Radiological Protection Institute of Ireland

An Institiúid Éireannach um Chosaint Raideolaíoch

# A survey of tritium in Irish seawater

**RADIATION UNITS**

**Radioactivity** is measured in units called becquerels (Bq). One becquerel corresponds to one radioactive disintegration per second.

When measuring radioactive discharges to the environment or referring to the content of radioactive sources used in medicine, industry and education, it is more usual to talk in terms of kilobecquerels (kBq), megabecquerels (MBq), gigabecquerels (GBq) or terabecquerels (TBq)

1 kBq = 1000 Bq

1 MBq = 1,000,000 Bq

1 GBq = 1,000,000,000 Bq

1 TBq = 1,000,000,000,000 Bq

Much lower concentrations of radioactivity are normally found in the environment and so the measurement is often reported in units of millibecquerels (mBq). There are one thousand millibecquerels in a becquerel.

1 Bq = 1000 mBq

**Radiation Dose** When radiation interacts with body tissues and organs, the radiation dose received is a function of factors such as the type of radiation, the part of the body affected, the exposure pathway, etc. This means that one becquerel of radioactivity will not always deliver the same radiation dose. A unit called 'effective dose' has been developed to take account of the differences between different types of radiation so that their biological impact can be compared directly. Effective dose is measured in units called sieverts (Sv).

The sievert is a large unit, and in practice it is more usual to measure radiation doses received by individuals in terms of fractions of a sievert.

1 sievert = 1000 millisievert (mSv)

= 1,000,000 microsievert (µSv)

= 1,000,000,000 nanosievert (nSv)

In RPII reports the term 'effective dose' is often referred to as 'radiation dose' or simply 'dose'.

**Collective dose** is the sum of the radiation doses received by each individual in the population. This allows comparison of the total radiation dose received from different sources. Collective dose is reported in units of man sieverts (man Sv) or man millisieverts (man mSv).

**Per caput dose** is the collective dose divided by the total population. Per caput dose is reported in units of sieverts, or fractions of a sievert.

RPII 13/02

# A survey of tritium in Irish seawater

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## Executive Summary

This report provides a comprehensive record of the study and measurements of tritium in Irish seawater undertaken by the Radiological Protection Institute of Ireland, RPII. The majority of the samples analysed were found to have tritium concentrations below the limit of detection and a conservative assessment of radiation dose arising showed a negligible impact to the public.

Tritium is discharged in large quantities from various nuclear facilities, and mostly in liquid form. For this reason it is included in the list of radioactive substances of interest to the OSPAR (Oslo-Paris) Convention to protect the marine environment of the North-East Atlantic. To fulfil its role within OSPAR, to provide technical support to the Irish Government, RPII carried out a project to determine the levels of tritium in seawater from around the Irish coast to supplement its routine marine monitoring programme. A total of 85 seawater samples were collected over a three year period and analysed at the RPII's laboratory.

Given that the operational discharges for tritium from the nuclear fuel reprocessing plant at Sellafield, UK, are expected to increase due to current and planned decommissioning activities RPII will continue to monitor tritium levels in seawater around the Irish coast, including the Irish Sea, as part of its routine marine monitoring programme.

# Introduction

## RPII Marine Monitoring Programme

Since 1982, the RPII, has monitored the levels of radioactive contamination in the Irish marine environment. The principal aims of the RPII's monitoring programme are:

- to assess the level of radioactivity to which the Irish population is exposed in the environment,
- to study trends and establish the geographical distribution of contaminating radionuclides so as to better understand the long term behaviour of artificial radioactivity in the food chain and the environment.
- to ensure that any increase in radiation levels resulting from an accidental release of radioactivity to the environment is detected and assessed rapidly.

### Sampling

The sample types collected include fish, shellfish, seaweed, sediment and sea water. Fish and shellfish are collected from major landing ports and aquaculture areas, while sea water, sediment and seaweed are collected regularly from coastal and offshore locations. Since the highest concentrations of radioactivity are found along the east coast, the sampling frequency is greatest in this region.

### Analysis

The concentrations of gamma emitting radionclides are determined for all samples by high resolution gamma spectrometry. The concentrations of alpha and beta emitting radionuclides are determined using standard radiochemical procedures, alpha spectrometry, liquid scintillation counting and gas proportional counting.

Quality control procedures which include background measurements, processing of reagent blanks and duplicate samples are implemented for all analyses. In addition, the laboratory regularly participates in international intercomparison exercises.

## National and International Commitments

In addition the Irish marine monitoring programme is designed to take account of national and international obligations. It also supports the RPII's advisory and information provision functions.

The remit of the RPII, as set out in general functions of the RPII Act, 1991, explicitly requires the RPII:

*to monitor activity or ionising radiation levels in any thing in the State and in any waters, including international waters, surrounding the State, and, in particular, without prejudice to the generality of the foregoing, to monitor any activity or ionising radiation levels in individuals, animals, fauna, poultry, eggs, crops, fish, seaweed, or any food, soil, minerals (including rocks of all descriptions), air or water.*

## International Commitments

There are a number of international requirements and commitments which are of relevance to RPII's marine monitoring programme, in particular the Oslo-Paris or OSPAR Convention which is described briefly in the following paragraph.

