from all over Europe and Russia, including large companies in the petroleum, shipbuilding and ship supply industries. This will be the last joint Euro-Russian expedition to the Arctic before the end of the millennium. Four different vessels are participating: one nuclear Russian icebreaker, one conventional Russian icebreaker and two oil product carriers, one from the Finnish company Neste and one from Russia.

As well as developing the sea corridor as a fully operational, environmentally friendly alternative to the pipeline system, the ships involved will also act as mobile laboratories. In particular, the demonstrator – the oil product carrier, M/T "Uikku" from Neste Shipping - will test new technology and equipment developed to load liquid oil products in temperatures as low as -30 °C.

Several other European projects are hitching a ride with the ARCDEV expedition to test out their developments during a real voyage. One of these is the Voyage Data Recorder developed by the Maritime Black Box project. Catastrophes at sea can result in loss of human life and severe damage to the environment. If, in the future, all ships carry electronic automatic incident data recording systems (similar to the obligatory Black Box installed on all aeroplanes) it should be easier to find out the cause of accidents at sea and to prevent similar tragedies in the future. This device complies with standards recommended by the International Maritime Organisation that come into force on January 1st, 2001. ■

Learning to communicate

Good communication at sea can mean the difference between life and death. People from many different nationalities work together, often in difficult conditions, and misunderstandings can and do arise. Many EU-funded projects aim to overcome this potential threat to human safety and to the environment.

MARCOM, for example, is looking at the impact of multicultural and multilingual crews on maritime communications. This project aims to enhance safety and efficiency on ships, particularly those operated by multi-European crews, by developing:

- verbal and non verbal tools for communication;
- training packages to extend communication skills;
- a pilot syllabus for teaching maritime English;
- clear instructions of the language that should be used in emergencies;
- improved manuals and other printed instructions on board;
- guidelines to help crews avoid cross-cultural tensions.

Many other European projects are using training programmes of all kinds to enhance skills of workers within the maritime industry. Some projects assess the future technical skills that workers will need, some look at how training programmes can be implemented and others identify deficiencies in current programmes. Others develop distance learning and on-line access to information to ensure greater consistency and to allow more workers to participate.

On-going training improves communication and personal safety and encourages practices that are environmentally-friendly. It also allows workers to obtain the further qualifications and skills that enable them to maintain a sense of progression throughout their working life.

The Four Seas of Europe

Millions of people are dependent on the stressed waters of the Mediterranean, the Baltic, the North Sea and the Black Sea. The whole of Europe must share the responsibility for preserving them for future generations.

The Sunny Mediterranean

With its golden beaches and blue waters and skies, the Mediterranean is one of the most attractive seas in the world. Its waters are also vital to the economies of 20 European countries, supporting tourism and a whole range of other industries. Since 1988, Europe has been funding a coherent effort to understand this complex sea. The EROS 2000 project in the Western Mediterranean, which ran from 1988 until 1995, provided a great deal of important information on water circulation patterns and pollution levels in the Mediterranean. The Mediterranean Targeted Project (MTP), currently the largest multidisciplinary research project covering both the Western and Eastern areas of this sea, was established by the European Commission in 1993. MTP is a major European effort to understand the Mediterranean better and to identify the human activities that have the potential to cause serious damage to its delicate systems.

MTP's pilot phase (1993 to 1996) brought scientists from different countries together in a close-knit team. This active co-operation paid dividends and in just three years the project made significant scientific progress. The second phase started in 1996 and runs until 1999. MTP-II is building on the solid foundations of MTP-I and is taking co-operation to even greater heights, gathering together 54 research groups from 13 EU countries and 3 non-EU countries (Switzerland, Morocco, Tunisia).

Small changes, serious consequences

MTP has discovered that the temperature of deep water in the Western Mediterranean basin has risen by 0.13°C during the last forty years. This might not seem very much but, in geophysical terms, this is a large increase in a very short time. Scientists throughout Europe believe that it is another serious indication that the global environment is changing in response to our urban and industrial activities.

MTP's most recent findings suggest that the rise in salt concentration detected during the same period is no less important and that this too could be our fault. Construction of key dams, notably the Aswan High Dam on the Nile and the dam on the Ebro in Spain, has cut the flow of fresh water into the Mediterranean over the last 50 years. This has led to a general increase in its salinity. Because salty water is more dense than fresh water, this has altered circulation patterns within the main waters of the Mediterranean and also between the Mediterranean and the Atlantic Ocean.

