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International Atomic Energy Agency

Marine Environment News

A newsletter of the IAEA Marine Environment Laboratory, Monaco
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International Conference on Isotopes in Environmental Studies — AQUATIC FORUM 2004 — Monaco, 25–29 October 2004

Contents

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Director's introduction

Aquatic Forum 2004

Welcome to our 4th issue of the Marine Environment Newsletter. In October 2004, MEL hosted a very successful *International Conference on Isotopes in Environmental Studies – Aquatic Forum 2004,* organised together with IAEA's Isotope Hydrology Section and co-sponsored with the IOC and the International Hydrological Programme of UNESCO, Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranée, and the Abdus Salam International Centre for Theoretical Physics. The Conference was opened by HSH Prince Albert of Monaco and attended by almost 400 participants from 78 countries and 7 international organizations. The conference received important presentations on radionuclide processes in the sea, and many new and diverse applications of tracers to assess ocean climate coupling, ocean circulation, ground water cycling, coastal pollution, and toxic algal blooms were presented. The conference proceedings are expected in June.

Tsunami

The devastating impact of the Indian Ocean tsunami disaster has galvanised UN humanitarian agencies to assist affected Member States (MS) in their relief operations. United Nations Environment Program is advising MS about ecologically sustainable rehabilitation of the coastal zone and the Intergovernmental Oceanographic Commission (IOC) of UNESCO is now coordinating a Tsunami Early Warning system for the Indian Ocean. We considered marine radioecological assessments of affected coastal zones with nuclear facilities but this was deemed unnecessary since reports received from MS indicated there was no damage or radioactive leakage from any coastal nuclear facility in the affected areas. However, the risks from chemical pollution from tsunami damage to coastal industrial and infrastructure facilities remain unassessed. In the longer term, MEL is considering the feasibility of using isotope-dated sediments to reconstruct the frequency and magnitude of past tsunami events.

Prince Rainier III of Monaco

We were greatly saddened by the passing away in April of HSH Prince Rainier III of Monaco. Prince Rainier had significantly extended Prince Albert I's pioneering oceanographic activities (eg the Musée Océanographique) with a visionary initiative to champion and host the IAEA's Marine Environment Laboratory (MEL) in Monaco in the early 1960s. He recognised the urgent need for new science to reliably measure, assess and advise UN Member States on the effects of chemical and radioactive pollution on marine ecosystems. In 1998, Prince Rainier and our Director General Mr Mohamed ElBaradei jointly inaugurated our unique state-of-the-art facilities

in Quai Antoine which, to this day, remain the UN's only marine research laboratories. The world class research, publications and international collaborations achieved by MEL in Monaco is our legacy to Prince Rainier's enduring environmental partnership with the Agency. We offer our deepest sympathies to Prince Albert II and his family.

New Head for Radiometrics Lab targets coastal contamination & climate change

I would like to formally welcome Joan-Albert Sanchez-Cabeza as our new Section Head for Marine Radiometrics Laboratory. He joined the Agency in September 2004, coming from the Universitat Autònoma de Barcelona (UAB), where he was Director of the Environmental Radioactivity Laboratory and in charge of Environmental Sciences Studies. With over 20 years experience in research, his work has been devoted to many aspects of environmental radioactivity, with emphasis on the use of environmental radiotracers to understand and quantify environmental processes. He has published over 60 papers in international journals, including articles on atmospheric fluxes, river transport, dispersion in the marine environment (including modelling), particle fluxes and the study of the sedimentary record for reconstructing the history of pollution from urban areas or other specific sources. Joan-Albert has a long record of collaboration with the Agency, and has participated in various Technical Cooperation projects, acted as scientific collaborator on several international projects and as reviewer for the Agency's environmental activities. In 2000 he was appointed the IAEA's expert on GESAMP, the UN Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection. During this new research period, entered into with high expectations and much optimism, Joan-Albert expects to implement new techniques for the use of radiotracers in the marine environment and to collaborate with laboratories around the world, sharing their fascination for marine issues. New challenges include the use of environmental radiotracers in global climate studies and the study of coastal processes.

Prof. Joan-Albert Sanchez-Cabeza (seated left), new Radiometrics Laboratory Head, with his team.