### OSPAR Convention

The Convention for the Protection of the Marine Environment of the North-East Atlantic, known as the OSPAR Convention (www.ospar.org), sets out a framework for international cooperation on the protection of the marine environment of the North-East Atlantic. The OSPAR Convention is the mechanism by which fifteen Governments of the western coasts and catchments of Europe, including Ireland, together with the European Community, cooperate to protect the marine environment of the North-East Atlantic. OSPAR aims to achieve reductions in artificial radioactivity levels in the marine environment through the implementation of the OSPAR Radioactive Substances Strategy (RSS). All signatories to the RSS, also called Contracting Parties are committed to progressive and substantial reductions in radioactive discharges from their facilities. Contracting Parties have agreed that 'they would ensure the continued evolution and implementation of their national plans so as to achieve the objective of the Strategy in accordance with its timeframe for 2020'. RPII's role within OSPAR is to provide technical support to the Irish Government within the Radioactive Substances Committee (RSC) through provision of scientific advice, attendance at meetings, collation and provision of data on the discharges to and concentrations of radioactive substances in the Irish marine environment. Ireland's first National Plan for implementation of the OSPAR RSS was published in 2002 and it was further revised and updated in 2009.

An essential part of the RSS is an effective monitoring programme for concentrations of radioactive substances in the marine environment so that progress in achieving the OSPAR aims can be measured. This is achieved through collaboration between the Contracting Parties in regular monitoring and assessment of the radioactivity in the marine environment. RPII provides data from its marine monitoring programme to the OSPAR Commission on an annual basis.

Prior to the study, very little data existed on the levels of tritium in Irish coastal waters. In order for RPII to fulfil its OSPAR commitments (OSPAR, 2003) and also, given the possibility of tritium discharges from nuclear power production abroad increasing in the future (European Commission , 2008), RPII took the decision to carry out a project to determine the levels of tritium in seawater from around the Irish coast to supplement its routine marine monitoring programme.

This report presents the results of a tritium in seawater survey carried out by the RPII from 2008-2010.

### Tritium in the environment

Tritium, H-3, is an isotope of hydrogen that is radioactive. It behaves chemically like hydrogen, forming a gas, combining with oxygen to form water, and combining with carbon and many other elements to form chemical compounds. The most common forms of tritium are tritium

gas (HT) and tritium oxide, also called 'tritiated water'. In tritiated water a tritium atom replaces one of the hydrogen atoms so the chemical form is HTO rather than H2O. Tritium decays with a half-life of 12.312 years (www.nucleide.org ) by emitting a beta particle to produce helium-3.

The presence of tritium in the environment is ubiquitous. It decays entirely through the emission of a beta particle into stable He-3. The beta particles, while of low energy (18.6 keV maximum, 5.7 keV average), have enough energy to produce ionisations and excitations of molecules in their path.

Tritium in the environment has two origins, natural and man-made. Naturally occurring tritium is produced by the interaction of cosmic neutrons with nitrogen, oxygen and argon. A global natural inventory of about 1.3 x $10^{18}$ Bq (1300 PBq or 3.5 kg) has been calculated by UNSCEAR (UNSCEAR , 2000).

The annual addition of man-made tritium to the environment ranges from 50 to 70 PBq. The tritium from man-made origin comes from many sources (European Commission 2008):

- Far above all other sources is the tritium released during the testing of nuclear weapons in the atmosphere in the 1950s and 1960s, in both hemispheres. From 1945 to 1963, these tests released over 186,000 PBq of tritium to the environment. Taking account of the radioactive decay of tritium, about 13,000Bq remained in 2007, with about nine tenths in the sea, one tenth in continental waters and about 1% in the atmosphere.
- Another source of tritium is spent fuel reprocessing plants. Most of the reprocessing plants are near the sea and releases are primarily liquid. The La Hague reprocessing plant in France releases about 10 PBq/y (Carmin, 2005) while Sellafield in the UK releases about 2 to 3 PBq/y.
- Several other sources contribute to the inventory of tritium in our environment including the continuous release of tritium from nuclear power plants and tritium production facilities under normal operation, incidental releases from these facilities and consumer products .

About 99% of all tritium, whether natural or man-made, is incorporated in water and follows the water cycle from the high atmosphere to the sea.

From an Irish perspective the primary man-made source of tritium in the marine environment is the nuclear fuel reprocessing plant and associated facilities at Sellafield, which discharged 1510 TBq of tritium in 2009 (Environment Agency, Food Standards Agency, Northern Ireland Environment Agency and Scottish Environment Protection Agency, 2010,).

**Radiological Impacts of tritium**

Tritium poses no external hazard since the beta particles released during tritium decay cannot penetrate the outer layer of dead skin cells due to their low average range in tissue (ICRP , 1983). Because of the low beta energy, dilution throughout all of the soft tissues, and elimination with an average biological half-life of around ten days in adults, tritium as tritiated water has relatively low radiological toxicity when compared to other pure beta emitters, such

as phosphorus-32 or strontium-90, or to common beta emitters, such as iodine-131 or caesium-137 (ICRP, 1979-1982).

