OSPAR COMMISSION

Second Periodic Evaluation of progress towards the objective of the Radioactive Substances Strategy

Radioactive Substances Series

2007

The Convention for the Protection of the Marine Environment of the North-East Atlantic (the "OSPAR Convention") was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. It has been ratified by Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, Netherlands, Norway, Portugal, Sweden, Switzerland and the United Kingdom and approved by the European Community and Spain.

La Convention pour la protection du milieu marin de l'Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d'Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998. La Convention a été ratifiée par l'Allemagne, la Belgique, le Danemark, la Finlande, la France, l'Irlande, l'Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume-Uni de Grande Bretagne et d'Irlande du Nord, la Suède et la Suisse et approuvée par la Communauté européenne et l'Espagne.

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CHAPTER 1 – Introduction

1. This report aims to show what progress the Contracting Parties to the OSPAR Convention[1] are making in reducing anthropogenic inputs of radioactive substances to the North-East Atlantic, in line with the commitments that they have made in the OSPAR Radioactive Substances Strategy.

2. The possibility of harm to the marine environment and its users (including the consumers of food produced from the marine environment) from inputs of radionuclides caused by human activities was always a subject with which the 1972 Oslo and 1974 Paris Conventions were concerned – a concern taken over by the 1992 OSPAR Convention and taken forward in the work of implementing it. When international action to protect the marine environment from all kinds of pollution was first agreed in 1972, the Oslo Convention[2] acknowledged that radioactive substances were one of the forms of wastes and other matter to be addressed, and committed the Contracting Parties to working in the appropriate UN specialised agencies and other international bodies to promote measures to protect the marine environment against them. When the Paris Convention[3] was adopted in 1974, in order to provide for international action against land-based sources of marine pollution, the Contracting Parties undertook "to adopt measures to forestall and, as appropriate, eliminate pollution of the maritime area from land-based sources by radioactive substances"[4].

3. When the Oslo and Paris Conventions were up-dated and unified in 1992 to form the OSPAR Convention, stringent restrictions were included not merely on the dumping of any radioactive waste or matter (which was then temporarily halted under an international moratorium) but also on any possibility of resuming such dumping, and radioactivity was included as one of the factors against which the need for control measures on discharges from land-based sources would be judged.

4. When the first Ministerial meeting under the 1992 Convention of the OSPAR Commission was held in 1998 at Sintra, Portugal, agreement was reached on both:

   a. a complete and permanent ban on all dumping of radioactive waste and other matter; and

   b. a strategy to guide the future work of the OSPAR Commission on protecting the marine environment of the North-East Atlantic against radioactive substances arising from human activities.

5. This strategy was revised and confirmed by the second Ministerial meeting of the OSPAR Commission at Bremen in 2003. The OSPAR Radioactive Substances Strategy thus now provides that

> "In accordance with the general objective [of the OSPAR Convention], the objective of the Commission with regard to radioactive substances, including waste, is to prevent pollution of the maritime area from ionising radiation through progressive and substantial reductions of discharges, emissions and losses of radioactive substances, with the ultimate aim of concentrations in the environment near background values for naturally occurring radioactive substances and close to zero for artificial radioactive substances. In achieving this objective, the following issues should, *inter alia*, be taken into account:
>
> a. legitimate uses of the sea;
>
> b. technical feasibility;
>
> c. radiological impacts on man and biota."

6. The Strategy further provides that:

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1 OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic, Paris, 22 September 1992. The Contracting Parties are Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom, together with the European Community.

2 Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft, Oslo, 15 February 1972.

3 Convention for the Prevention of Marine Pollution from Land-Based Sources, Paris, 4 June, 1974.

4 Article 5(1).

> "This strategy will be implemented in accordance with the Programme for More Detailed Implementation of the Strategy with regard to Radioactive Substances[5] in order to achieve by the year 2020 that the Commission will ensure that discharges, emissions and losses of radioactive substances are reduced to levels where the additional concentrations in the marine environment above historic levels, resulting from such discharges, emissions and losses, are close to zero."

7. The Programme for More Detailed Implementation of the Strategy with regard to Radioactive Substances (the "RSS Implementation Programme")[6] and the agreements made at the second OSPAR Ministerial meeting, in effect, provide that

a. the Contracting Parties will each prepare a national plan for achieving the objective of the Strategy,

b. they will monitor and report on progress in implementing those plans, and

c. the OSPAR Commission will periodically evaluate progress against an agreed baseline.