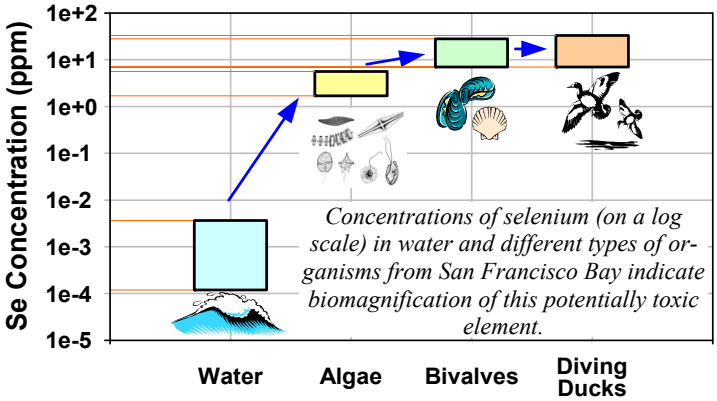
Pavel Povinec retires after 11 years of distinguished service

Pavel Povinec (left on photo, with MEL Director) joined the Agency in January 1993 as Section Head of MEL's Radiometrics Laboratory. He acquired his nuclear and environmental background at the University of Bratislava (Slovakia), where he was Vice-Dean of the Faculty of Mathematics and Physics, Head of the Physical Faculty and Head of the Department of Nuclear Physics (where he discovered for example the 11-year solar cycle in ^{14}C record in wines, published in Nature). At MEL he engaged in major Agency projects concerning the radioactive contamination of the marine environment. He started, in collaboration with over 30 laboratories, an international project on worldwide marine radioactivity studies. The project received a substantial extrabudgetary support (almost 5 millions US $) from the Government of Japan to cover organisation of sampling expeditions, analyses of collected samples, construction of new laboratories, and cost free experts. Within this project, Pavel organised an expedition to the NW Pacific Ocean, 'IAEA 1997', which was the first expedition to the open ocean fully organised and financially covered by the Agency. A special issue of the journal Deep Sea Research published the project's findings on the distribution, inventories and behaviour of radionuclides in the world ocean. The underground counting laboratory recently constructed at MEL with support from the Government of Monaco is also a by-product of this project. Pavel organised many prestigious international conferences. He published in peer-reviewed journals over 300 scientific papers on isotopic investigations of the marine and terrestrial environment. Pavel greatly contributed to the visibility of MEL in the Agency as well as in the scientific world through wide co-operation and assistance to our Member States.

R. Fauzi C. Mantoura, *F.Mantoura@iaea.org*

Guest Article: Selective biomagnification of metals and radionuclides in marine food chains

Concern over the presence of contaminants in the environment stems from the toxic actions they may exert on living organisms, including humans. Hence, there is considerable interest in assessing the extent to which different contaminants are bioaccumulated out of water by aquatic organisms. In recent years, the importance of the trophic transfer of contaminants in marine systems has been reco gnized in terms of influencing metal concentrations and effects in animals and their human consumers, and as a process with important implications for the geochemical cycling of metals. While much work has already evaluated the uptake of metals and radionuclides by marine organisms, there has been relatively



Concentrations of selenium (on a log scale) in water and different types of organisms from San Francisco Bay indicate biomagnification of this potentially toxic element.

little work on the important issue of biomagnification of metals in marine food chains. This issue is of interest to environmental managers, toxicologists, and public health personnel since risk analyses have shown that consumption of seafood is a major route of exposure of humans from marine contaminants.

Biomagnification occurs when a contaminant is present at higher concentrations in the tissues of a predator than in the tissues of its prey, resulting from greater assimilation of metal from food than loss from the predator's tissues. Contaminants that display biomagnification are most likely to attain toxic concentrations in harvested organisms and therefore present greater risks to consumers of seafood than contaminants that do not biomagnify. Recently, evidence has emerged for certain food chains that indicates that biomagnification may occur for some potentially toxic elements, including cadmium, zinc, silver, polonium, and the metalloid selenium (Se) (see chart). Explanations for variations in assimilation efficiencies of ingested metals have centered on the cytological location of the metal in the prey organism; numerous studies with diverse species suggest that metals (and other elements) in the cytoplasm of ingested cells, probably in organic form, display assimilation efficiencies commensurate with the extent of penetration of the metal in the cytoplasm. Mechanistic explanations for efflux rates out of a predator's tissues have not been precisely elucidated.

