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Technologies for marine environmental surveillance

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1. Introduction

The oceans represent an extremely important factor in determining the state of the ecological system and the nature of global weather patterns. In addition, it is increasingly being recognised that ocean parameters may provide early warnings of general imbalances in these systems. Human usage of the oceans includes transportation, tourism and exploitation of living and non-living resources, and most of these activities will to some extent negatively affect the marine environment. However, it is clear that land-based human activity is also important in affecting the state of this environment.

The oceans are subject to a complex interaction between, and a fine-tuned balance in, many factors. Small changes in this balance may propagate and amplify to cause serious environmental impacts. Potentially, the end result is something over which nobody has any control, thus a chief concern when utilizing the oceans is to make sure that the balance is maintained. Public concern for the environment is growing, and at the same time information technology is making it possible to rapidly monitor changes in important parameters. Marine environmental surveillance is therefore becoming increasingly important.

This article provides a brief introduction to the technologies concerning modern marine environmental surveillance and forecasting. Equipment and principles for buoy systems and oil spill remote sensing is given a more detailed description, because these are areas where modern technologies are most likely to contribute to a sound development of the oceans' resources.

2. Performing marine environment surveillance

Oceanography – the study of the oceans – includes biology, chemistry and geology, together with several other sciences. It is clear that due to the multiplicity of areas represented, oceanographers seek to understand an exceedingly complex system. Accordingly, samples and measurements from the seas are taken on numerous parameters and in several different manners. Sampling heavy metals traces on the sea bed surrounding the offshore installations in the North Sea and assessing fish resources in the Indian Ocean are both examples of where marine environmental surveillance is important.

Traditionally, samples and measurements are taken from manned expeditions and metering stations, combined with observations from aircraft and research vessels. There is, however, a growing use of automated systems positioned on buoys and satellites, giving researchers regular and accurate real-time data. One such system is illustrated in figure 1. Some measurements still cannot be automated and thus have to be performed by man. The task of detecting oil slicks and red tides are examples of phenomena that generally have to be monitored from manned stations such as aircraft and vessels.

3. The market outlook

The market for marine environmental technology is substantial. In Europe alone it has been estimated at about £500 million annually. In the field of marine environment *surveillance* technology alone the annual turnover is probably several hundred million pounds sterling worldwide. The market for such technology is still in the preliminary phases of development, but is expected to experience a rapid expansion in the near future as needs and demands for marine pollution control technology increase. It is likely that in some years all major seas will to some extent be covered by surveillance systems, and the need for spare parts, maintenance and new technology will surely keep this industry prosperous in the future.

According to one manufacturer in the industry, there is not too much concern about the fact that sales figures are relatively low at present. The research

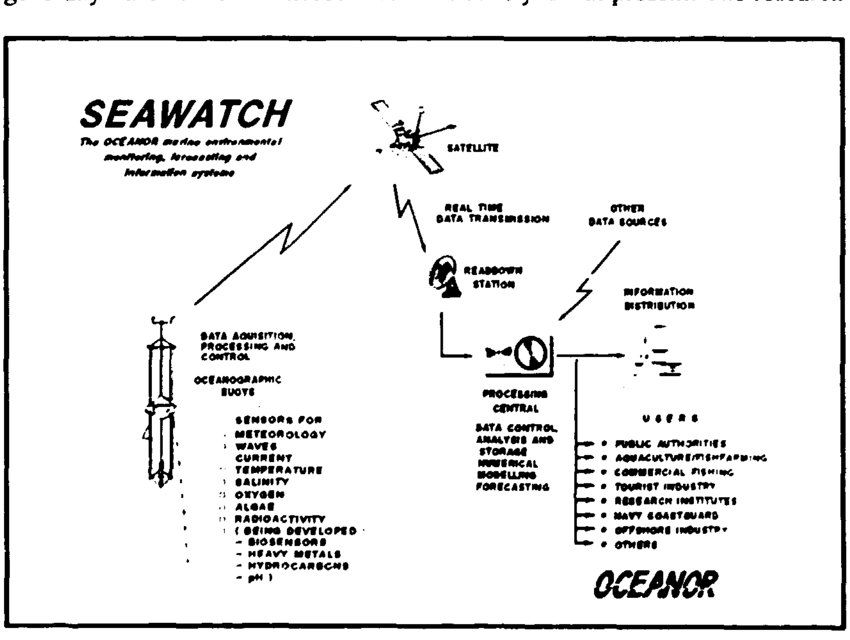

Fig. 1 Typical marine environmental monitoring, forecasting and information systems.

programmes are intended to produce technology that is certain to be in increased demand in the future rather than generate short-term profits. The focus of these programmes is mostly on electronics, data telemetric and simulation/modelling computer programmes. Due partly to EUROMAR's (European Research Coordination Agency, EUREKA's project for a better understanding of the marine environment and its treatment) efforts in promoting cooperation in this field, Europe has progressed considerably in terms of know-how and resources required to compete with the USA and Japan in the international market for marine environment technology.

