Monitoring the marine environment

IAEA's Laboratory at Monaco offers valuable instruction in measuring contaminants in the sea

by S.W. Fowler, E. Holm, and L.D. Mee

The IAEA's International Laboratory of Marine Radioactivity (ILMR) at Monaco trains nationals of Member States in advanced technical aspects of measuring radioactive and non-radioactive marine contaminants in the sea and their possible transfer to man.* Because the field of marine pollution is so multidisciplinary in nature, training provided at Monaco is quite broad in scope.

The primary requirement of most nationals entering the field is the need to learn how to properly survey or "monitor" the marine environment adjacent to a proposed or existing nuclear facility in a beneficial and cost-effective manner. The number of available local personnel is often limited; therefore, it is important to know precisely what to monitor, how to take measurements, how often and, ultimately, how to interpret the data. To adequately carry out such work, one must have a good knowledge of marine radiochemical and biological methodologies. The radiogeochemistry and radioecology sections at ILMR provide specialized training in these areas.

How radionuclides are bio-accumulated into marine food chains and to what degree they may be passed on to man is the focus of marine radioactivity monitoring programmes and surveys. ILMR's radioecology section conducts a food chain programme in an effort to help answer these questions. Trainees and fellows are routinely integrated into these activities to learn animal culture and maintenance techniques, methodologies for assessing the potential of various organisms to bio-accumulate radionuclides, and standard counting techniques for measuring radionuclides in live marine species. This type of "hands on" training allows trainees to better predict the movement and biological transfer of radionuclides in typical food chain species existing in their local waters.

Messrs Fowler, Holm, and Mee are Heads of the Radioecology, Radiogeochemistry, and Marine Environmental Studies Laboratories of the IAEA's International Laboratory of Marine Radioactivity, 2 avenue Prince Héréditaire Albert, MC-98000 Monaco.

* For a general report on the ILMR's work, see *IAEA Bulletin*, Vol. 29, No. 3 (1987).

Radioecological programmes

Current marine radioecological programmes also seek to identify potential species which have special abilities to accumulate select radionuclides to relatively high concentrations which are then easily measured by standard radiometric techniques. These "sentinel" species thus serve as rapid biological indicators of radioactive contamination which might otherwise go unnoticed due to the time required to perform lengthy, sophisticated analyses for low levels of radioactivity in sea water. Trainees in this field learn the merits of different types of such "bio-indicator" species and concentrate their work on the types found in their local waters. Field collection and maintenance techniques for such species are emphasized. Environmental and biological factors such as salinity, temperature, light, season, growth, reproductive stage, sex, and size can significantly alter radionuclide bio-accumulation patterns and rates in these organisms. Therefore, importance is placed on methodologies for delineating these effects.

The radioecology training programme also focuses on teaching field techniques for collecting biological materials, including live species. Frequent field trips and cruises on two ships belonging to the Oceanographic Museum, Monaco — the *Winnereta Singer* and the *R/V Physalie* — are conducted. Once aboard, IAEA trainees and fellows learn a variety of standard oceanographic collection techniques which include use of phytoplankton and zooplankton nets, midwater trawls for larger shrimp and fish, and benthic dredges for species living on and in the bottom sediments. Trainees are instructed in the proper handling and maintenance of live species destined for laboratory studies as well as contamination-free preparation of biological materials for low-level environmental analyses. Recently, ILMR personnel have become experienced in deploying sophisticated, time-series sediment traps in deep waters to sample the small biological particles which carry radionuclides downward towards the sediments. Such studies apply directly to many radionuclide monitoring programmes in coastal ecosystems.

The Monaco Laboratory is particularly well-suited to carry out field and laboratory training in biological tech-

niques because of its proximity to the sea, its ready access to oceanographic ships for collection of materials, and its variety of sea water aquaria for experimentation. Training capabilities are expected to improve considerably following ILMR's recent move to new laboratories.

Radiochemistry training

The radiogeochemistry section of ILMR offers a broad-based field and laboratory training programme with emphasis on low-level radionuclide detection in environmental materials. The key to proper measurement in all marine environmental monitoring studies is usually found in the choice of the analytical method. The method can be at times relatively simple, but more often in environmental studies, advanced techniques involving radiochemical separations of environmental samples and sophisticated nuclear spectrometry are necessary. Training covers a wide variety of chemical separations of gamma-, beta-, and alpha-emitting radionuclides as well as the different nuclear techniques used to measure them. The training is tailored to enable participants to become sufficiently familiar with reliable radiochemical methodologies so that they can return to their home laboratory and properly carry out the measurements in on-going national programmes. If this objective is achieved, then the quality of their data is normally automatically ensured. Programmes which demand such high quality data include monitoring in the vicinity of nuclear facilities, monitoring of radioactive substances originating from transboundary exposure, and the use of radioactive substances in geochemical studies. These projects are often an important part of the Agency's technical assistance programme.

Marine radiochemical training requests from Member States have focused on increasing the capability to analyse actinide elements, chiefly the plutonium isotopes and americium-241. ILMR's many years of experience in the field of transuranic nuclide measurements have made this type of training attractive to Member States. Experience has shown that such analyses are time-consuming and extremely difficult to accomplish without proper training. Emphasis is generally geared to the countries' requests. In the case of the actinides, however, the training is more likely to be useful in marine geochemistry studies than in making routine monitoring measurements around nuclear facilities. Following the Chernobyl accident, there was a noticeable increase in interest in learning state-of-the-art gamma spectrometric techniques for marine monitoring.