Recent data suggest that metals bound to protein (e.g., mercury, cadmium, selenium, polonium) are likeliest to display biomagnification, but no systematic assessment has yet been performed to evaluate biomagnification among different kinds of metals in marine food chains. Experimental protocols to evaluate assimilation efficiencies and efflux rates in marine organisms, primarily using gamma-emitting radioisotopes, are now well established. Such experiments are now being performed at MEL to compare Class A, or oxygen-seeking, and Class B, or sulfur-seeking, metals in diverse phytoplankton/zooplankton/fish combinations. From these, patterns among different types of metals can be explored to assess the extent of metal biomagnification. Complementary studies are exploring the biochemical association of these metals in animal tissues. Laboratory findings and model predictions are also being compared with evidence of biomagnification of metals from field studies.

The IAEA Marine Environment Laboratory is in a unique position to pursue these studies and has all the necessary sampling, analytical, and experimental equipment for such work. The results could have important implications for assessing the extent to which different marine food chains could transfer metals to higher organisms, including humans.

Contributed by Dr. N. Fisher, U.S.A.

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This article represents a personal view and does not necessarily reflect the views of the IAEA

MEL joins international study in the South Pacific

The Radioecology Laboratory of MEL participated last fall in a major sampling expedition in the South Pacific to study the biological, biogeochemical and bio-optical properties of different trophic regimes. The area surveyed is one of the less studied, major oceanic entities of the world ocean, and presents the interesting particularity of being remote from any terrestrial dust source which can play a fertilization role in the oceans. The sampling covered the rich eutrophic zone associated with the upwelling regime off the Chilean coast, the poor oligotrophic area associated with the central part of the South Pacific Gyre, and the mesotrophic area associated with the plume of the Marquises Island. The project, named BIOSOPE (Biogeochemistry & Optics South Pacific Experiment) is supported by the French Research Council (CNRS-INSU), IGBP-SOLAS (Surface Ocean Lower Atmosphere Studies), and the two space agencies, NASA and ESA. It involves scientists from France, USA, Chile and the IAEA. MEL's contribution to the project is the study of carbon export in the contrasting environments visited during the cruise. This was done through direct measurement of particles using drifting sediment traps and by estimating particle removal rates from surface waters by measuring the associated disequilibrium between ^{234}Th and its conservative parent ^{238}U.

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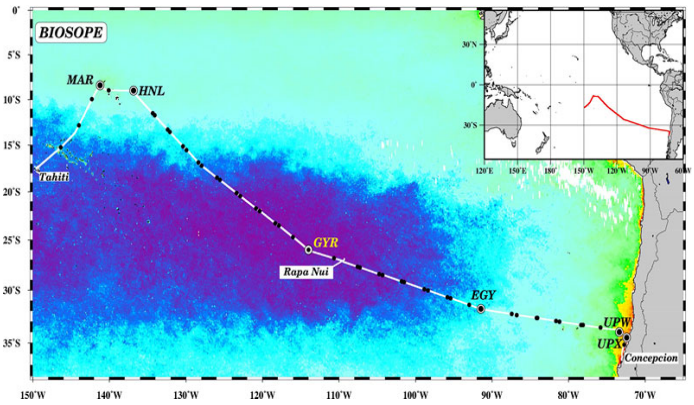

Sampling track of Biosope cruise overlaid on SeaWiFS satellite image of ocean productivity (BIOSOPE-PROOF).

The French research vessel "Atalante" offshore Easter Island (Credit J.C. Miquel).

Charting radionuclides in the World Ocean

The IAEA's Marine Information System (MARIS), developed by the MEL in Monaco and implemented on the web by IAEA's IT division, is a relational database based on GIS software. MARIS covers the marine distribution of radioactive and stable isotopes and, in the near future, other tracers such as organic compounds and trace metals. The database also contains oceanographic parameters such as seawater temperature, salinity and bathymetry. The map in Fig. 1, generated by MARIS, shows the first set of sites (red dots) for which MARIS contains data on radionuclides in marine samples. New data sets continue to be added. MARIS is accessible at http://maris.iaea.org/