One feature of the market for this technology is that the manufacturers do not need to develop special products or marketing techniques. That is to say that the relevant technological solutions are quite similar regardless of the uses to which it is put.

Typical direct or indirect users of the technologies include:

- Research institutions
- Public authorities
- Aquaculture/fish farming interests
- Commercial fishing interests
- Tourist industries
- Research institutions
- Navy and coastguard
- Oil companies.

4. Data acquisition buoy systems

4.1 Data buoys

The initial open ocean data buoys were large, stable steel structures of more than eight metres in diameter. Their size necessitated police escort during road transport, and maintenance costs, particularly of the three point moorings, were high. Later, smaller buoys proved impractical due to difficulties in deployment or access from small boats when servicing. Today's buoys are usually one to five metres in diameter and have a displacement of about a hundred kilograms. Their shape may differ, depending mostly on how the buoy is supposed to move in relation to the sea's surface. The wave directional type follows the wave frequency, while the vertically stabilized type adjusts to the resonant frequency of the waves and will remain vertical. Figure 2 is an illustration of a typical modern data buoy. As this figure shows, a modern buoy usually has the following parts:

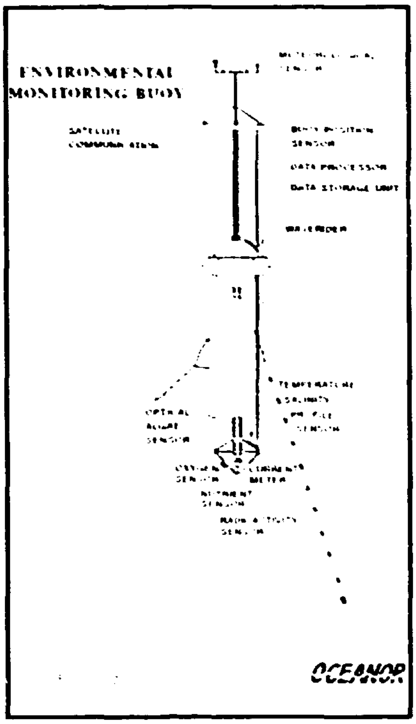

Fig. 2 Oceanographic data buoy.

- Central buoyancy unit, either of wave directional or vertical stabilized type
- An instrument well, which is protected from moisture. This system is often integrated in the central buoyancy unit
- Mooring system
- Instrument/sensor tower
- Sensors for data acquisition
- Equipment for data transmission
- Data processing and storage
- Power supply.

Since maintenance is difficult and costly, system reliability and durability is one of the chief design goals for such buoys. Acceptable reliability is usually achieved by the careful selection of system components and a high degree of redundancy within the system itself, causing duplication of many components. Durability is partly a function of the reliability, but also involves considerations of the power supply's duration.

4.2 Sensors for data acquisition

A wide range of sensors may be connected to buoys, the most common of which are those designed for measuring the following parameters:

Physical data

- Wind speed and direction
- Atmospheric pressure
- Humidity
- Sea temperature profiles
- Significant wave height
- Wave period and direction
- Current velocity profiles
- Radioactivity
- Particle concentrations

Chemical data

- Salinity at various depths
- Chemical compounds, such as oxygen and traces of heavy metals

Biological data

- Concentrations of nutrients, such as phosphor and sulphur compounds
- Algae concentrations

There are numerous manufacturers of these sensors, but most manufacturers of buoy systems have to choose a limited range for adaption and will therefore normally propose a limited selection of sensing devices.

4.3 Data processing and storage

The sensors must be interfaced with an operating system that triggers measurements at the correct time and preprocesses the data before transmission, if such transmission is needed. The system design also depends on whether the data will be transferred in batch or real-time. In the former, there will also be a need for temporary storage, but in any case backup files are sometimes stored on a hard disc on the buoy itself as a safeguard against system failures. The computers are quite similar to powerful personal computers and are usually assembled on the buoy. Considerable efforts have been vested into reducing the power requirements of the computers and the connected systems.