- As indicated above, tritium is almost always found as tritiated water and primarily enters the body when people eat or drink food or water containing tritium or absorb it through their skin . People can also inhale tritium as a gas in the air.
- Once tritium enters the body, it disperses quickly and is uniformly distributed throughout the soft tissues. In adults half of the tritium is excreted within, approximately, 10 days of intake.
- Everyone is exposed to small amounts of tritium every day, because it occurs naturally in the environment and the foods we eat.

## Field Survey

The RPII has routinely monitored the levels of radioactivity in the Irish environment since 1982 at locations around the Irish coast and at a number of offshore locations (McGinnity P., et al, 2010). Seawater samples are collected offshore in the western Irish Sea and Carlingford Lough using the Marine Institute's research vessel, the Celtic Voyager, while samples from the north and northeast coast are collected through collaboration with the Northern Ireland Environment Agency. The sampling frequency for each site ranges from monthly to once every two years. The sampling locations routinely monitored are shown in Figure 1. These locations were used for the tritium survey.

Sampling of surface seawater for the purpose of determining tritium levels is straightforward as long as the usual sampling precautions are taken. One litre surface water samples were collected at 20 sampling locations either directly from the sea (onshore samples) or via a ship's pump (offshore samples). Amber glass bottles were used to minimise the possibility of tritium egress. Each bottle was tightly sealed with a cap, clearly labelled and returned to the laboratory for analysis.