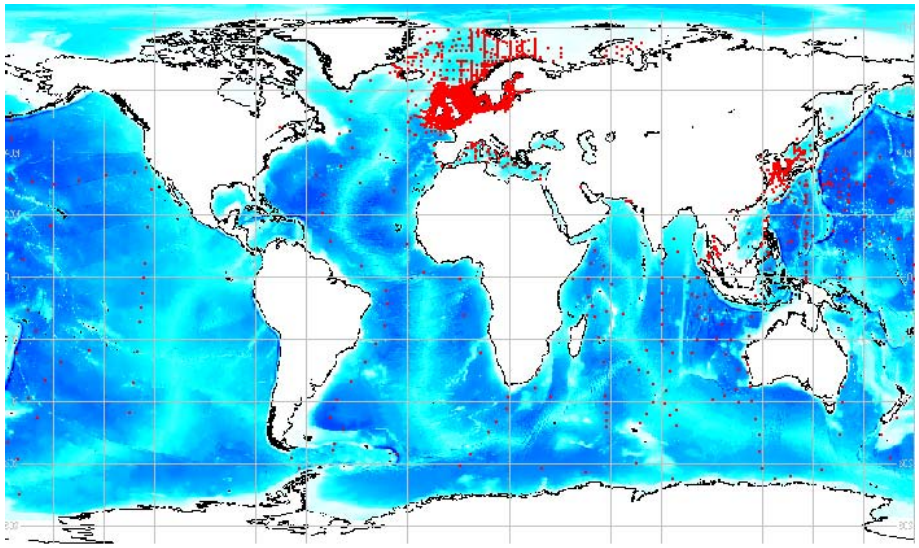

Figure 1. World map showing sampling sites for the sets of data accessible to date through MARIS

Main Objectives

The first objective of MARIS is to provide information on the radioactive contamination of the marine environment. MARIS contains data on the most important radionuclides in the world's oceans and seas, specifically in seawater, particulate matter, biota and sediment. These data originate from published scientific papers, reports and databases created within institutes or scientific programmes in Member States and can be used with appropriate quotation of sources and references. Quantification of contributions from the sources of radionuclides in the world's oceans and seas, computer modelling of the dispersion of radionuclides and radiological assessment studies, require that IAEA Member States be provided with information on the past and present levels of radionuclides in the marine environment. The data provided by MARIS serve as the international reference source on radionuclide contamination of the marine environment so that any further eventual contributions from the nuclear industry, radioactive waste disposal, nuclear weapons test sites and possible nuclear accidents and/or unathorized discharges can be identified.

The second objective of MARIS is to provide information on the distribution of radioactive and stable isotopes, trace metals and organic compounds in the world's oceans and seas which could be used as tracers in the investigation of marine processes. This part of the database will grow substantially in the near future, so that data on all-important oceanic tracers will be available to IAEA Members States for oceanographic investigations. The data stored in MARIS can be used for water and sediment dynamics studies, investigation of processes in the water column, seawater-sediment interactions, seawater-groundwater interactions, etc., as well as for validation of models used in climate change studies. Data on supporting oceanographic parameters such as bathymetry and seawater temperature, salinity are also included in MARIS.

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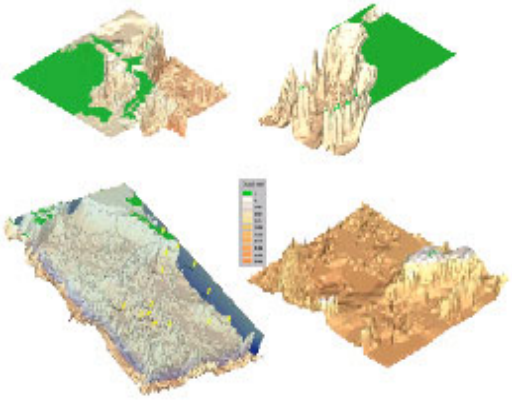
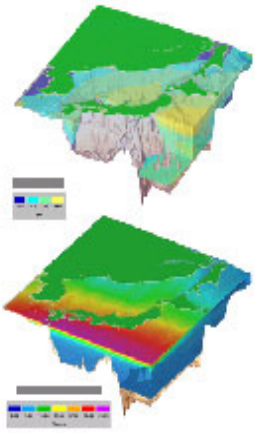
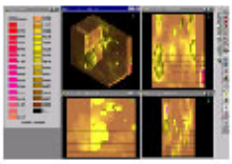
Typical outputs of MEL's GIS



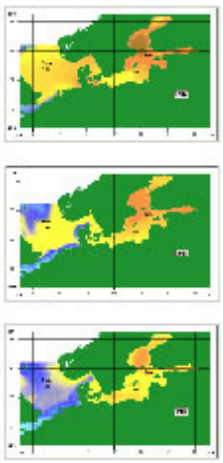
Illustrate bathymetry in support of planning sampling cruises



Analyse ocean parameters such as temperature, salinity, etc.



Investigate concentration levels in sediment and water samples



Carry out statistical analyses and create time series of concentration maps, scenarios, etc.