4.4 Data transmission

The only means of transferring data in real-time from the buoy to the shore station when the buoy is far away from the shore is currently through satellite transmission. For short distances (the destinations have usually to be in sight), VHF (very high frequency) or UHF (ultra high frequency) communication systems are used. There are currently several satellite communication systems in use, for instance ARGOS, INMARSAT and METEOSAT, and more of them will be appearing in the future. The choice of system depends on customer needs, the orbit of the relevant satellites, the interface on-board the buoy and, of course, a willingness to pay the required price. Future systems may incorporate solutions based on signal transmission through the water, but the test results of such prototypes have yet to be made public.

4.5 Power supply

The power supply for the data acquisition buoys constitutes an important obstacle to development and deployment. Until recently traditional batteries have been the sole source of energy, but the problem with this solution is that the batteries have to be totally sealed against seawater, producing power within bulky casings. The batteries themselves are subject to leaks and are large, bulky and heavy. They are also difficult or dangerous to handle and require frequent maintenance.

As a solution to most of these problems, Westinghouse Science & Technology Center has developed a new seawater battery: SeaCell. The core idea behind SeaCell is to benefit from the high levels of dissolved oxygen in the seawater to spark a chain of reactions. When deployed, the whole cell is immersed in and flooded by seawater and is thus not affected by pressure. There is therefore no need for a pressure regulation system, and the system's bulk, weight and complexity is greatly reduced. The process involved is relatively simple. A lightweight membrane (the cathode) forms an open shell. The membrane is thin and rubber-like, composed of carbon and Teflon film and is hot-pressed onto a metal screen. A particular component in the membrane acts as a catalyst to produce hydroxyl ions (OH) from the dissolved oxygen and the water. These ions then enter into a reaction with magnesium plates or rods (the anode) within the shell to produce electricity. This solution may provide a stable long-term supply of electricity for underwater and in-water devices.

Total available electrical current from this system is, in part, a function of the surface area of the cathode and the anode. Accordingly, SeaCell can be designed to deliver power appropriate to mission requirements. An example of an existing battery is one that can deliver 3 watts at 1.4 volts continuously for one year. This 3-watt system weighs approximately 32 kilos and can be designed in many geometries. Unlike traditional batteries, SeaCell is not negatively affected by temperature. In fact, low sea temperatures actually improve battery performance because cold water normally contains more oxygen than warm water.

The fact that a data buoy is surrounded by natural energy sources, like the sun, waves and wind, has brought a focus on efforts to make the buoy self-supplied with energy. Oceanor explains that this idea was investigated and abandoned by them [Graabak, 1991]. The problem is that current technology cannot prevent the power plant from affecting the buoy's movement and stability. Thus, most current power plants are likely to cause unreliable measurements from the most sensitive of metering devices. In addition, even with such power plants – some buoys do utilize solar panels that do not affect motion – a battery must be added to provide a steady supply of energy to compensate for changing weather conditions.

5. Available marine surveillance systems

5.1 SASEA

The Johns Hopkins University Applied Physics Laboratory (JHU APL) has developed a System for At-Sea Environmental Analysis (SASEA). SASEA supports the acquisition and almost real-time analysis of environmental data for a wide range of meteorological, oceanographic and environmental studies. Data is collected by a variety of sensors connected to a network of computer-based analysis systems installed on surface ships, stationary platforms and P-3 Orion aircraft.

Typical at-sea experiments include units fitted out with meteorological, sea surface and water-column measurement sensors. SASEA software – having a user-friendly interface – runs on personal computers under the MS-DOS operating system to monitor and control data acquisition and processing at the various locations. Data collected at sea are stored in SASEA-formatted databases. The pre-processed databases are then transferred over the International Maritime Satellite Organization (INMARSAT) telecommunications network. Except for the stations aboard P-3 aircraft, the SASEA subsystems are connected to standard INMARSAT equipment with both dial-up and leased commercial line capability. Stations aboard aircraft, naval air stations (NAS), can for instance download temperature-profile data to JHU APL within minutes after the aircraft lands.

Data collected by all at-sea units and the NASs are integrated into master databases. These databases are then supplemented with historical data and satellite remote sensing data to develop a complete near-real-time picture of conditions at the test-area. Results from these analyses may then enable experimenters to adjust the station's computers and optimize the testing undertaken from the stations.

The sensors support continuous measurement of up to 16 parameters. Participating vessels are fitted out with Endeco Wave Track buoy systems, which immediately transfer data to the ship for the detection of wave height and direction. Each profile can contain up to 6,000 data pairs.