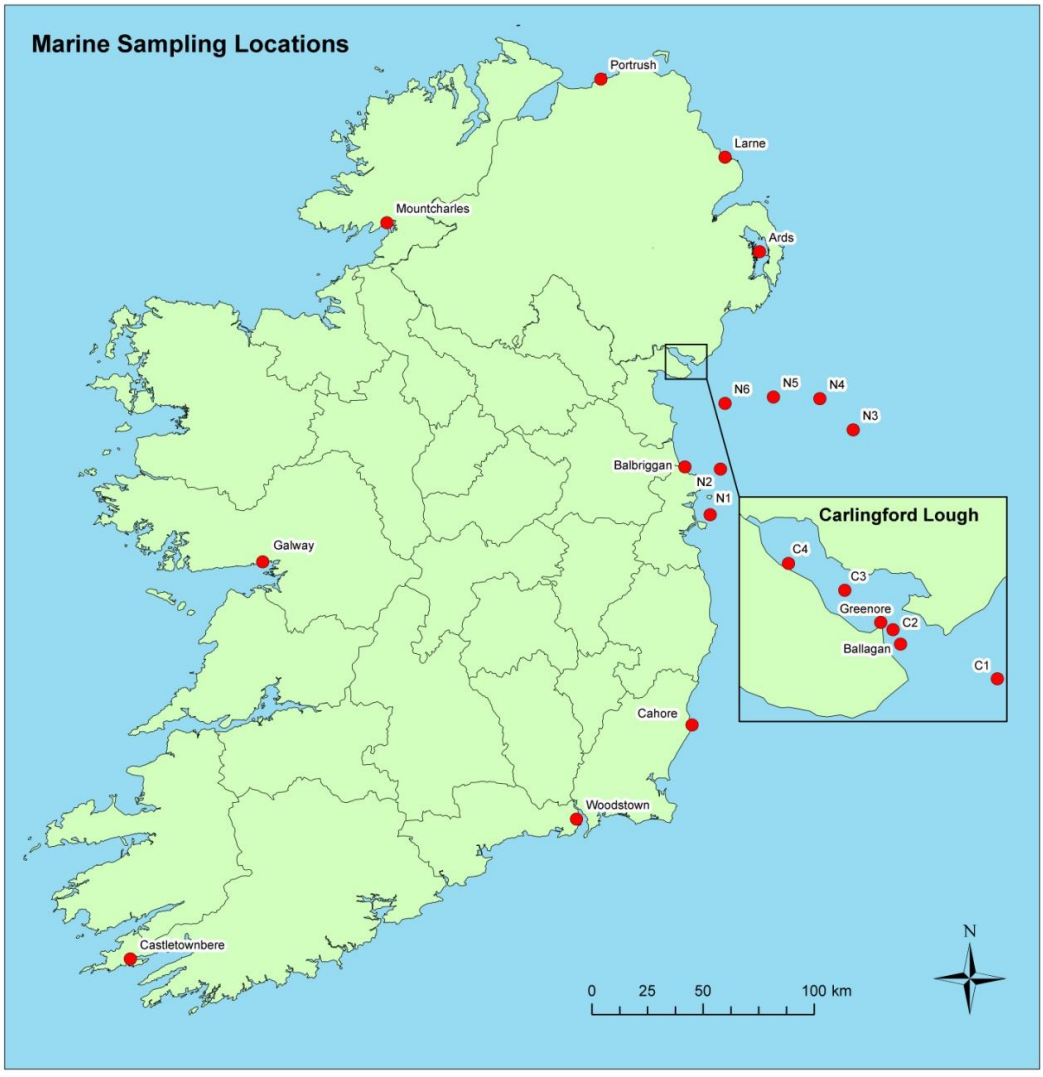
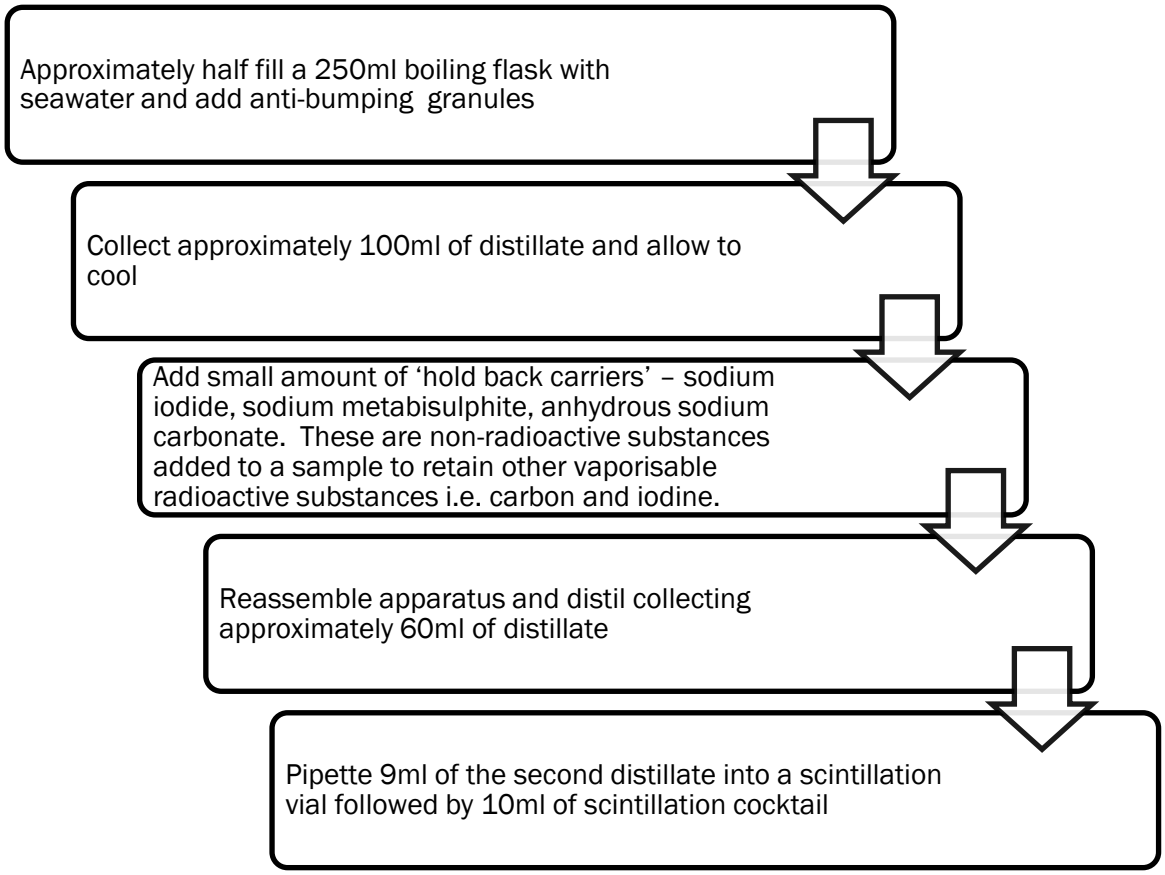



Figure 1: Marine Sampling locations for the tritium survey

## Sample Analysis

The amber glass bottles containing the sea-water samples were returned to RPII for analysis of their tritium content.

The method used to analyse the sea-water samples is based on the method developed by the Centre for Environmental, Fisheries and Aquaculture Science, Cefas, UK and involves double distillation, to concentrate the tritiated water and remove other radionuclides that might interfere with the analysis, and counting using liquid scintillation (CEFAS 2008). The steps are, briefly, as follows:




A detailed description of the analysis is given in Appendix 1.

A counting efficiency of typically 28% for an energy window setting of 0 - 18.6 keV is determined in-house using a spiked seawater samples. The sample was spiked with a tritium standard (product type H3ELSB[30]) supplied by Areva . The mean reagent blank count rate was found to be on average 1.3 counts per minute. The counting time for all samples was 24 hours and a corresponding minimum detectable activity of typically 1 Bq/l on the basis of the Currie criterion (Currie, 1968).

This procedure for seawater samples is only appropriate for determination of tritium as HTO. The method was validated using seawater sourced near Cap de la Hague, France which had been analysed by the Institut de Radioprotection et de Sûreté Nucléaire, IRSN. The results, shown in Table 1, were found to be in good agreement.

Table 1: Results of intercomparison exercise

| Cap de la Hague Samples | RPII reference | RPII analysis | IRSN analysis |
|---|---|---|---|
| H-3 activity Bq/l | ES1000453 | 12 ± 1 | 11 ± 0.44 |

## Results

A total of 85 seawater samples from around the Irish coastline and from the Irish Sea were collected and analysed between 2008 and 2010.