Exploratory fish radioecology

There are still many unanswered questions in marine radioecology! The marine environment contains a diverse array of life forms, many of which have received scant and inadequate attention with regard to our ability to predict direct toxic impact of contaminants on them or their capacity to bioaccumulate radionuclides and other contaminants, and potentially transfer them to humans. One such group of relatively understudied fauna includes the rays and particularly the sharks (*Chondrichthys*), that have physiological and anatomical characteristics, such as the possession of a cartilaginous skeleton, which are quite different from the much better-studied bony fishes (*Teleostei*).

The sharks and rays are important in commercial and artisanal fisheries, several species are thought to be endangered by pollution, and their particular biological characteristics could make marine contaminants particularly detrimental to them.

This broad question is being probed with exploratory laboratory studies to assess the capacity of these organisms to bioaccumulate some radionuclides that are important contaminants associated with nuclear activities and radiotracers of heavy metals typically found in mining, industrial and urban effluents that may be released into coastal environments. This study began with a common Mediterranean and Atlantic fisheries shark species - the spotted dogfish. Its bioaccumulation behaviour was compared with that of the turbot, a bony fish of similar size and feeding habits, and also an important edible species.

The first results are showing some quite distinct differences between the two 'fish models'. Most of the tested radionuclides are concentrated to a greater degree in dogfish than in turbot during short-term experimental exposure, suggesting its potential as a bioindicator and its potential role as a non-negligible source of radionuclide and metal intake for its consumers. For example, ^{241}Am (Fig. 1) and ^{65}Zn show the most extreme contrast in rates of bioaccumulation, both being a factor of about 100 greater in dogfish than turbot. In contrast, ^{134}Cs is accumulated at a greater rate in turbot (Fig. 2). Together these first results draw a distinct contrast between the two species in their bioccumulation behaviours, that could be representative of their respective taxonomic groups. Tests on additional species will be needed to confirm this hypothesis!

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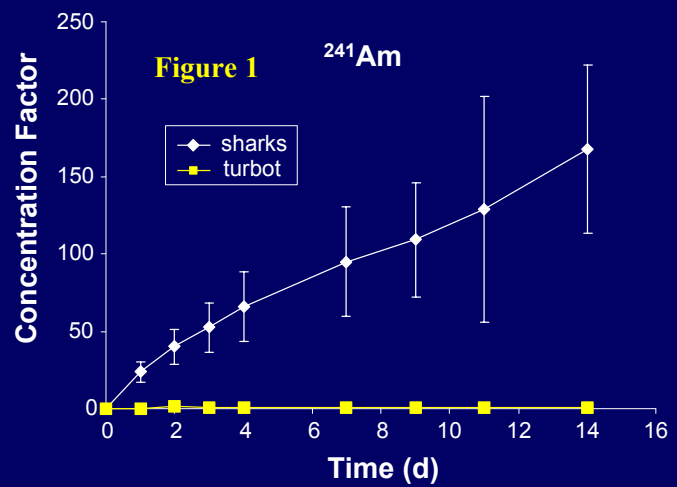

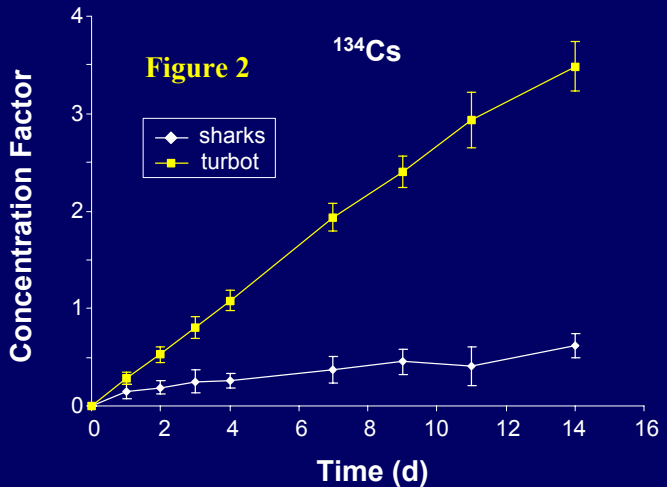

Inter-Agency collaboration in the study of marine pollution

The Marine Environmental Studies Laboratory (MESL) at MEL is the only marine laboratory in the UN system with the operational capacity to investigate non-nuclear pollution in the marine environment. As a result, other UN and Regional Organisation have called upon the expertise and experience of the laboratory to assist with the assessment of marine pollution. Presently MESL has partnerships with several Regional Seas Programmes and GEF International Waters Projects. Recent and current collaborations are described here