This report contains the second of these evaluations.

8. Under Annex IV to the OSPAR Convention, OSPAR is required to produce periodic assessments of the quality status of the maritime area covered by the Convention. A general assessment of the whole of the North-East Atlantic was produced in 2000, supported by five sub-regional reports. A further general assessment is planned to be produced in 2010, which will concentrate on the extent to which the aims of the thematic strategies of the OSPAR Commission have been delivered. In preparation for this, it in planned to produce in relation to the OSPAR Radioactive Substances Strategy the following thematic assessments:

2006: RA-1 First Periodic Evaluation of Progress towards the Objective of the Radioactive Substances Strategy (concerning progressive and substantial reductions in discharges of radioactive substances, as compared with the agreed baseline)

2007: RA-2 Second Periodic Evaluation of the Progress towards the Objective of the Radioactive Substances Strategy (concerning concentrations in the environment as compared with the agreed baseline and including an assessment (for those regions where information is available) of the exposure of humans to radiation from pathways involving the marine environment. (that is, this report)

2008: RA-3 An assessment (for those regions where information is available) of the impact on marine biota of anthropogenic sources (past, present and potential) of radioactive substances.

2009: RA-4 Third Periodic Evaluation of the Progress towards the Objective of the Radioactive Substances Strategy (being an overall assessment of radionuclides in the OSPAR maritime area).

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5 OSPAR agreement reference number: 2001-3.

6 Adopted by the OSPAR Commission in 2000, and slightly revised in 2001, the Programme for the More Detailed Implementation of the OSPAR Strategy with regard to Radioactive Substances is OSPAR Agreement 2001/3.

CHAPTER 2 – Derivation of Baseline Elements for Concentrations in the Marine Environment and Comparisons with the Assessment Period

2.1 Introduction

This chapter presents the approach used for establishing the baseline element for concentrations in the marine environment building on existing information from monitoring data published by several Contracting Parties and further data on marine environmental concentrations submitted by Belgium, France, Germany, Iceland, Ireland, the Netherlands, Norway, Spain, Sweden and the UK. In addition, the results of the Marina II study were made available by the European Commission.

Furthermore, this chapter presents the approach used for deriving values for the assessment period (2002 to 2005) and the approach used for comparing baseline elements with the assessment period.

2.2 Criteria for coverage

2.2.1 Selection of regions

The first action was to establish a table which subdivided the OSPAR maritime area into regions, and which shows where sufficient data were available to enable the calculation of some baseline values. The overall approach to deriving baseline values was intended to be one of simplicity. The regions are summarised in Table A1 of Annex 1 and have been defined taking into account which concentration data are available at this moment of time, and which marine areas have been used in the MARINA II study. Some of the marine areas in the MARINA II study have been grouped together but they do not correspond in all cases. Using coordinates of the boundaries of the OSPAR maritime area, Map 1 identifies the regions for the establishment of the baseline element for concentrations of radioactive substances. Map 2 presents a zoom-in of the regions identified in the Greater North Sea.

2.2.2 Selection of radionuclides

Efforts were concentrated on tritium, Cs-137, Tc-99 and Pu-239,240. Am-241 was also considered, but the conclusions are that baseline values for this would not be useful because concentrations could increase in the future due to decay of Pu-241 already in the environment. Other nuclides should also be considered to cover non-nuclear sectors. As soon as possible, data should be collected relating to long-lived radionuclides discharged by industries and activities outside the nuclear sector, and baseline values on their concentrations should be established.

