Journal of Radioanalytical and Nuclear Chemistry, Vol. 263, No. 2 (2005) 437–440

Monitoring of radioactivity in NW Irish Sea water using a stationary underwater gamma-ray spectrometer with satellite data transmission

I. Osvath,[1] P. P. Povinec,[1]* H. D. Livingston,[1] T. P. Ryan,[2] S. Mulsow,[1] J.-F. Commanducci[1]

[1] *International Atomic Energy Agency, Marine Environment Laboratory, BP 800, Monte-Carlo, MC-98012 Monaco*
[2] *Radiological Protection Institute of Ireland, Clonskeagh Sq., Dublin 14, Ireland*

(Received April 6, 2004)

A “sentinel”-type device, equipped with a NaI (Tl)-based underwater gamma-spectrometer mounted on a stationary buoy, transmitting data through satellite connection, was deployed in the north-western Irish Sea.The data recorded and received in real-time indicated that no detectable significant changes occurred in the concentrations of ^{137}Cs at the mooring site in the period September to November, 2000. Other anthropogenic gamma-emitters were not detected.

Introduction

The Irish Sea has important fishing grounds shared by several European countries, therefore, the quality of its marine environment is being closely monitored. Radioactivity has been of interest particularly in relation with authorized discharges from the Sellafield nuclear reprocessing plant on the Cumbrian coast. Measurement campaigns are carried out regularly by British and Irish institutes[1,2] to assess radionuclide levels and their dynamics.

Gamma-ray spectrometers operating at stationary underwater locations have found applications in marine environmental monitoring, whereby they can be effectively used for remotely recording time series of measurements. In specific cases these measurements can prove to be a cost-effective replacement for infrequent sampling campaigns and time-consuming laboratory-based analytical work.[3,4] If required, satellite, radio or telephone connections allow access to measurement data in real-time. Critically such an instrument has application as a “sentinel” device, to record and signal changes in gamma-radioactivity levels. IAEA’s Marine Environment Laboratory (IAEA-MEL) tested such a device mounted on a stationary buoy in the Mediterranean Sea and then, in collaboration with the Radiological Protection Institute of Ireland (RPII), deployed it in the Irish Sea.

The western Irish Sea gyre is a stably-located seasonal circulation feature persistent during the summer months,[5,6] discovered in 1990 and studied also in relation to valuable fisheries resources in the area. It develops in relation with a dome-like density structure of the water mass, present in the warm season (spring-summer) due to thermal stratification. In this area tidal currents are weak. The residual surface cyclonic flow entrains water southward along the Irish coast as described above. The gyre is thought to generate a retention mechanism for marine plankton and any conservative contaminants introduced into its central area, this potentially exposing the respective biota populations, including commercially valuable species and their consumers, to risk. Therefore, it was found of interest to locate the buoy’s mooring station in relation to this gyre as described further in the paper.

Experimental

The “NEMO Observatory” is a stationary underwater monitor which was developed by Oceanor, Norway.[7] It is used to record gamma-spectra together with a suite of environmental parameters including seawater temperature, salinity, current speed and direction. These data are transmitted via satellite link to a base station in the International Atomic Energy Agency’s Marine Environment Laboratory (IAEA-MEL) at Monaco. Radioactivity is measured using a RADAM radioactivity sensor which comprises a 3”×3” NaI(Tl) ruggedized crystal with 7% resolution, a 512-channel analyzer and a power supply. The limit of detection for ^{137}Cs in water is 19 $Bq \cdot m^{-3}$ for a 24-hour spectrum integration time, 7 $Bq \cdot m^{-3}$ for 7 days and 4 $Bq \cdot m^{-3}$ for 30 days integration time. The system has both a hardware temperature compensation and a software compensation for improving spectrum stability over long periods of integration. The current speed and direction are measured with a 3-axis ultrasonic transducer, with ranges of 0–300 $cm \cdot s^{-1}$ and 0–360° and uncertainties of 3% and 2°, respectively. The temperature sensor has an operational range of –5 to +45 °C with an uncertainty of 0.1 °C. Salinity is determined from conductivity measurements performed with an electrode-less induction type cell, with an operational range of 2–77 $mmho \cdot cm^{-1}$ and an uncertainty of 0.06 $mmho \cdot cm^{-1}$.

* E-mail: p.povinec@iaea.org

0236–5731/2005/USD 20.00

Akadémiai Kiadó, Budapest
Springer, Dordrecht

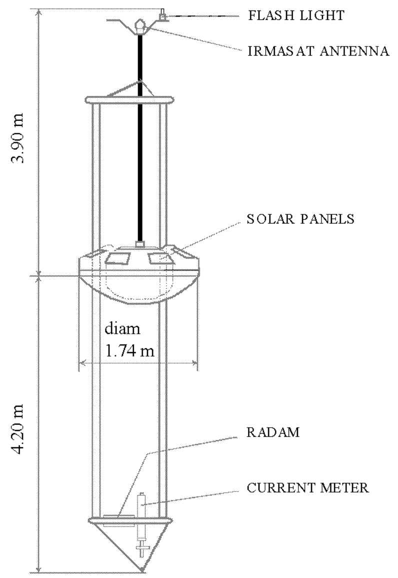

Fig. 1. Schematic construction of the NEMO Observatory[9]

The sensors are suspended 4 metres underwater on a structure attached to a floating buoy (Fig. 1). The buoy is equipped with signal processing electronics, including a microcomputer and a marine transceiver and a set of lead-acid batteries. These instruments and batteries are maintained in a nitrogen atmosphere. The Observatory's autonomy is supported by a set of solar panels installed on the buoy. An integrated GPS receiver continuously records the buoy's position.