The measured concentrations of tritium, together with the associated uncertainties are given in Table 2.

Table 2: Tritium activity concentrations (Bq/l) in Irish Seawater, 2008-2010

| Location | RPII reference | 2008 | RPII reference | 2009 | RPII reference | 2010 |
|---|---|---|---|---|---|---|
| Greenore | ES0800027 January | 1.3±0.6 | ES0900031 January | <1.0 | ES1000014 January | 1.1 ± 0.6 |
| | ES0800189 April | <1.0 | ES0900235 May | <1.0 | ES1000225 May | <1.0 |
| | ES0800513 July | <0.9 | ES0900415 July | <1.0 | ES1000370 July | <1.0 |
| | ES0800740 October | <1.0 | ES0900694 October | 1.2 ± 0.6 | ES1000746 October | <0.9 |
| Balbriggan | ES0800038 January | <1.0 | ES0900007 January | <1.0 | ES1000035 January | <1.0 |
| | ES0800082 February | <1.0 | ES0900074 February | <1.0 | ES1000083 February | <1.0 |
| | ES0800140 March | <1.0 | ES0900109 March | <1.0 | ES1000118 March | <1.0 |
| | ES0800186 April | <0.9 | ES0900173 April | <1.0 | ES1000151 April | <1.0 |
| | | | ES0900242 May | <1.0 | ES1000245 May | 2.4 ± 0.6 |
| | ES0800440 June | <0.9 | ES0900372 June | <1.0 | ES1000326 June | <1.0 |
| | ES0800560 July | <0.9 | ES0900448 July | <1.0 | ES1000422 July | <0.9 |
| | | | ES0900517 August | <1.0 | ES1000434 August | <1.0 |
| | ES0800655 September | <0.9 | ES0900626 September | <0.9 | ES1000657 September | <0.9 |
| | ES0800709 October | <1.0 | ES0900682 October | <1.0 | ES1000728 October | <0.9 |
| | ES0800796 November | <1.0 | ES0900766 November | <1.0 | ES1000978 November | <0.9 |
| | ES0800814 December | <1.0 | ES0900797 December | 0.9 ± 0.6 | ES1001106 December | <1.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Cahore | ES0800225 May | <1.0 | ES0900315 June | <1.0 | ES1000317 June | <1.0 |
| | ES0800677 September | <1.0 | ES0900525 August | <1.0 | ES1000457 August | <0.9 |
| Galway | ES0800496 July | <1.0 | | | ES1000420 July | <1.2 |
| Mountcharles | ES0800500 July | <1.0 | | - | ES1000421 July | <1.2 |
| Ards | ES0800504 July | <1.0 | ES0900697 October | 1.1 ± 0.6 | ES1001168 December | <1.0 |
| Larne | ES0800507 July | <1.0 | ES0900696 October | 0.9 ± 0.6 | ES1001165 December | <1.0 |
| Portrush | ES0800510 July | <1.0 | ES0900695 October | <1.0 | ES1001167 December | <1.0 |
| Castletownbere | ES0800613 August | <1.0 | | - | ES1000459 August | <1.2 |
| Woodstown | ES0800616 August | <1.0 | | | ES1000458 August | <1.2 |
| Irish Sea N1 | ES0800592 August | <1.0 | ES0900530 August | 1.2 ± 0.6 | ES1000164 April | 1.3 ± 0.6 |
| Irish Sea N2 | ES0800595 August | <1.0 | ES0900533 August | <1.0 | ES1000167 April | <1.0 |
| Irish Sea N3 | ES0800598 August | <1.0 | ES0900536 August | <1.0 | ES1000170 April | <1.0 |
| Irish Sea N4 | ES0800601 August | <1.0 | ES0900539 August | <1.0 | ES1000173 April | <1.0 |
| Irish Sea N5 | ES0800606 August | <1.0 | ES0900544 August | <1.0 | ES1000178 April | <1.0 |
| Irish Sea N6 | | | ES0900549 August | 1.1 ± 0.6 | ES1000183 April | <1.0 |
| Carlingford Lough C1 | | | ES0900554 August | 1.1 ± 0.6 | | |
| Carlingford Lough C2 | | | ES0900557 August | 1.1 ± 0.6 | | |
| Carlingford Lough C3 | | | ES0900562 August | <1.0 | | |
| Carlingford Lough C4 | | | ES0900567 August | <1.0 | | |

Uncertainties were calculated in accordance with the ISO Guide to the Expression of Uncertainty in Measurement [ISO, 1995] and are quoted as combined standard uncertainty values. It should be noted that no tritium was detected in the majority of samples. Twelve, around 14%, of the 85 samples, analysed contained measurable amounts of tritium at concentrations from 0.9 - 2.4 Bq/l. These compare with results previously observed in the Irish Sea and reported in the UK's Radioactivity in Food and the Environment Report (Environment Agency, Food Standards Agency, Northern Ireland Environment Agency and Scottish Environment Protection Agency, 2008). The remaining samples were found to have activities below the minimum detectable activity of typically 1 Bq/l. The maximum tritium activity measured at each location is shown in Figure 2

