# The IAEA Laboratories

*While nuclear technology continues to expand in all scientific fields, both research and analysis become increasingly important aspects of the work carried out at the IAEA's two principal laboratories at Seibersdorf and Monaco.*
*They also provide training facilities for students and graduates from many Member States. The following outlines give a brief history of their development, and their present work.*

## THE SEIBERSDORF LABORATORY

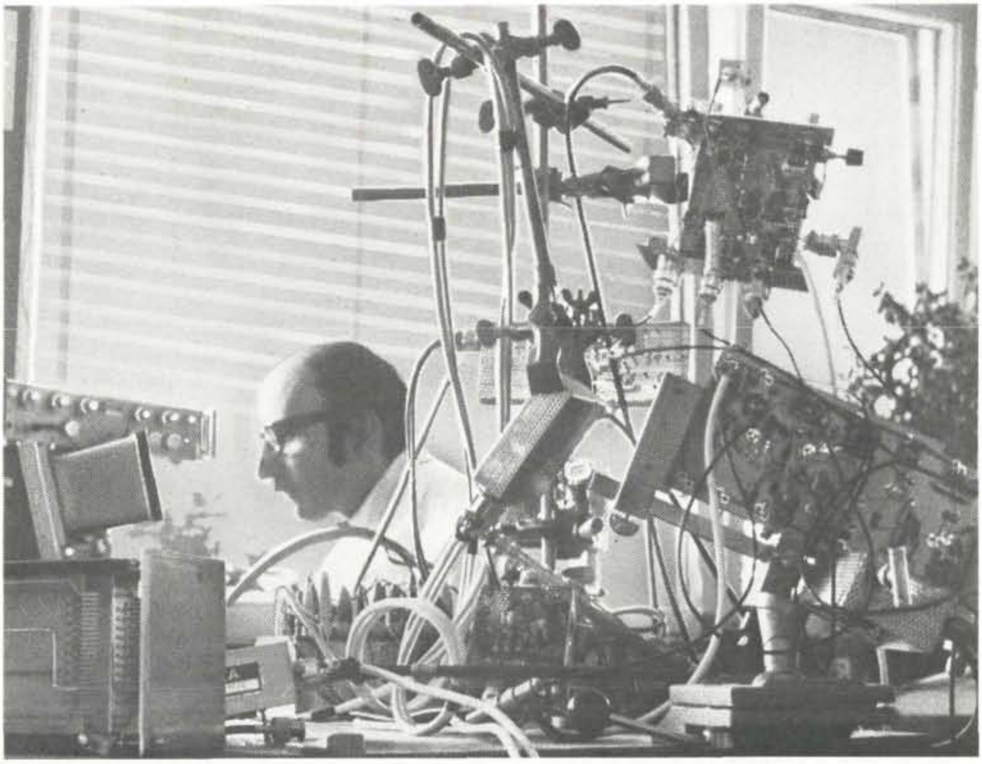
The Laboratory at Seibersdorf is situated adjoining the Austrian Reactor Centre in Niederösterreich, about 35 km. SW of the centre of Vienna. It was officially opened in September 1961. Before this, laboratory work in the metrology of radioisotopes and in low level radioactivity (LOWRA), and an electronics and workshop section had been functioning in the Headquarters basement. In early 1962 a Chemistry section was started and later that year an Agriculture department.