One of the most important currents that is being affected is a plume of salty water that leaves the Mediterranean Sea at the Straits of Gibraltar. This flows west and helps shape the course of the Gulf Stream that warms the climate of Europe. As water inside the Mediterranean becomes more salty, so does this plume, but the long-term consequences of this are proving difficult to predict. It might deflect the Gulf Stream west, producing a drastic cooling of the climate of northern Europe or it might push the Gulf Stream east, making the climate much warmer. European researchers cannot yet say which scenario is more likely, and all are redoubling their efforts to achieve more accurate forecasts.

Sound science means sound policies

Growing industries and intensive farming methods have also taken their toll on the Mediterranean, causing an increase in eutrophication that has produced large-scale algal blooms. These have led to serious problems for tourism in some areas, as well as disrupting the natural balance of the marine ecosystem. Research is helping governments to control what is put into the sea and scientists expect to see some improvements in the next few years. Work done in the MTP Project, for example, showed that the European regulations on lead additives in petrol were effective: lead levels fell from 1990, and should continue to fall further. ■

Caulerpa taxifolia, the "killing seaweed", has disrupted the natural balance of the marine ecosystem of the Mediterranean and led to serious problems for tourism along some coasts. Its massive development is the result of an increase in eutrophication caused by industrial growth and intensive farming methods.

The Atlantic Ocean meets the North Sea

Although most projects within MTP concentrate their research efforts on the waters of the Mediterranean, some follow what happens to the water that flows out into the Atlantic and then up into the North Sea. Other projects outside MTP overlap and then extend their area of study to ensure that we build up a complete picture of the oceans.

At the Straits of Gibraltar, water from the Mediterranean, and also from the African and Iberian coasts, mixes into the main body of water to give the North Sea/Eastern Atlantic area its unique characteristics. Changes in currents that could affect this process are being studied by the CANIGO project.

One European project that provides a perfect complement to MTP is CANIGO. This regional sea project looks at how water from the Mediterranean, and also from the African and Iberian coasts, mixes into the main body of water to give the North Sea/Eastern Atlantic area its unique characteristics. Water circulation patterns here are important for two reasons. Firstly, they influence the Gulf Stream and its role in world climate and, secondly, the turbulent waters of the African and Iberian coasts provide an ideal site for the vigorous plankton growth that sustains many economically important fish populations. Of course, water mixing is not the whole story and the 45 research labs involved in CANIGO provide the breadth of expertise needed to tackle detailed studies of the individual creatures and processes that contribute to the finely balanced biology and chemistry of the Atlantic.

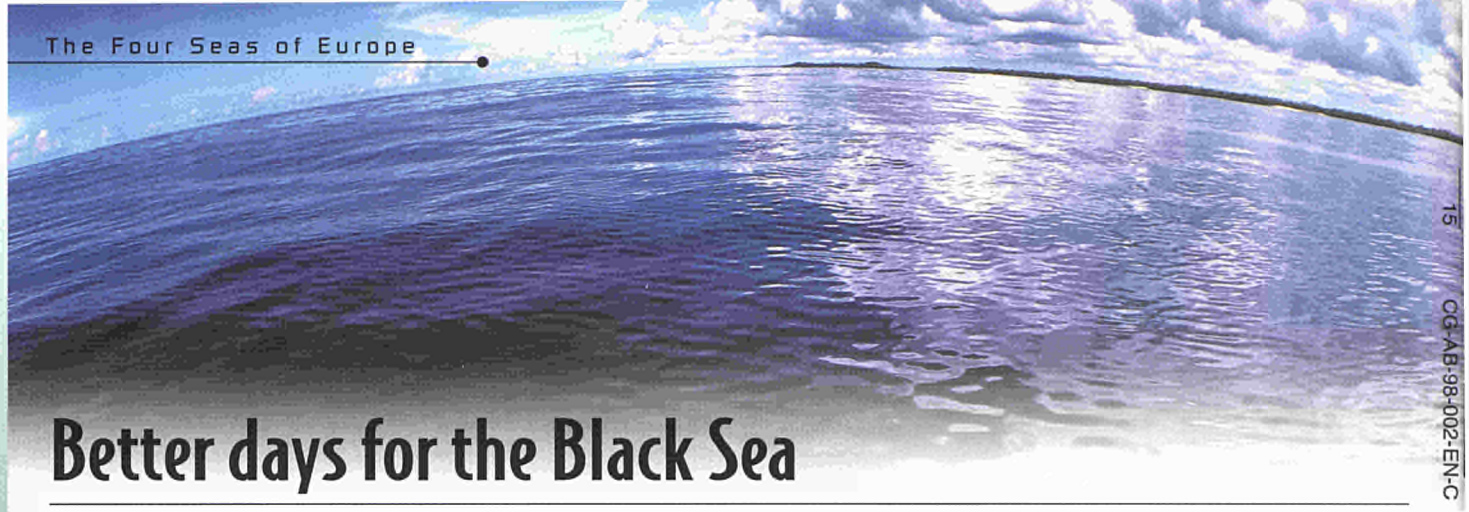
The Baltic Sea: past, present and future