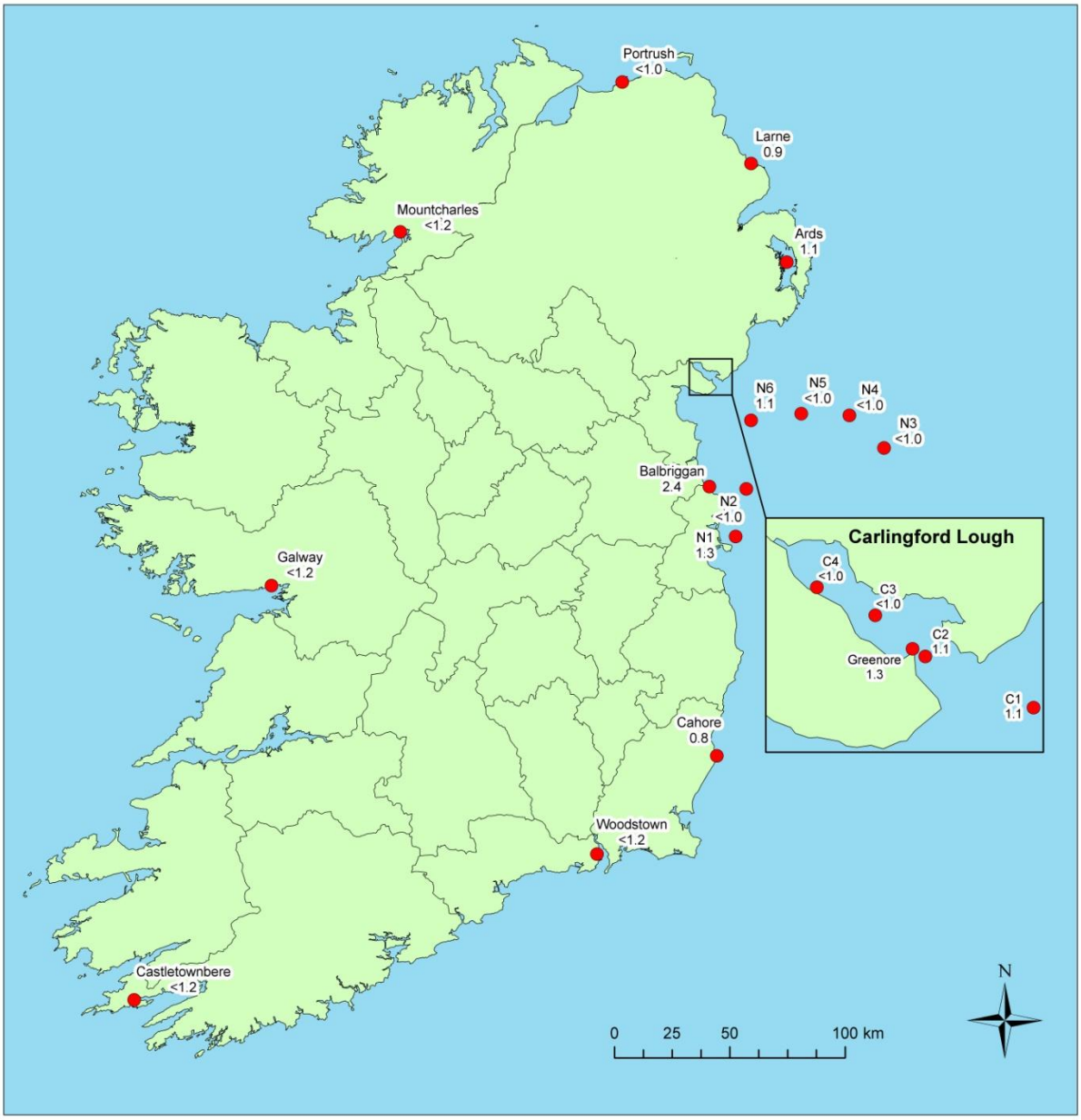



Figure 2: Maximum tritium activities in Irish seawater (Bq/l) 2008 - 2010

A conservative assessment of dose arising was made using the European Commission CREAM methodology, which was used to model the transfer of tritium from seawater into other

environmental media including fish and shellfish, in conjunction with seawater concentration data from this survey and the results of the RPII habits survey (Kelleher, 2011). The Habits Survey identified two critical groups of high-rate seafood consumers, designated Group A and Group B. Group A are commercial fishermen based along the North-East Irish coast who consume large amounts of fish and crustaceans. Group B are commercial oyster and mussel farmers based along the North-East coast who consume large amounts of molluscs. Using the highest seawater activity measured of 2.4 Bq/l and assuming that this did not change over time, the doses arising from ingestion of seafood to both critical Groups A and B are found to be 1.56 $x10^{-3}$ µSv and 1.08 x $10^{-3}$ µSv.