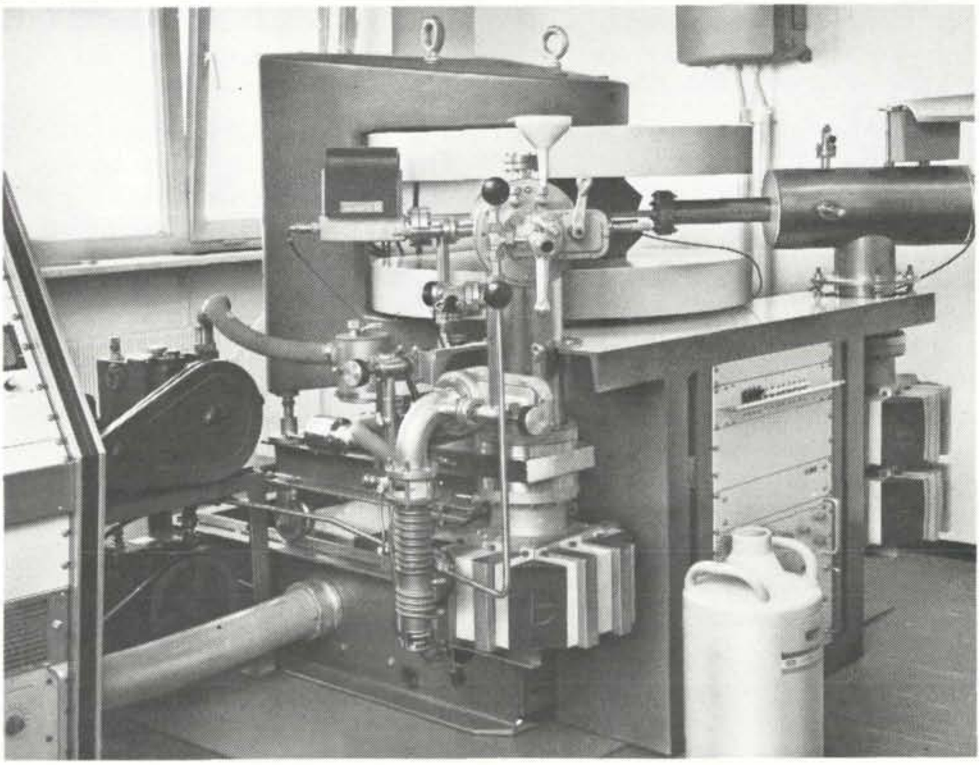
### AGRICULTURE

Research in agriculture was begun in order to assist in a co-ordinated research contract programme concerned with studies on the most efficient way to add fertilizers to rice paddies, using phosphorous-32 as the radioactive tracer. Similar experiments are still continuing in all parts of the world in wheat, maize, legume and tree crops. In the latter case, interesting work is at present being done using a double tracer technique in which both P-32 and P-33 are being used.

A significant step forward was made in 1963, when the Laboratory started using nitrogen-15 as a tracer in agricultural work. Nothing had previously been done with this important plant nutrient in field experiments because of the expense of enriched nitrogen-15 preparations and the necessity of using a mass-spectrometer for measurement. In the frame of a co-ordinated research programme relatively large quantities could be purchased, thus reducing the cost, and measurements could all be carried out by the mass-spectrometer at the Laboratory, though this involved the staff in a great deal of work as 4,000 - 5,000 samples of plant material were sent annually. However, a result of this problem was the development of the emission-spectroscopic method by the Laboratory, which is much cheaper and does not require such advanced technical operation and maintenance as a mass-spectrometer. As the N-14/N-15 radio can be determined in samples as small as 1 $\mu$g N or less, many new possibilities have been opened up in the field of plant physiology and biochemistry. As a result of this work, the Laboratory has attained a leading position in the world in the agricultural use of nitrogen-15.

Work in plant breeding began with investigation into the conditions of irradiation and of treatment of seeds in order to produce the highest number of mutations with minimal other damage. At present scientists are looking for mutants of wheat and other grain crops which produce both more protein and a better quality of protein. As a change in protein quality will not necessarily produce a visible change, a massive programme of analysis involving many thousands of seed analyses per year has been undertaken.





Entomology and research into the sterile insect technique was described in the IAEA Bulletin, Volume 15/3.

## CHEMISTRY

New work is being done in the Chemistry Section for the Department of Safeguards and Inspection. This involves accurate determinations of the uranium and/or plutonium content of samples taken by Safeguards inspectors; it is not a simple job, as many types of samples with varying composition and impurities must be taken into account. In addition, isotopic analyses must be made, for which the Laboratory has a new mass-spectrometer of the latest design — the most expensive single piece of equipment there.

The Analytical Quality Control Service offered by the Laboratory was described in the IAEA Bulletin Volume 15/3.

## METROLOGY

The Metrology Section has been concerned for many years with the absolute calibration of radioactive isotopes, a difficult and many-sided problem. A succession of samples have been used, and in the case of lithium-drifted germanium, sets of long-lived gamma ray emitting sources safely sealed between foils, were sold, and provided a good income for the Laboratory until 1971. (It was then decided that commercial suppliers of radionuclides could satisfy the demand.)

Work on calibration of radioisotopes was not stopped, however, and a long-term inter-comparison service has now been set up. Calibrated samples sent to Seibersdorf are measured in an ionisation chamber of very stable response. Later a second sample from a new calibration can be sent and measured, allowing a comparison to be made, although the half-life of the radioisotope is quite short. A second service is the supply of calibrating sources for the measurement of neutron fluences in reactors through the use of threshold detectors.