5.2 ODAS

The Ocean Data Acquisition System (ODAS) from Space Technology Systems Ltd. is developed to fill the weather data information gap in the Eastern Atlantic. The system makes automatic environmental observations and transmits compiled reports to the land-based centre via the METEOSAT geostationary satellite link. The collected data include wind speeds and directions, atmospheric pressures, air temperatures and humidities, sea temperatures, significant wave heights and wave periods. The data acquisition units are designed to minimize power requirements, performing necessary signal conditioning and logging functions without using a microprocessor. Due to system redundancy, a full synoptic report can be received even in the event of failure of one data acquisition unit and one data transmission unit.

Buoy locations are given by two ARGOS satellite transmitters, which also transmit reduced data sets of 32 bytes to shore.

The ODAS buoy uses an elastomer foam hull covering a steel skeleton and instruments. The combination offers great durability and self-fending properties; the buoys are able to operate with maintenance intervals of six months.

5.3 SEAWATCH

The SEAWATCH system, developed as a part of the EUROMAR programme, is proposed as a marine environment monitoring system. The development of the system is primarily undertaken by the Norwegian company OCEANOR. Fully developed, SEAWATCH is supposed to cover all the seas surrounding Europe: the Mediterranean Sea, the Eastern Atlantic, the North Sea, the Barents Sea and the Baltic Sea. The purpose of SEAWATCH is to:

- Provide information on the current status of, and changes in, marine environmental conditions and selected pollution parameters
- Document trends in environmental conditions
- Document the effects of protective actions
- Provide warnings so that immediate action can be undertaken, for instance in the case of algal blooms or major oil spills.

The key feature of this system is a new generation of buoys, the TOBIS (Mark 3) buoys, developed by OCEANOR for real-time monitoring and forecasting of marine and meteorological conditions. TOBIS is vertically stabilized and based on a transparent frame surrounding a central buoyancy. This frame is the platform for sensors making meteorological and oceanographic observations. Processor and interfacing electronics are designed to minimize energy consumption, and the buoy is able to operate at sea for months without maintenance. The data acquisition system is built up around a powerful GENI-200 unit that facilitates instant and accurate data collection and processing. The TOBIS buoy has a 40 megabyte hard disc on-board where all transmitted data can be stored as backup. There are several sensors available for the system, for instance sensors to monitor waves, wind speed and direction, air temperature and pressure, current velocity and direction, multi-frequency transmittance, radioactivity, nutrients, oxygen and temperature and salinity profiles. Some of these sensors, for instance those measuring radioactivity, are unique for SEAWATCH.

Communication with shore stations is conducted via satellite. The data telemetry/satellite system ARGOS is the standard at present, but in the future INMARSAT Std-C is expected to replace this system. One advantage with INMARSAT is that two-way communication with the buoys is made possible. With such a communication system researchers at shore stations can, for instance, change logging intervals and transmit software to the buoy, improving the quality of the surveillance and thus the utilization rate of the expensive buoys.

The SEAWATCH system is presumed to be marketable outside Europe as well as in the proposed EUROMAR programme.

6. Oil spill remote sensing

Recent large oil spills have turned public attention towards oil pollution and triggered increased concern for the problem. Remote sensing is one of the more efficient ways of tracing oil spills for counter-measures and is gradually becoming more important. The minimum expectation from such systems is that the clean-up authorities or the spiller receive information of the location and extent of the contamination. It is increasingly recognized by spill clean-up personnel that remote sensing can be used to significantly increase spill combat efficiency. Advances in electronics have made advanced instrumentation much cheaper and many new capabilities are now within reach.

Unlike general marine environment surveillance, which mostly focusses on spot-sensing to get information to generate statistics on environmental conditions, oil spill remote sensing traces slicks explicitly. Therefore oil spill surveillance systems have to cover the whole area of concern and the job can normally not be performed adequately by data acquisition buoys.

The definition of remote sensing is that mechanical or electronic devices are used to detect the target from a distance. The most common form of remote sensing as applied to oil spills is aerial remote sensing – using an aircraft as a platform for equipment and control. Satellites may be used, but this is more rare.

There are currently five well-known techniques for aerial remote sensing. They will be described briefly hereunder.

6.1 Optical techniques

The most common techniques utilize optical sensors. Cameras, both still and video, are particularly common due to their low price and are normally used in aerial mapping. The technology utilizes the fact that oil has a high reflectance factor in the visible spectrum and is thus easily detectable. It is however largely restricted to documentation because of several interferences and the lack of an error-proof oil detection mechanism. For instance, sun glints and wind sheens are commonly mistaken for oil. Still, several companies are equipped with aircraft and cameras based on this technology. The cameras used can be ordinary television cameras, home videos, laser-illuminated televisions, scanners and still cameras. Manufacturers include Texas Instruments, Bendix, Daedalus, HRB Singer, MDA, CCRS and Actrum.