UNEP-MAP-MEDPOL

MESL has now worked with the Mediterranean Pollution Programme, part of UNEP's Mediterranean Action Plan, for 30 years. The assistance to MEDPOL has changed with the evolution of MEDPOL into a mature Regional Seas Programme. Technical support to Phase III (1996-2005) has focussed on the provision of an external data quality assurance programme. Also, an extensive capacity building programme was undertaken in the course of Phase III, ensuring that laboratories in the region were equipped with suitable instrumentation for the determination of metals and several organic contaminants. There have been a number of support activities provided to the MEDPOL laboratory network to help obtain high quality, validated data for marine pollution assessments. MESL annually organizes regional interlaboratory studies and hosts training courses in Monaco (Figure 1). Staff contribute to the development of protocols, for instance the determination of nutrients and phytoplankton pigments. Expert advice is given through communications with individual analysts in regional laboratories for trouble shooting analytical problems and via the participation of IAEA experts at MAP meetings and Mediterranean conferences. One topical example is the assistance of MESL in helping formulate the MEDPOL Phase IV programme that will start in 2006.

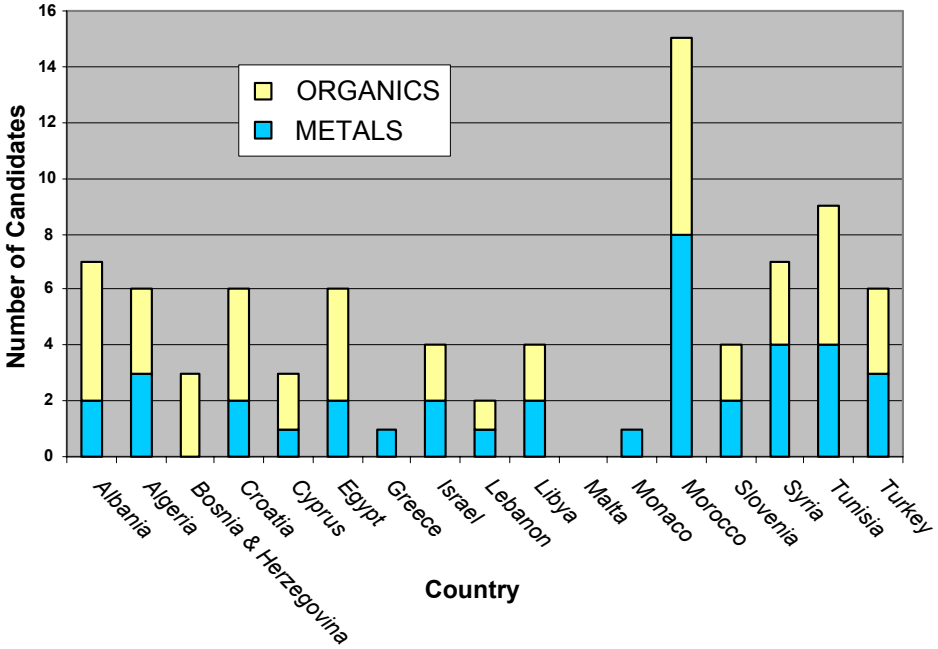

Figure 1. Participation from different countries in MEDPOL-sponsored training courses for the analysis of organic contaminants or metals in marine samples, held in Monaco during 1998-2004.

ROPME

The Regional Organization for the Protection of the Marine Environment (ROPME) serves as the secretariat to oversee the Kuwait Convention and Action Plan. MESL has collaborated with ROPME throughout the Gulf region and in the Gulf of Oman since the early 1980s. A notable ongoing activity involves contaminant-screening surveys of coastal water (both sea surface microlayer and bulk seawater), sediments and biota (fish and bivalves) for a suite of inorganic and organic pollutants. The consequent pollution assessments are published in the international literature and lately included a regional study of tributyltin, the antifouling biocide used in many marine paints. Five concurrent surveys are planned in 2005. MESL has operated a longstanding quality assurance programme for the region. Site visits were undertaken to Bahrain, Iran, Kuwait, Oman, Qatar, and the United Arab Emirates in order to assess infrastructure and training needs. Separate training courses for the analysis of metals and organic contaminants have been undertaken in all these countries, including Saudi Arabia but excluding the UAE. MESL periodically organises regional laboratory studies for the ROPME laboratory network and produces regional reference materials.