Duplex data transmission is facilitated by the Inmarsat-C satellite, Atlantic Ocean Region East (AOR-E), via Eik (Norway) Land Earth Station. A PC, based at IAEA-MEL in Monaco, controls the electronics on board the buoy and receives and processes all measurement data.

In preparation for deployment further a field, IAEA-MEL carried out operational tests in the Mediterranean offshore Monaco in 1999. Then, as part of a joint programme in 2000 between IAEA-MEL and RPII, NEMO was deployed and operated in the NW Irish Sea at a mooring station situated on the descending arm of the seasonal western Irish Sea gyre, at 53°46.404' N 5°38.362' W, in 87 m water depth.

Results and conclusions

The results presented in this paper are those obtained from the observatory during the period September to November 2000. Data were recorded 4 times a day following a synoptic time scheme (00:00, 06:00, 12:00 and 18:00 UTM). Over 350 6-hour gamma-spectra were analyzed. The monthly averaged output spectra are presented in Fig. 2. ^{137}Cs is the only anthropogenic gamma emitting radionuclide that could be identified in the spectra. The monthly mean ^{137}Cs concentrations in seawater at the deployment position during the measurement period were 17±7, 19±8 and 23±10 Bq·m^{-3}. This indicates that at the timescale of months no significant changes were detectable in ^{137}Cs concentration in seawater, that is any fluctuations of the ^{137}Cs level over shorter time-scales would have been within the range of uncertainty of the determinations.

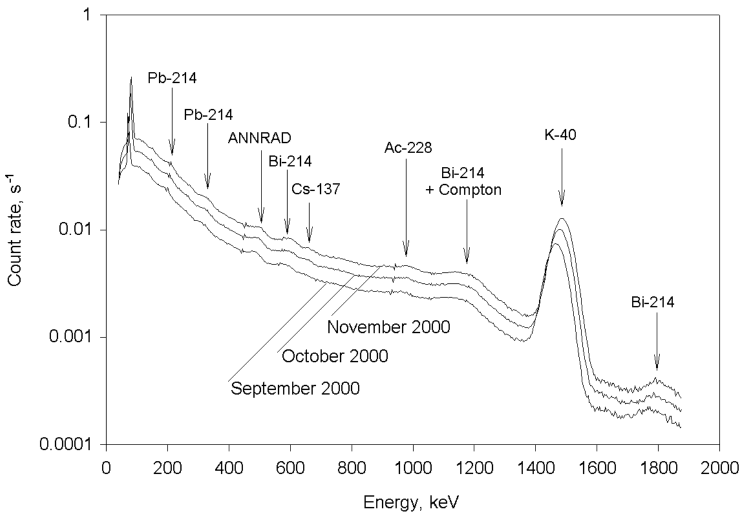

Fig. 2. Gamma-spectra recorded in water, integrated over one month. The spectra have been slightly shifted along both axes with respect to each other to allow easier viewing