## Discussion

As already stated, tritium poses no external hazard since the beta particles released during tritium decay cannot penetrate the outer layer of dead skin cells. In addition, because of (i) the low beta energy, (ii) the dilution throughout all of the soft tissues, and (iii) the elimination with an average biological half-life of around ten days in adults, ingested or inhaled tritium (as tritiated water) has a relatively low radiological toxicity when compared to other pure beta emitters.

In the previous three decades the impact of discharges from the nuclear fuel reprocessing plant at Sellafield, UK has been readily apparent. However, concentrations of tritium in seawater samples round the Irish coastline are low when compared to tritium concentrations measured in seawater in the eastern Irish Sea (Environment Agency, Food Standards Agency, Northern Ireland Environment Agency and Scottish Environment Protection Agency, 2008 and 2009).

According to the UK's Discharge Strategy (Department of Energy & Climate Change 2009), the operational discharges for tritium from the nuclear fuel reprocessing plant at Sellafield, are expected to increase due to current and planned decommissioning activities for the period 2011-2015. RPII will continue to monitor tritium in seawater for that period as part of its marine environmental programme. In particular, the data gathered during this survey and its follow-up will form an essential part of the Irish submissions to the OSPAR Commission.

## Acknowledgements

The authors gratefully acknowledge the assistance of those who made a contribution to the RPII's tritium in seawater project, including colleagues from the Northern Ireland Environment Agency, colleagues from Centre for Environment, Fisheries and Aquaculture Science, Cefas, UK and from the Institut de Radioprotection et de Sûreté Nucléaire IRSN, France as well as from the School of Physics, University College Dublin, Ireland.

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# Appendix 1

### Copy of RPII Test Procedures

## Determination of Tritium in Seawater

| | |
|---|---|
| Introduction: | Tritium is a radioactive isotope of hydrogen, it is essentially a hydrogen atom with two extra neutrons. The most common form of tritium in the environment is in water. Like hydrogen, radioactive tritium reacts with oxygen to form water by replacing one of the stable hydrogen in the molecule to form tritiated water (HTO). As it undergoes radioactive decay, tritium emits a very weak beta particle.<br><br>Water samples should be stored at <5°C in the dark.<br><br>Each batch of samples should contain a reagent blank and a spiked or quality control sample. |
| Environmental Requirements: | N/A |
| Safety: | Appropriate PPE should be worn.<br>Care should be taken when handling chemicals.<br>This analysis should be carried out in a fumehood.<br>Take care when handling electrical and mechanical equipment.<br><br>Ensure that you are familiar with the Material Safety Data Sheet for the chemicals used in this procedure and with the chemical risk assessment, where appropriate. These are stored in the chemistry laboratory in files 05/01/131/03 and 05/01/131/02, respectively |
| Reagents and Equipment: | • Tritium Free Water<br>• Ultima Gold™ LLT<br>• Condenser<br>• 250 ml Round Bottom Flask<br>• 100 ml Round Bottom Flask<br>• Heating Mantle<br>• Collection Flask<br>• Distillation Receiver Adaptor<br>• Distillation Stillhead<br>• 2 Retort Stands<br>• Sodium Iodide<br>• Sodium Metabisulphite<br>• Anhydrous Sodium Carbonate |

- pH indicator strips

**Procedure:**

| Step | Procedure | Note |
|---|---|---|
| 1 | Measure approximately 150 ml of the seawater sample and transfer to a 250 ml round bottom distillation flask. | |
| 2 | Assemble the distillation apparatus ensuring that all joints are clean and sealed. | |
| 3 | Heat the sample on the mantle at setting 9 and collect approximately 100 ml of the distillate. | If the temperature setting is too high there may be a significant carry-over of other isotopes. |
| 4 | Transfer the distillate to a clean and dry round bottomed distillation flask. | |
| 5 | Add 0.4 g of sodium iodide, 0.4 g sodium metabisulphite and approximately 1 g of anhydrous sodium carbonated. | |
| 6 | Check that the sample is now alkaline by using a broad range pH strip. | |
| 7 | Reassemble the distillation apparatus ensuring that all joints are clean and sealed. | |
| 8 | Heat the sample on the mantle at setting 9 and collect approximately 100 ml of the distillate. | |
| 9 | Reject the initial fraction of the distillate. | Up to approximately 20 ml |
| 10 | Collect approximately 60 ml in a labelled container and allow to cool. | |
| 11 | Using a pipette transfer 9 ml of the distilled sample into a liquid scintillation vial. | Ensure the cap of the liquid scintillation vial is clearly labelled. |
| 12 | Add 10 ml of Ultima Gold™ LLT to the liquid scintillation vial containing the distilled sample | |
| 13 | Shake the vial and allow the sample to dark adjust for at least one hour in the LSC detector. | |