## ELECTRONICS AND WORKSHOP

The Laboratory has its own Electronics section and Mechanical Workshop, providing services to the Laboratory, and in some cases to Member States. Apart from maintenance, Electronics is concerned with the design of equipment not available commercially, and computer inter-facing and command circuits for various semi- and fully-automatic equipment designed and built by the Workshop.

## TRAINING

Nearly 100 Fellows have received "in service" training at Seibersdorf, spending from one month to two years there. Where possible the later months of training are concentrated on studies related to the trainees's own country and its problems. The Laboratory has also been fortunate in attracting several University research workers for their sabbatical year, particularly those interested in working with nitrogen-15.

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▲ Part of the conglomeration of equipment in the electrical workshop at the Seibersdorf Laboratory.

◀ The new mass-spectrometer at the Seibersdorf Laboratory.

## THE INTERNATIONAL LABORATORY OF MARINE RADIOACTIVITY

Marine radioecological research is a relatively new field of investigation within the 'young' discipline of oceanography. The introduction of artificial radioactivity into the diet of humans by seafoods prompted investigations in this field thirty years ago. But because of the unmatched physical and chemical stability of oceans and seas, scientists have also been concerned that perturbations of this environment might seriously influence both organisms and ecosystems; once altered, recovery might be low or impossible.

Artificial radioactivity continues to be one of the better understood artifacts of man's impingement upon the oceans. The orderly development of nuclear power with the attendant considerations of waste disposal and other environmental impacts will require a continuing effort in this field.

The International Laboratory of Marine Radioactivity at Monaco has as its major goals: a) the development of reference analytical methods and techniques for investigating the behavior of radioactivity in the oceans; b) to promote the intercomparability of radioactivity measurements made in national laboratories of Member States; and c) to obtain scientific information not yet available which is needed to evaluate the effects of radioactivity in the ocean.

For the past twelve years, the laboratory, which occupies a part of the Musée Océanographique, has engaged in both basic and applied research to satisfy these terms of reference. While small, the laboratory has had an influence on the field of marine radioecology; nearly 100 scientific articles have been published by the staff covering virtually all aspects of the field. Senior scientists have organized and participated in panels and symposia whose topics range from analytical radiochemistry to the effects of ionizing radiation on marine ecosystems. Literature reviews have been prepared by the staff on topics as varied as mercury as a marine pollutant to aspects of organic marine pollution. As a consequence, the laboratory has attracted senior research scientists from both developed and developing countries, and trainees from Portugal, Yugoslavia, Turkey and Japan. The staff continues to have collaborative efforts with a number of european research institutions including the CNEN laboratory at Fiascherino, Italy, the Institute Rudjer Boskovic in Rovinj, Yugoslavia, the Fisheries Radiobiological Laboratory in Great Britain and the CEKMECE Nuclear Research Centre of the Turkish Atomic Energy Commission in Istanbul.

Presented here are highlights of current work in progress at Monaco and some possibilities for future programmes.

### CHEMISTRY

The number of nuclear power plants and the capacity for processing nuclear fuels will increase substantially during the late 1970's through 1980. In order to minimize the impact of nuclear power production on the environment by ensuring the safe operations of these installations, increasing efforts will be directed to the monitoring of radioactive substances that are released. Since the siting of many nuclear power plants has been and will continue to be along coastal areas, radioactivity will find its way, directly or