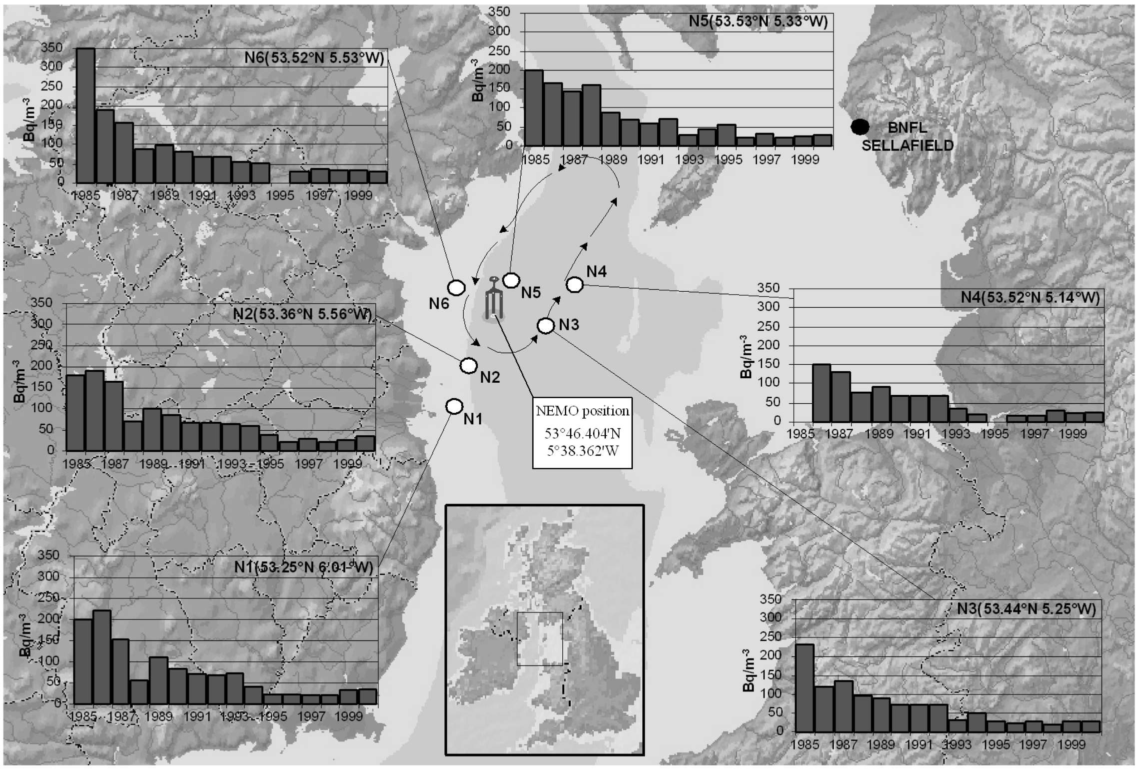

Fig. 3. ^{137}Cs in seawater from locations in the NW Irish Sea, 1985–2000. The position of the NEMO observatory is indicated on the map

The counting rate integrated over the whole energy range (50–1900 keV) is a sensitive parameter used for immediate signalling of any changes in the level of radioactivity and prompting a detailed analysis of the gamma-spectrum. This count rate has been noted to vary with as much as 15% due to variations in the concentrations in seawater of natural radionuclides in the U-Ra and Th series. Since no significant simultaneous variation of ^{40}K activity is observed, it can be deduced that these variations are due to atmospheric washout by rainfall. Even higher such variations (up to 40% of the average countrate) were observed during the buoy's operation in a coastal environment, where atmospheric concentrations of radon and thoron daughters as well that of scavenging aerosols are higher than at the open sea. As detailed atmospheric precipitation data were available, these variations could be directly related to atmospheric washout by rain. They were attributed to subsequent increases in seawater of the concentrations of cosmogenic ^{7}Be and of radionuclides in the decay chains of the primordial U–Ra and Th series observed in the spectra.

The data for ^{137}Cs are in agreement with the monitoring data collected by the RPII during its routine marine monitoring programme in the region (see, e.g., RPII).[8] The RPII's data over recent years are summarized in Fig. 3. NEMO provided continuous information to complement the year 2000 sampling campaigns. The data recorded and received in real-time indicated that no detectable significant changes occurred in the concentrations of ^{137}Cs at the mooring site in the period September to November, 2000. Other anthropogenic gamma-emitters were not detected. The seawater radioactivity, temperature and salinity and the current speed and direction data derived from the project will provide input into an analysis of the hydrography of the area.

*

The IAEA-MEL operates under an agreement between the International Atomic Energy Agency and the Government of the Principality of Monaco. The authors wish to acknowledge the contribution to the project made by Mr. Ken LEDGERWOOD, Environment and Heritage Service, Department of Environment, Northern Ireland and the oceanographic support given by Dr. Mike HARTNETT of the National University of Ireland Galway. Also the assistance of the Captain and crew of the *R.V. Celtic Voyager* and of the Marine Technical and Development Services (Galway) is gratefully acknowledged.

References

1. M. MCCARTNEY, P. KERSHAW, D. WOODHEAD, D. DENOON, Sci. Total Environ., 141 (1994) 103.
2. P. KERSHAW, D. DENOON, D. WOODHEAD, J. Environ. Radioact., 44 (1999) 191.

3. International Atomic Energy Agency, Report of Experts' Meeting on In-situ Stationary Monitoring of Radioactivity in the Aquatic Environment, IAEA-MEL, Monaco, 1995.
4. I. HARMS, P. POVINEC, The Outflow of Radionuclides from Novaya Zemlya Bays – Modelling and Monitoring Strategies, Ext. Synop. Intern. Symp. on Marine Pollution, IAEA, Vienna, 1998, p. 730.
5. A. E. HILL, R. DURAZO, D. A. SMEED, Continental Shelf Res., 14 (1994) 479.
6. A. E. HILL, J. BROWN, L. FERNAND, Oceanol. Acta, 19 (1996) 357.
7. U. R. AAKENES, Chem. Ecol., 10 (1995) 61.
8. RPII, Radioactivity Monitoring of the Irish Marine Environment, 1998 and 1999, Radiological Protection Institute of Ireland, Dublin, 2000.
9. OCEANOR, The SEAWATCH Buoy, IAEA, User's Manual, Oceanographic Company of Norway, Trondheim, 1998.