Black Sea Ecosystem Recovery Project

The MESL assistance to Phase 1 of the GEF UNDP/UNOPS Black Sea Ecosystem Recovery Project (BSERP) comprised three main components: data quality assurance, analysis of sediment core samples and the provision of expert advice. An expert visited laboratories in Turkey, Romania, Bulgaria, Ukraine and the Russian Federation to appraise the current state of infrastructure, equipment and staff for measuring nutrients, metals and organic contaminants in marine samples from the Black Sea. An overview of quality assurance and quality control (QA/QC) procedures was gained in order to make recommendations regarding capacity

building and training requirements. Three proficiency tests of laboratories in the Black Sea region were conducted, dealing independently with the analysis of nutrients, organic contaminants (petroleum and chlorinated hydrocarbons) and metals. Sediment cores, collected from seven sites in the Black Sea, were analysed for metals and chlorinated hydrocarbons in marine samples. Regarding pollution assessment of metals, Cu, Hg, and Ni showed evidence of contamination. Whereas there was no contamination of PCBs, widespread pollution of DDT was evident. MESL is now preparing to continue this partnership into Phase II of the GEF Project.

Caspian Environment Programme

The Caspian Environment Programme (CEP) is an intergovernmental programme of the five Caspian littoral states, namely Azerbaijan, Iran, Turkmenistan, Kazakhstan and the Russian Federation. MESL collaborated with CEP on a GEF UNDP/UNOPS contaminant-screening project in the Caspian Sea.

Oil derricks in Baku Bay, Azerbaijan (Photograph by SJ de Mora).

During Phase I, an assessment of marine pollution was completed, producing some important and hitherto unknown findings that influence environmental management in the Caspian Sea region. Most notably, numerous locations in the coastal zone of Azerbaijan and Iran were contaminated with DDT-related compounds. Anthropogenic activities, notably mining, have enhanced the metal burdens in the sediments of the Caspian Sea, apparently explaining hot spots for copper and zinc in Azerbaijan and Iran. With the commencement of Phase II, MESL continues to assist CEP with the implementation of the project, particularly through the provision of expert advice and continued technical support in establishing a regional monitoring programme.

PERSGA

MESL has only recently started to work with PERSGA, the Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden. MESL staff and external experts visited countries in the region to assess national and regional capacity to undertake marine monitoring, and thereby provide recommendations for training and capacity building. They formulated a Regional Environmental Monitoring Programme (REMP), which included a four-year implementation plan. Finally, MESL hosted an advanced training course aimed at senior people involved in planning and implementing monitoring and assessment programmes in their own country. The purpose of the course was to give a broad background in marine pollution monitoring and demonstrate various chemical analyses.

UNDP Iraq Programme

MESL recently collaborated with the UNDP, ROPME and the Department for International Development (DFID UK) on a survey of shipwrecks in Kuwaiti and Iraqi waters. Sediments from the vicinity of 35 wrecks were collected by divers and shipped to Monaco for chemical analyses. The total oil content, several metals and uranium isotopes (235, 238) were determined in all samples. Also, detailed chemical analyses of petroleum hydrocarbons and chlorinated compounds, including PCBs and several pesticides, were undertaken for some samples. In general, no notable contamination was found other than some oil pollution near two wrecks. Further marine environmental studies in the region are anticipated, but contingent upon an improved security situation for UN undertakings in Iraq.

UNEP Regional Sea Programme

At the request of the UNEP Regional Seas Programme (UNEP-RSP), a review of the RSP was conducted. The four key objectives were to provide i) a review of ongoing monitoring and assessment activities in relation to the provisions of all the Regional Seas Conventions; ii) an appraisal of how monitoring and assessment lead to action as defined in the Conventions and their Protocols; iii) suggestions for a realistic and focussed strategy for monitoring and assessment in support of policies and actions of Regional Seas; and iv) recommendations for funding strategies. Although the report centred on the six UNEP Regional Seas Programmes (East Asian Seas, Eastern Africa, Mediterranean Sea, Northwest Pacific Ocean, West & Central Africa, and the Wider Caribbean), the recommendations would be broadly applicable to monitoring programmes under the auspices of other regional organisations. This report is available upon request from MESL.