6.2 Infrared sensors

Oil, being 'optically-thick', absorbs solar radiation and re-emits it as thermal energy, a phenomenon that makes oil detection by infrared sensing possible. Thick oil appears 'hot', or white in infrared representation, intermediate thicknesses appear cool, or 'black', while thin oil is not detectable.

Scanners with infrared detectors were largely used in the past, but today infrared cameras are the most common. The method, providing relative thickness information, is useful because it becomes possible to direct countermeasure equipment to the thickest sections of the slick. Oil detection in the infrared is not a definite method due to interference and subsequent identification of false targets. Such interferences include weeds, shoreline and oceanic fronts. Infrared sensing is, however, relatively inexpensive and is currently an important tool used by oil-spill remote sensors. Several commercial units are available, among which are those manufactured by Flir Systems, Honeywell, Lockheed, Aerosystems, Barr & Stroud, General Electric, Booth, Agema, and Hughes.

6.3 Ultraviolet sensors

Thin layers of oil-slicks display high reflectivity of ultraviolet radiation, in contrast to infrared radiation. Ultraviolet sensors are therefore suitable for mapping thin sheens of oil. Not surprisingly, overlapped ultraviolet and infrared images are often used to provide a relative thickness map of spills. Scanner data and push-broom scanners facilitate easy super-imposition of data and the production of IR/UV overlay maps. Ultraviolet cameras, although inexpensive, are not used to a great extent because of difficulties in such image overlapping. Like infrared, ultraviolet sensing is subject to many interferences and false images such as wind slicks, sun glints and biogenic material. However, because these interferences are often different from those arising from infrared sensing, the combination of IR and UV will frequently give a better picture of oil-spills than the one given by using either technique alone.

6.4 Fluorometric sensors

Fluorometric sensors exploit the property of some compounds in the oil to absorb ultraviolet light and re-emit part of this energy as visible rays. Since very few other compounds exhibit this behaviour, fluorescence is a strong indication of oil presence. Natural fluorescent substances, such as chlorophyll, fluoresce at wavelengths sufficiently different from oil to avoid erroneous identification. In addition, different types of oil give slightly different fluorescent responses, which under ideal conditions, makes a differentiation possible between, for instance, heavy and light oil. Despite the excellent promise of this technique, an ideal instrument has yet to be designed, but development continues, primarily on laser fluorosensors. Oldenburg, Italian, Barringer and British Petroleum are among the companies working with the development of such instruments.

6.5 Microwave and radar

Capillary waves on the ocean reflect radar energy producing a 'bright' image known as sea clutter. Oil on the sea surface dampens some of the small capillary waves, and the presence of an oil slick can thus be detected as a 'cold' sea, or the lack of sea clutter. Unfortunately, oil slicks are not the only phenomenon that can be detected in this manner. Interferences are many, including freshwater slicks, wind slicks, wave shadows behind land or structures, calm water above weed beds, glacial fluor, biogenic oils, ice, and whale or fish sperm. Radar is, despite these limitations, an important tool for oil spill remote sensing because it is the only useful sensing technique for large area searches and is one of the few that can be used at night and through clouds or fog. There are two basic types of radar that may be used in oil-spill and general environment remote sensing, Synthetic Aperture Radars (SARs), and Side-Looking Airborne Radars (SLARs), where the latter is the oldest and cheapest system. Standard military or ship radars have little, if any, application to oil spills. They may, however, be customized to be useful in tracking oil-spills and may then prove useful. Erickson, Motorola, EMI, CAL, Westinghouse, ERIM, Goodyear, JPL, and MDA are among the manufacturers of these radars.

Microwave Scatterometers and Microwave Radiometers Quite show similar properties as radars. A scatterometer is a device that measures the scattering of microwave or radar waves by the target surface. It has the advantage of nadir aspect, and has capabilities during aerial coverage similar to that of optical sensors. The chief disadvantages of the scatterometers and radiometers are the lack of positive identification of oil and the lack of imaging capability. Ryan and MPB are among the producers of these instruments. The Radiometer has been tested for years without success in oil-spill remote sensing.