Unlike the Mediterranean, the Baltic Sea is one of the most carefully studied marine ecosystems. Ongoing European research projects here therefore tend to build on previous research to fill specific gaps in our knowledge. In particular, current projects are concentrating on processes which, when we understand more about them, will help us develop more accurate models for predicting how the Baltic system will change in the future.

BASYS aims to understand the external factors, both natural and human in origin, that will cause these changes. This is an ambitious project that uses a systemic approach to study the physics, chemistry, biology and geology of the whole Baltic Sea in all possible time scales. This means looking at all the processes that go on in the sea using historical data, using field research to collect new information on the current state of the waters and predicting future events using sophisticated computer models.

Another important Baltic project that aims to predict the future is POPCYLING. Scientists from 7 EU countries are developing a multimedia model to study the fate and behaviour of POPs - Persistent Organic Pollutants - in the Baltic Region.

In the Baltic Basin Case Study, researchers are concentrating on the socio-economic aspects of environmental systems in coastal regions. The research, due to be completed in 1999, is building an information base which describes the natural resources of the Baltic Basin. This will be used to help develop more sustainable methods of exploiting those resources that will encourage economic growth without damaging the environment. A few key ecosystems have been chosen as sites for study by resource managers, decision makers and citizens' groups, as well as scientists. ■



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Better days for the Black Sea

The coasts around the Black Sea have supported human settlements for thousands of years. For thousands of years different civilisations have depended on the rich diversity of plant and animal life in the sea and on the fertile soils on its coasts. The human population has increased steadily during that time but it is only in the last 40 years that the Black Sea has become unable to cope with our demands on it.

Urban and industrial development has poured increasing amounts of waste into the rivers leading into the Black Sea and into the seawater itself. By the early 1990s the Black Sea was in the grip of an extreme environmental crisis. Nitrogen, phosphorus and pesticides, added to agricultural land, were present at extremely high concentrations. These excess nutrients were causing massive blooms of micro-organisms. Heavy metals were building up as a result of unrestricted industrial output in eastern and central European countries and oil pollution and pesticide contamination was at an all time high.

The combined effect of this mass off-loading had a devastating effect on ecosystems in the area. The fishing industry collapsed completely: fish populations were unable to survive the great change in conditions and this, combined with overfishing, reduced their numbers to practically zero. A species of jellyfish, introduced into the area accidentally, soon multiplied to fill the ecological niche that was left. Frequent outbreaks of serious water-borne diseases such as cholera and hepatitis A occurred in coastal areas and there were numerous hot spots of very high levels of heavy-metal contamination - so high that investigators checked their instruments for faults when they first saw the readings.

When political events in central and eastern Europe led to economic collapse this proved to be a turning point for the Black Sea. A new spirit of co-operation developed in the months that followed and scientists from the European Union were allowed to see the extent of the environmental tragedy for the first time in 1993. All agreed that everything possible should be done to return the Black Sea to its former glory.

Coping with such an enormous disaster is not easy, but progress is being made. Scientists from EROS, one of the major European projects dedicated to the task, began by studying exactly what had happened to the ecosystem whilst monitoring what was still happening. As it turns out, this was probably the very best course of action because the latest results from EROS show that the Black Sea is showing a great capacity to recover naturally.

When results taken in Spring 1997 were compared to those from the 1995 EROS cruise, there were some very positive signs that the ecosystem was regenerating. Oxygen concentrations in the water at the upper levels had improved considerably. Some species of plankton and invertebrates, which were thought to have become extinct, were again common. Jellyfish numbers had stabilised while the number of anchovy eggs and larvae had increased. Now, on the solid basis of sound scientific data, we are taking more steps to help the Black Sea. For example, governments are working together to ensure that, by the end of 2000, all Black Sea discharges will be regulated through national licensing systems. ■

A sea under stress

- Waste from 17 countries drains into the waters of the Black Sea
- Almost two thirds of the nitrogen and phosphorus in the seawater comes in from the Danube basin
- Over 10 million people are connected to sewage systems in the Black Sea Coastal region
- 111 000 tons of oil enters the Black Sea each year from transport of oil through the Danube.

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