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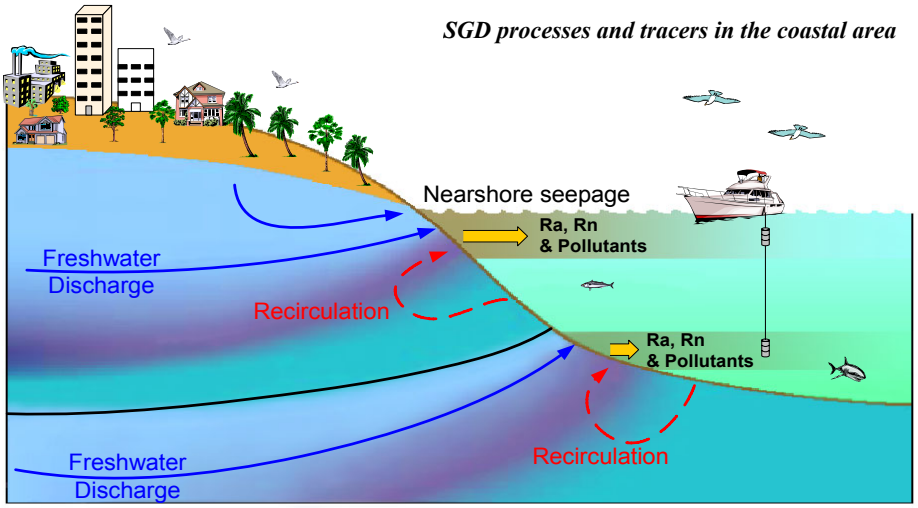
For news on MEL training courses, interlaboratory comparisons, reference materials and publications please see our website at http://www-naweb.iaea.org/naml/

IAEA and UNESCO coordinate studies on submarine groundwater discharge

The 2nd Research Coordination Meeting of the Coordinated Research Project (CRP) on "Nuclear and Isotopic Techniques for the Characterization of Submarine Groundwater Discharge (SGD) in Coastal Zones", combined with a joint IAEA-UNESCO coordination meeting on SGD was held in IAEA-MEL from 21 to 24 June 2004. The meeting aimed to review the present status of SGD investigations carried out by the participants, to plan collaborative activities, including missions and publications, and to prepare a joint IAEA-UNESCO progress report on investigation of SGD in coastal zones.

The CRP is coordinated jointly by IAEA-MEL's Radiometrics Laboratory and the IAEA's Isotope Hydrology Section in Vienna. The investigations, notably the field missions, were carried out together with UNESCO's Intergovernmental Oceanographic Commission and the International Hydrological Programme. CRP participants from Brazil, Italy, Japan, Russian Federation, Slovenia, Turkey, and USA, together with four experts from USA supported by UNESCO, presented results obtained in the framework of the project, notably from a 2003 expedition to the Brazilian coast offshore Santos. The latter will be published in a special issue of the journal Estuarine Coastal and Shelf Science. At the meeting, based on the criteria established for SGD intercomparison experiments, Mauritius was selected as study site for the final expedition of the project, which was undertaken during March 2005.



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Collaborative research on "Nuclear and Isotopic Studies of the El Niño Phenomenon" launched in 2004

The socio-economic aspects of El Niño Southern Oscillation (ENSO) on both the marine environment and the Earth's climate have been regarded as a very important environmental phenomenon, having significant regional and global effects. It has been recognized that corals archive isotopic records in their annual growth bands and therefore could be used for the reconstruction of past ocean temperature records if an appropriate absolute chronology of their growth could be established. When completed, this will enable sea-surface temperature and the frequency and intensity of past El Niño events to be reconstructed for different locations and so permit better predictions of ocean-atmosphere coupling in the future.

IAEA has launched the Coordinated Research Project (CRP) "Nuclear and isotopic studies of El Niño phenomenon in the ocean", in which 13 laboratories from 10 Member States participate. The first meeting of the CRP took place at IAEA-MEL between 25 and 29 October 2004 and it was attended by 19 experts from 10 countries. Prof. Robert Dunbar (Stanford University) served as Chairman of the CRP. The purpose of the CRP is to apply the latest knowledge and techniques concerning chemical and isotopic methods to the study of the history of ENSO (El Niño-Southern Oscillation) and its inter-ocean linkages extending from the Pacific basin into the Indian Ocean and back in time beyond the instrumental era. CRP activities focus on two objectives: i) advancement of CRP scientific goals related to ENSO and interannual variability and ii) education, outreach, and technology transfer among CRP member countries. These objectives will be achieved through the participation in common field expeditions, training activities and scientific meetings. The first planned activity is a coral sampling expedition to Indonesia.

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