7. Satellite remote sensing

Despite the quite common notion that satellites may detect every object of sizes down to that of an apple, there are several problems involved in using them for remote sensing, the most important limitation of which is the small frequency with which overpasses occur. Another is that most satellites rely on clear skies to perform optical work. These two factors combined give a low detection capability of oil-spills. This is illustrated well through the *Exxon Valdez* oil-spill case; although vast areas were covered by the spill for over a month, only one clear day and one satellite overpass occurred in conjunction in this period. A third disadvantage of satellite remote sensing is the difficulty in, and time needed for, developing algorithms for choosing the object of survey. Although the location was precisely known, it took more than two months before the first group managed to detect the *Exxon Valdez* spill in satellite images. From this, one is led to conclude that optical satellite imagery does not offer much potential for remote sensing of oil-spills. Available systems include NIMBUS, GOES, LANDSAT, SPOT, SEASAT, ERS-1, JERS-1, and RADARSAT. The last four of these are equipped with radar and may thus offer some potential for detecting big objects like large offshore oil-spills.

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General

Over the horizon

Oil and gas exploration and production in the Barent's Sea may be severely hindered by ice. Researchers at the Norwegian Polar Research Institute have found that the occurrence of large icebergs (exceeding one million tons) is far more frequent than has so far been assumed. While artificial islands are sometimes built as a base for oil-production facilities, this is unfeasible in deep waters. Thus, since no other fixed structures, such as gravity based platforms, can resist the impact from objects of this size, oil platforms must have the ability to relocate and have the means to assess when there is imminent danger of impact. The threat of icebergs is one of the main reasons that the arctic oceans, while containing unknown hydrocarbon resources, are still almost free of production activity. Another, but related issue is that the arctic environment is particularly sensitive to pollution.

Prediction of ice movement can be performed through a new system from Batelle, located in Columbus, Ohio, USA. A prototype of the system, which will be able to provide near real-time data in all weather conditions, is to be tested and evaluated by the end of 1991. The system combines microwave data, such as that from satellite synthetic aperture radar (SAR), with other observed data and gives it as input to an ice prediction model. It is claimed that SARs positioned on satellites in arctic orbit will be able to detect ice of sizes down to 6 metres, even in the dark or cloudy weather. The programme is a joint effort including several large US companies. (**Sea Technology**, January 1991, pp. 75-76)

Conferences

The First International Conference on Health, Safety and the Environment in Oil and Gas Exploration and Production is to be held in the Hague, Netherlands, from 10-14 November, 1991. Information can be gained by contacting the Programming Department, Society of Petroleum Engineers, P.O. Box 833836, Richardson, TX 75083-3836, USA.

Monitoring systems

MERMAID, Marine Environmental Model and Integrated Database, is a modelling and database software package developed at the University of Wales in Bangor (UK) with funding from the Admiralty Research Establishment at Portland. MERMAID combines modelling results with a database established from sea or air observation, where the database is used to calibrate and verify the model. Among others, the model and database shows the annual cycle of temperature and stratification of the northwestern European shelf seas. This is important information in instances of oil spills in the North Sea, since bottom and surface temperatures are important in assessing the rate of degradation and evaporation of oil. However, it is also important to know the surface layer thickness (through information of the stratification) in order to predict how the oil will spread both horizontally and vertically once conditions have been assessed after a spill. The hardware requirements are small, since the program runs on an ordinary IBM compatible personal computer. (**Offshore**, June 1990, p. 73)

A device for detecting suspended particles in the se is being developed at the Fisheries Laboratories of the United Kingdom Ministry of Agriculture, Fisheries and Food. The apparatus works by transmitting acoustic pulses (16 per second) and registering the back-scattering caused by dissolved particles. It is part of a submersible system with the prime purpose of estimating particle sizes in an effort to detect traces of radioactive heavy metals near discharges from nuclear plants. The device measures particle sizes only the composition is analyzed separately from samples. The range of the detector is at present approximately 120 cms. (**Electronics World**, March 1991, p. 259)

The National Oceanic and Atmospheric Administration (NOAA) in the United States has used a new climate model to predict that the northern hemisphere will be more affected by the greenhouse effect than the southern hemisphere. In addition, NOAA has predicted that the sub-polar southern will not experience any surface warming. The model couples atmosphere and ocean circulation models to investigate the impact of global warming. Dr. Kirk Bryan of NOAA attributes the difference between north and south to the fact that the southern oceans are larger than the northern and that they also have a more efficient downward mixing of heat, particularly in the vicinity of the Antarctic circumpolar current, which greatly reduces the warming of the ocean surface. The experiments on the models also revealed two major reasons for the rise in sea level caused by global warming. One is that the ocean expands due to increased temperatures. The other is that currents and amount of precipitation will lead to a redistribution of the actual amount of water, thus causing differences from region to region. (**Sea Technology**, February 1990, pp. 63-64)