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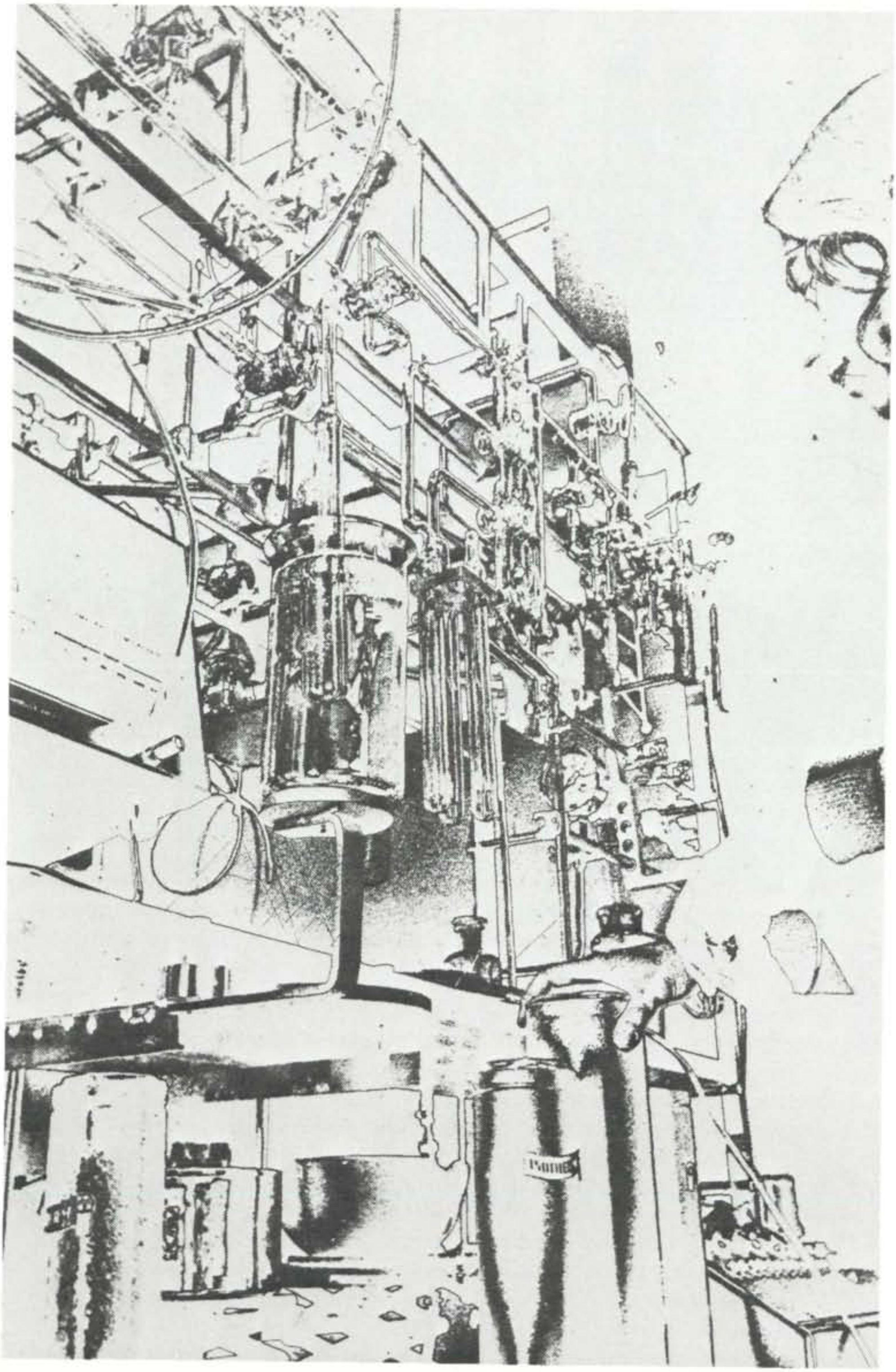
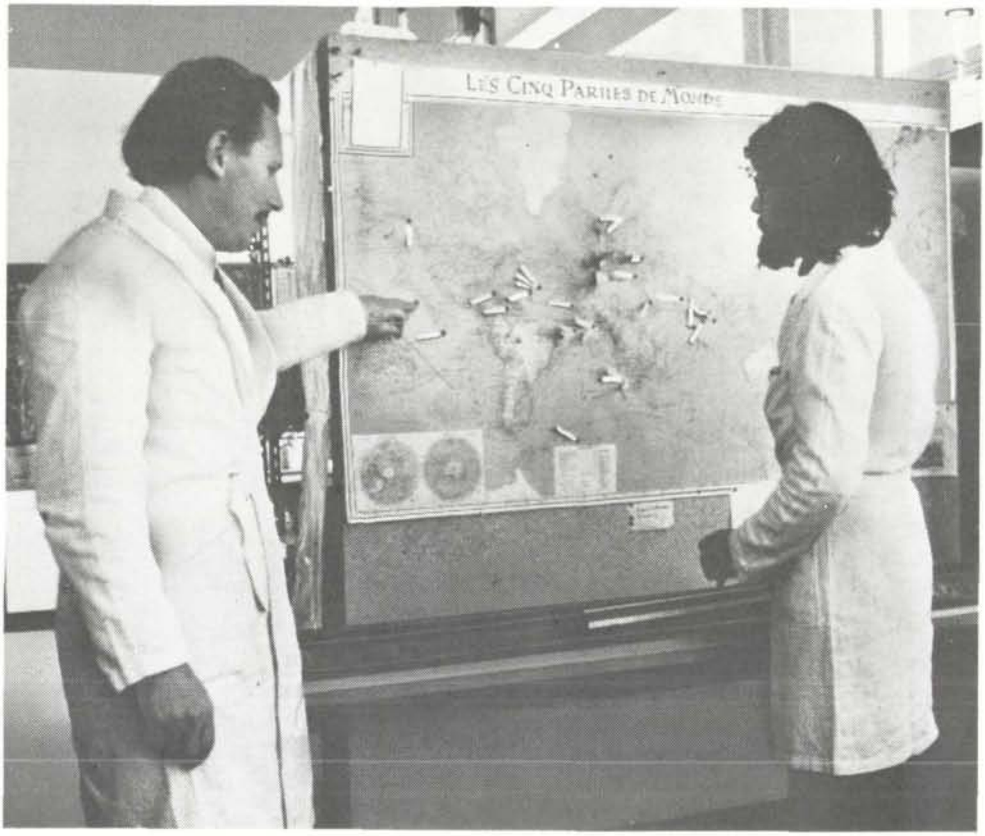
The preparation line in the Agency's basement laboratory where $Co_2$ samples of organic matter are measured for the isotopic $^{12}C/^{13}C$ ratio. ▶