General guidance is given routinely in the proper choice of instrumentation for beta-measurements, and alpha- and gamma spectrometry, as well as where necessary items can be purchased for the radiochemical operations, such as radiochemical yield determinants. Assistance is also given in the design and construction of electro deposition units, preparation of sources, calibration of spectrometers, and evaluation of data.

Trainees normally spend between 3 and 12 months at ILMR depending on their level of education and prior experience; this is generally sufficient time to become competent with the required analytical methodology. Most who have spent at least 1 year at ILMR have become involved in a specific scientific project to learn first hand the relevant applications of each method.

An important aspect in the field of marine radioactivity measurements is the need for standard reference methods and careful quality control in the laboratory. Methods currently in use internationally often require rather expensive chemical reagents which must be carefully selected and obtained from a limited number of suppliers worldwide. Trainees are therefore urged to recognize these potential difficulties. They are also made aware of the availability of reference materials and the ILMR quality control service programme.

Follow-up assistance

Follow-up to the radiochemical and radioecological training given at Monaco is also a factor in the eventual success of the trainee. Often after the trainee returns home, ILMR staff are sent to the Member State to assist in establishing the analytical methodologies and carrying out the measurements under local conditions. They provide a combination of instrument trouble-shooting, improvisation on standardized techniques, and evaluation of locally-obtained results. Such work under the existing conditions in the trainee's home country offers valuable feedback to the ILMR instructor which is used to design more appropriate IAEA training programmes at Monaco.

Marine pollution monitoring

The Marine Environmental Studies Laboratory (MESL) of ILMR was established in 1986 to consolidate IAEA's interests in non-radioactive marine contaminants in association with other United Nations and non-governmental agencies in response to international concern on pollution of the marine environment. The laboratory is the only one of its type in the UN system and is actively supported by the United Nations Environment Programme (UNEP) through its Regional Seas programme and by the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific, and Cultural Organization (UNESCO). Based upon IAEA's pioneering efforts in analytical quality control, MESL has become a primary centre for the development and testing of analytical techniques, global and regional intercalibration exercises, pilot monitoring and research programmes, and the development and implementation of regional data quality assurance programmes. Nuclear techniques are also an important tool for studying non-radioactive marine contaminants, whether by "benchmark techniques" such as neutron activation analysis, or through

the use of radiolabelled analogues of organic contaminants in controlled microcosm tracer studies.

Training is an integral component of MESL's activities, particularly in the regional data quality assurance programmes. These programmes are presently being conducted on a pilot scale in the Mediterranean and Gulf regions (within the framework of UNEP's Mediterranean and Kuwait Action Plans) and may well be extended to other regions (such as West Africa, the Caribbean, and South America) in the future. Analysts from national marine pollution monitoring programmes are given specialist courses at the Monaco Laboratory in the analysis of chlorinated hydrocarbons (PCBs or pesticides), toxic trace metals, or petroleum hydrocarbon residues.

Upon return to their home countries, a joint sampling mission is organized in which a specialist member of the MESL staff, with the UNEP-sponsored MESL maintenance engineer, visit the trainee's laboratory and participate in a routine monitoring exercise. The maintenance engineer ensures that the relevant analytical instruments are working and gives instruction in basic user-servicing and calibration. The specialist staff member then works together with the local team providing practical advice and complementing the basic training given in Monaco where necessary. Towards the end of his stay, the specialist staff member and his hosts prepare and calibrate a large batch of relevant internal working reference material. After completion of the mission, the material is then measured routinely in the national centre to provide a continuous check of the data quality. All participants are also encouraged to participate in the Agency's intercalibration exercises and employ the IAEA-UNEP-IOC Reference Methods for Marine Pollution, also edited at the Monaco Laboratory.

During 1988, three target countries were selected for the Mediterranean quality assurance programme: Egypt, Algeria, and Morocco. Within the first 3 months of the year, eight analysts from these countries received specialist training in Monaco; the first joint sampling mission (to Egypt) took place in April.

MESL also provides specialist training to individual scientists from Member States in marine pollutant measurements and assessment. The suite of parameters studied is under constant review and new priority contaminants (of recent international concern), such as organomercury and organotin, form part of the laboratory's programme. Emphasis is placed not only on the analytical techniques, but also on sampling, sampling strategy, and the use of the data for making pollution assessments. Trainees from Iraq and Nigeria recently spent periods of 1 to 2 months in the laboratory and trainees from Latin American countries are expected later in 1988.

Laboratory staff have provided group training in diverse aspects of marine pollution studies in Member States with English, French, and Spanish as working languages. A group training programme in the user maintenance and optimum calibration of analytical instruments is currently being designed.

As with the other sections of ILMR, training at MESL is not considered a passive "classroom" or "demonstration laboratory" exercise but a dynamic and interactive process in which trainees continue to be involved long after their initial stay at the Monaco Laboratory. Active participation of the MESL staff in pilot monitoring and research programmes, conferences, and scientific working groups allows them to balance state-of-the-art developments in methodology and pollution science with the real capabilities and priorities of Member State laboratories in this field and thus design meaningful training courses and follow-up exercises.