NOAA will also start a programme aimed at assessing the profile of sea water and surface in the Pacific Ocean between the Galapagos Islands and New Guinea. The $2.5 million project, financed by the United States, France and Japan, will include the deployment of 65 monitoring stations that will transmit data back to the laboratory daily. The buoys, to be deployed by the end of 1992, will supplement 18 existing moored instrument buoys. The parameters to be measured include surface winds, air and water surface and column temperatures, relative humidity, two sub-surface pressures and salinity. The ultimate aim of the programme is to provide information for a climate change study. (**Sea Technology**, April 1991, p. 9)

Scientists at the Woods Hole Oceanographic Institute (WHOI) in the United States have raised questions however regarding the theory that the rise in sea level is attributable to global warming. They suggest that the cause of the rise, which presently appears to be about one millimetre per year, may be land movement and compression caused by volcanoes, faults and oil-drainage. In any case, such phenomena leaves scientists without a constant surface against which to measure actual changes of sea level. The common notion is that global warming causes ice at the poles to melt and the sea water to expand. The scientists, David Aubrey and K.O. Emery, have presented their findings in a book called *Sea Levels, Land Levels and Tide Gauges*. (**Sea Technology**, April 1991, p. 96)

Sampling water at great depths while preserving pressure at the sampling location has so far been accomplished by advanced and expensive specially made instruments that are complicated to use during large-scale testing. Such testing devices are important in instances when it is crucial to investigate the existence of dissolved gases or chemical, biological reactions in the sea water. Such experiments may have a role in the investigation of green-house effects, the suitability of ocean thermal energy conversion at the location hydrocarbon seepage, and the impact of dissolved gases on life in the deep seas. Michael Jordan of the Atlantic Foundation, Inc. describes three solutions designed to be user-friendly. The prototypes could be assembled in a hurry and from off-the-shelf components. A one litre sampler to operate down to depths of 1,000 metres weighs approximately 7 kilogrammes. (**Sea Technology**, March 1991, p. 47)

Environmental protection

The World Bank established a three-year agenda for action to combat environmental degradation in 1989. The agenda focussed on five specific issues: destruction of natural habitats; land degradation; degradation and depletion of fresh water resources; urban, industrial and agricultural pollution; and degradation of the 'global commons' such as atmospheric and marine pollution. The World Bank publishes annual reports on both the projects undertaken and the potential progresses that the organization could do, given sufficient funds to pursue additional projects. The programme is intended to bring the World Bank into the arena of important environmental matters, something it has been criticized for avoiding in the past. Two reports have been produced so far, namely *The World Bank and the Environment, Fiscal 1990 and 1991*. (**Marine Pollution Bulletin**, February 1991, p. 95)

A new oil skimming system has been proposed by two Texas inventors, Lynn Thomas and Bud Wailsath. The system, named MOSRAM, is claimed to be able to skim approximately 1.2 million barrels (approximately 200,000 tons) of liquid a day from the sea, and that about half, or 100,000 tons of this, would be oil. The system is based on a collection box mounted on a modified dredge with a Y-shaped boom in front of the collector box. The collector box is fitted with sensors and moving plates that ensure that only water containing oil is picked up. The fraction of water in the collector could thus be reduced from up to 90 per cent to 50 per cent. The oil water mixture is then sent through twelve Vortoil hydro-cyclones, developed at Southampton University. These hydrocyclones direct the oil-water mixture into a tapered, spiral tube at high velocity. The water is thrown to the sides of the cyclone and pushed towards an outlet where the diameter is small. The oil particles form a core that is pushed out from the thick end of the cylinder. Separate on-shore tests have shown that this technology can reduce the oil in the mixture from 14.5 per cent to 500 parts per million. The whole system is claimed to be operable in 6 foot waves and will cost approximately $20 million. (**Offshore**, June 1991, p. 29)