At the Monaco Marine Laboratory, scientists examine a marine sediment core obtained from one of the national oceanographic institutions that co-operated in the five-year programme to study radionuclide behaviour in ocean and coastal sediments.

indirectly, into the sea. While these releases will be localized, the radioactivity measurements which are made as part of a monitoring programme should be internationally comparable since the sea is an international body of water which inter-connects the continents.

In order to assist Member States who have or are planning national monitoring programmes, an intercalibration programme of radionuclide measurements on marine samples was initiated by the Monaco Laboratory in 1970. Since that time, several samples of seawater, marine organisms and sediments containing radioactivity at monitoring levels have been distributed to 60 laboratories from 30 Member States. Prior to distribution, homogeneity tests were performed at Monaco to ensure that any reported differences resulted from measurement technique and not from 'within-sample' variation. Results of the analyses have been compiled and carefully reviewed. The results indicate that the overall comparability of the reported results for radionuclides such as $^{90}Sr$, $^{95}Zr$-Nb, $^{106}Ru$, $^{134,137}Cs$ and $^{144}Ce$ is not always satisfactory. In the case of $^{106}Ru$, for example, the ratio of the maximum reported value to the minimum reported value in the labelled sediment sample reached a value of nearly 10,000. It should be emphasized that these large differences cannot be attributed to difficulties in radiochemical techniques themselves. Indeed, many participating laboratories now use only non-destructive gamma-ray spectrometric techniques for the majority of their measurements. It is clear that problems still exist in the standardization and calibration of these sophisticated instruments.

Several participants in the intercalibration exercise have included measurements of the transuranic elements $^{238}Pu$, $^{239,240}Pu$ and $^{241}Am$. In view of their long radioactive half-lives (T 1/2 $^{239}Pu$ = 24,400 years) and their decay mode (alpha-particle emission), these radionuclides may become important in assessing the environmental impact of some nuclear operations. Preliminary results indicate that the agreement between participating institutions for measuring $^{239,240}Pu$ in the same homogeneous sample is satisfactory.

The continuation of this exercise will permit participants to evaluate critically their performance and to correct shortcomings where they exist. As the comparability of the data improves, the results of both monitoring and research data can form the basis of predicting the capacity of the marine environment to accept radioactive wastes safely.

## BIOLOGY

A major programme undertaken by the biology group at Monaco has been an assessment of the importance of zooplankton on the cycling and vertical transport of radionuclides and heavy metals in the marine environment. Studies on krill (small crustaceans which comprise a large portion of the world's planktonic biomass), have shown that the fecal pellets from these organisms were responsible for over 80% of the total zinc transported to the sea floor by this organism. The fact that zooplankton fecal pellets contain relatively high concentrations of many other metals suggests the possibility that biological effects on heavy metal transport in the sea might be greatly simplified by studying only fecal deposition, thereby facilitating quantitative comparisons between biological and physical transport mechanisms. The use of this approach to study the movement and fate of natural alpha emitters as well as transuranic elements is presently under study.