| | | |
|---|---|---|
| 14 | Count the sample in accordance with test procedure TP046<br><br>For each sample calculate the tritium counting efficiency, ES using the following formula:<br><br>$$E_S = \frac{S_E - S_S}{60 \times A}$$<br><br>Where<br>$S_E$ = The E vial count rate (cpm)<br>$S_S$ = The S vial count rate (cpm)<br>A = The activity of tritium added to the vial<br><br>If any of the sample count rates are close to the corresponding background count rates (within about 2 cpm) then carry out a t-test to determine if there is any tritium activity detectable in the sample, as follows<br><br>$$t = \frac{S_S - B}{\sqrt{\frac{S_S}{t_s} + \frac{B}{t_b}}}$$<br><br>Where:<br><br>$S_S$ = Sample count rate (cpm)<br>B = Background count rate (cpm)<br>$t_s$ = Sample count time (min)<br>$t_b$ = Background count time (min)<br><br>If the result of the t-test is less than 3 this indicates that the tritium activity present is indistinguishable from background and a minimum detectable activity (MDA) is calculated instead of an activity.<br><br>The minimum detectable activity (MDA) for the tritium activity concentration (Bq/l) is given by<br><br>$$MDA = \frac{\frac{2.71}{t_b} + 4.66\sqrt{\frac{B}{t_B}}}{E_s \times V \times 60}$$<br><br>where | |

| | | |
|---|---|---|
| | B = Background count rate (cpm)<br>$t_B$ = Background count time (mins_<br>V = Volume of sample (l)<br>Es = Counting Efficiency<br>The tritium activity concentration, (Bq/l), is given by<br>$\frac{S_S - B}{E_S \times V \times 60}$<br><br>The combined standard uncertainty on the tritium activity concentrations given by<br><br>$\left( \sqrt{\left( \frac{\sqrt{\frac{S}{t_s} + \frac{B}{t_b}}}{S - B} \right)^2 + (0.03)^2 \times A_c} \right)$<br><br>Where:<br><br>$A_c$ = Activity concentration and 0.03 is an overall uncertainty for the efficiency determination. | |

## Liquid Scintillation Counting

**Introduction:** There are two Liquid Scintillation Counters (LSCs) in operation in the laboratory:

- Tri-Carb 2770/TR SL
- Tri- Carb 3170/TR SL

Both LSCs operate in the same manner but the software associated with each counter is different. The Tri-Carb 2770 runs on a DOS platform and the Tri-Carb 3170 runs on a windows platform.

A complete description of the operating procedures for this liquid scintillation counter can be found in the Tri-Carb 2770 TR/SL reference manual. A *Help* window is also available by selecting <alt> F1 or clicking on this option with the mouse.

The operating procedures for the Tri-Carb 3170 can be found on the desktop of this LSC's computer under the 'Tri-Carb Resources' icon.

**Environmental Requirements:** N/A

**Safety:** Wear suitable protective equipment when handling vials for counting

Care should be taken when handling mechanical and electrical equipment

Ensure that you are familiar with the Material Safety Data Sheet for the chemicals used in this procedure and with the chemical risk assessment, where appropriate. These are stored in the chemistry laboratory in files 05/01/131/03 and 05/01/131/02, respectively

**Equipment and Materials:** N/A

**Procedure:**

| Step | Procedure | Notes |
|---|---|---|
| 1 | Tri-Carb 2270<br><br>Decide which protocol will be used for storing the sample counting details. To edit this protocol, select F1 from the *status* window and enter the protocol number.<br>Tri-Carb 3170<br><br>Decide which assay will be used for storing the sample counting details. To edit the assay go to >>Open assay and select the appropriate one. | There are 60 protocols to choose from. The mouse may be used instead of the function keys for selecting options. |
| 2 | Tri-Carb 2270 | |

| | | |
|---|---|---|
| | Enter the *Protocol Id* (protocol name and user Id). Enter the *Count Conditions* (count time in minutes, number of cycles, data mode, and any other parameters as required. View *Special Conditions* and amend as appropriate). Edit *Printer Output* and *Disk File Output* so that the required parameters are printed and saved, respectively. In *Worklist* enter the sample codes in the order that they will be counted so that the sample codes will be on the printout. Exit edit mode by pressing F1.<br>Tri-Carb 3170<br><br>Enter the *Count Conditions* (count time in minutes, number of cycles, data mode, and any other parameters as required). Edit *Printer Output* and *Disk File Output* so that the required parameters are printed and saved, respectively. In *Worklist* enter the sample codes in the order that they will be on the printout. All of these parameters can be accessed via the appropriate tabs in the assay window. Click OK to exit the assay window. | |
| 3 | Tri-Carb 2270 & Tri-Carb 3170<br><br>Insert the protocol plug corresponding to the selected protocol into the left hand side of a cassette. Push the slide on the protocol plug to the left end of the cassette. | |
| 4 | Tri-Carb 2270 & Tri-Carb 3170<br><br>Load the samples into the cassette(s) and load the cassette(s) into the sample changer. | If more than one cassette is required insert the protocol plug into the first cassette. |
| 5 | Tri-Carb 2270<br><br>If the system is not already counting then press button marked “START”<br><br>Tri-Carb 3170<br><br>If the system is not already counting then click the start button (Green Flag) or alternatively hit F11. | Ensure the printer is online |

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# Mission Statement

To ensure that people in Ireland are protected from the harmful effects of radiation

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