The best way to prevent oil spills from large crude oil carriers have so far been thought to build the vessels with double hulls. In cases of groundings or collisions, the double hull would provide a buffer zone to prevent leaks from the oil tanks. However, this solution has disadvantages in cases of large accidents that would rip through both hulls. Mitsubishi Heavy Industries has proposed an alternative solution, which they claim is better than the double hull concept. They suggest that the vessel has a mid-deck, that is a lower and an upper oil storage tank. In this case, a rupture of the bottom tank would not lead to oil leaks, since the column of oil in the lower tank would be lower than the water column outside, and the hydrostatic pressure inside the tank would be less than outside. Thus the water would cause an inward pressure on the oil tank and no oil would be pushed into the sea. Ballast tanks are placed on the sides of the vessel in order to buffer collisions. The Japanese company is currently lobbying to have this solution termed an acceptable alternative to double hull vessels in lieu of the new US Oil Pollution Act. The fabrication cost is said to be about 25 per cent higher than for a single hull vessel, and 1 to 2 per cent less than that of a double hulled vessel. (**Marine Log**, January 1991, pp. 40-41) Intertanko has already stated that this solution could work just as well as, or better than, a double skinned vessel. (**Offshore**, June 1991, p. 29)

Algal blooms have been a problem on beaches surrounding the Adriatic Sea, making the water unattractive to tourists. Vikoma International Ltd. of the United Kingdom has proposed a method to address this problem. The company suggests that floating booms may be positioned outside beaches, particularly at the outlet of lagoons. These booms will in normal circumstances rest deflated on the sea bed, but can be inflated and elevated to the surface in the event of excessive algae activity. The boom will be connected to a 0.7 metre wall of neoprene and a 3 metre long net, which together prevent the algas from entering the beach area. The method is a short-term solution to meet the challenge of algal blooms, which occur in warm and light-abundant surface waters under certain conditions. (**Sea Technology**, August 1990, p. 66)

The International Convention on Oil Pollution Preparedness, Response, and Co-operation was signed by 90 countries after a meeting held in London from 19-30 November 1990. The Convention, a result of an initiative by major industrialized nations, recognized the fact that the combating of severe oil spills requires international co-operation. It puts particular emphasis on three issues: oil pollution emergency plans, response systems and international co-operation. Among others, it requires vessels transporting oil to have detailed plans in the event of pollution emergencies. It further requires involved parties to report pollution occurrences to the International Maritime Organisation and to any party State that is likely to become affected by the pollution. The Convention also encourages the establishment of national and regional contingency plans, including the stationing of oil spill combat equipment. It also details several areas for international co-operation, including joined efforts in R&D in technological areas. The Convention will enter into force 12 months after the ratification by 15 party States. (**Marine Pollution Bulletin**, April 1991, p. 52)

Notebook

A curiosity: **Aanderaa Instruments** has deployed an experimental monitoring buoy in the sea outside Steilene in the fjord of Oslo, Norway. Among the parameters measured at the buoy are sea and air temperatures, sea level, wind speeds and direction, humidity, barometric pressures, wave heights and frequency, sight and precipitation. The buoy transmits vocal messages in Norwegian through the commercial telephone system. It can be reached on 47-2-603696 at no charge beyond the cost of an ordinary telephone call.

Norway Exports – Environmental Technology and Services is a presentation of Norwegian companies supplying equipment and services for protection and monitoring of the environment. The companies and addresses are presented together with their profile and products. The publication is available free of charge from **The Export Council of Norway, Drammensveien 40, N-0255 Oslo 2, Norway**

Bacteria may be the solution to cleaning up large oil spills. Dr. Edward Bouwer of the Hopkins School of Engineering says that common bacteria found in oil and sewage chew on the oil and break it down to more primary elements such as carbon and energy. There is always bacteria present that will help degrade the oil. However, in cases of large spills there will be an overload on the natural population of bacteria and the existing organisms need to be encouraged to grow through the use of fertilizers and nutrients, a technique called bioremediation. In addition to nurturing native bacteria, however, there have also been experiments aimed at creating 'superbugs' which, when placed at the scene of a spill, will be more efficient in degrading the oil. The problem has been that these bacteria have not survived long enough in the often harsh environments that exist at the scene of a spill. In open waters, mechanical booms and skimmers remain the best ways to fight spills. (**Sea Technology**, March 1991, p. 71)

Information on a report on the use of bio-remediative techniques in cleaning oil spills, with a particular reference to the clean-up after the *Exxon Valdez* disaster, can be gained from **Technical Insights Inc, P.O. Box 1304, Fort Lee, NJ 07024-9967, USA.**

Environmental Consequences of Deep Seabed Mining is a book published by the Fridtjof Nansen Institute of Norway. The book, which is the result of a request by the United Nations Office of Ocean Affairs and Law of the Sea, covers both technological, legal and policy issues regarding the impact on the environment from deep sea bed mining, notably mining for polymetallic (manganese) nodules at the sea floor. The book can be ordered through **The Fridtjof Nansens Institute, Fridtjof Nansens Vei 17, N-1324 Lysaker, Norway.**