It is of interest to determine the availability of radionuclides to bottom dwelling marine organisms, once the radionuclides have been bound to the sediments. Experiments on the interaction of benthic biota with radionuclides sorbed to sediments have shown that burrowing organisms, such as worms, can effectively accelerate the loss of $^{65}Zn$ from the sediments. Based on results of accumulation and loss experiments, one can estimate that a population of worms typically present in an estuary could cause an annual loss of 3% or more of the $^{65}Zn$ sorbed in the upper 2 centimeters of the sediment.

The biology programme has also dealt with the availability of different physico-chemical forms of radionuclides to marine biota. Bioaccumulation experiments using $^{65}Zn$-spiked seawater which had aged several months in a large aquarium containing different types of marine biota resulted in concentration factors in mussels an order of magnitude lower than those organisms accumulating $^{65}Zn$ from freshly prepared seawater solutions. Experiments are in progress to isolate the different fractions of $^{65}Zn$ in the "aged" seawater and to perform bioaccumulation experiments to determine which physico-chemical fractions are available for uptake by marine organisms.

It is essential to know if the rates of radionuclides flux through marine biota, derived from laboratory experiments, truly reflect the natural condition. Experiments carried out simultaneously in the laboratory and in field enclosures have shown that $^{65}Zn$ flux rates in several marine species were in fact comparable under the two regimes. By contrast, exchange rates for cadmium in mussels were significantly more rapid in the laboratory animals than in those maintained under natural conditions. Therefore, for certain elements and marine organisms, care must be taken when interpreting radionuclide dynamics in the natural environment exclusively on the basis of laboratory results. In response to problems of this nature, the IAEA recently convened an international panel of experts at Monaco to discuss reference methods for marine radioecological studies.

The utility of using radioisotope techniques to study the fate of heavy metals in aquatic ecosystems is well established. A recently completed experiment at Monaco has shown that marine organisms of commercial interest assimulate cadmium primarily from food rather than water, and that once accumulated, the metal is slowly excreted. Measured biological half-lives ranged from 1 to 4 years. In principle, the bio-kinetic behavior of any heavy metal can be similarly investigated where appropriate radioisotopes exist.

## SEDIMENTOLOGY

The interaction of radionuclides and heavy metals with ocean sediments represents an important field of marine radioecological research since it has been shown that the distribution coefficients (the ratio of the amount of radionuclide per unit volume of sediment to the amount of radionuclide per unit volume of seawater) are normally large. In coastal areas, therefore, radionuclides released from nuclear power stations or fuel reprocessing plants can be effectively removed from the water column by suspended sediment and ultimately removed to depth. There are a number of variables, however, which effect the distribution of radionuclides and trace metals on sediments; composition of the sediment and particle size are two of the more important considerations. Since the characteristics of marine sediments vary from the different ocean basins forming the sea floor, an international co-operative study has been made over the past five years to investigate the capacity of these sediments to sorb radionuclides. More than 20 national laboratories co-operated in supplying characteristic marine sediments from the major ocean basins and from several coastal seas. Analytical determination and radionuclide-sediment studies were made principally at Monaco in collaboration with laboratories in the Netherlands, USA, Canada and Yugoslavia. The studies are now largely completed and the major conclusions have been published in the U.S. National Academy of Sciences Volume "Radioactivity in the Marine Environment", and in the proceedings of the IAEA Symposium "Radioactive Contamination of the Marine Environment", Additional studies are planned to investigate the behavior of plutonium and transplutonium radionuclides.

The sedimentology group is also investigating the reactions which occur when chlorine reacts with the organic constituents present in both seawater and fresh water. Hypochlorous acid is oftentimes used as a biocide in a number of installations using water for cooling in order to free piping systems from colonized aquatic organisms. Such is the case with many nuclear power plants. The identification of organo-chlorine compounds which may be formed during chlorination, their longevity in natural water systems, and their effects on marine organisms constitute a part of the 'non-radiological' impacts resulting from nuclear power plants, but which nevertheless deserve investigation. Recent donations of equipment from the U.S. Government, which include a 'state-of-the-art' gas chromatograph and an instrument for measuring total organic carbon in both sea water and fresh water have made these studies possible.