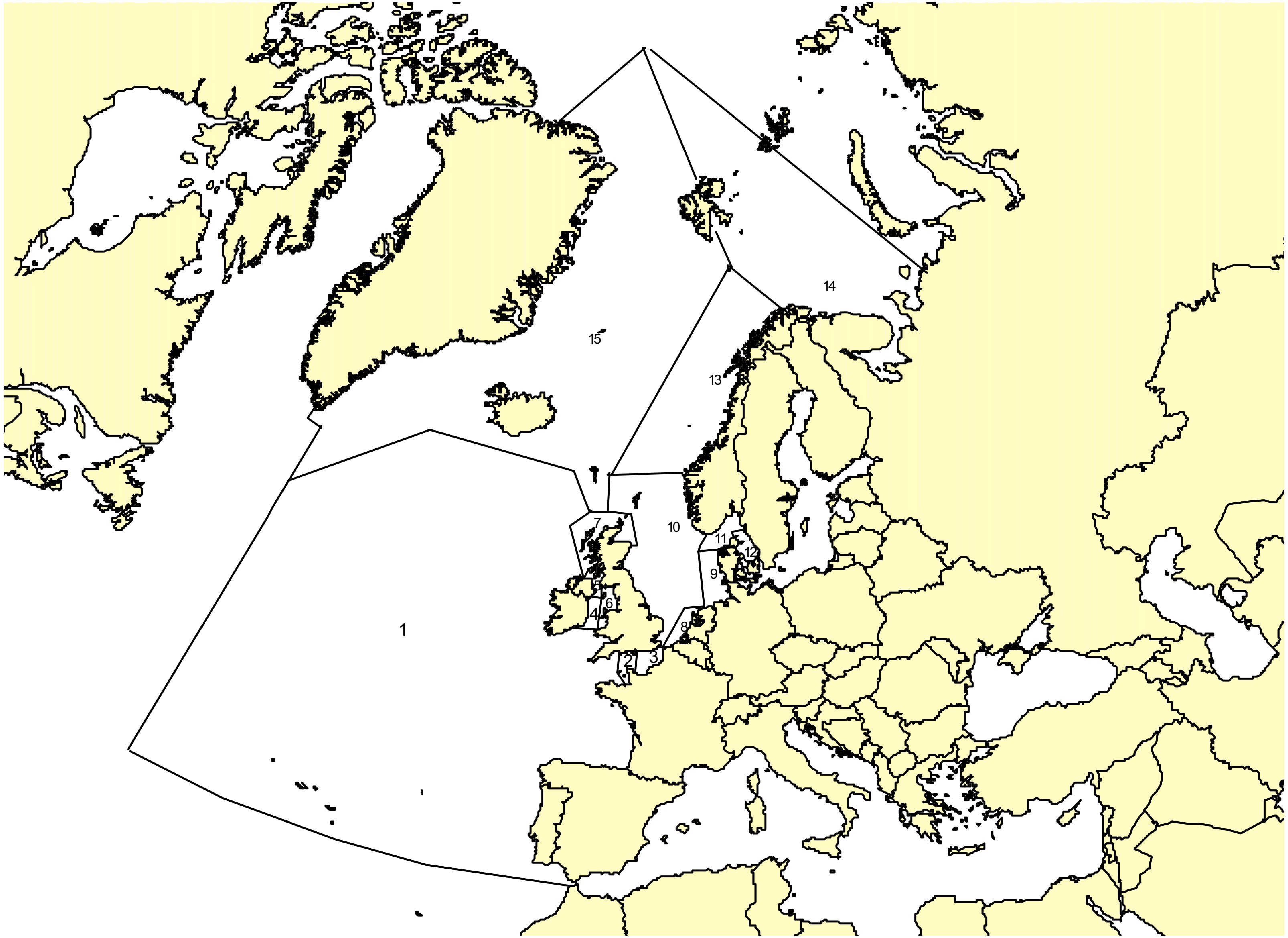
2.2.3 Selection of environmental compartments

Although the need was identified for establishing baseline values for, as far as possible, seawater, sediment and biota, generally sediments are not considered useful for this purpose. The concentration data depend heavily on the nature and properties of the sediment, so it is difficult and not reasonable to draw conclusions about sediment sampled at different locations. It would therefore be sufficient to derive baseline values for each radionuclide in seawater and in only one type of biota. For biota, data generally relate to coastal measurements with the exception of certain monitoring results in fish. Tritium was not considered relevant for biota due to the presence of natural levels of tritium, which makes it impossible to distinguish anthropogenic and natural sources. Additionally, there is generally little bioaccumulation of tritium by marine biota (with the exception of organic tritium compounds). Where biota (seaweed, fish and molluscs) concentration data has been reported as dry weight, a conversion factor of 5 has been used to calculate concentration data per wet weight.

2.2.4 Selection of years for averaging

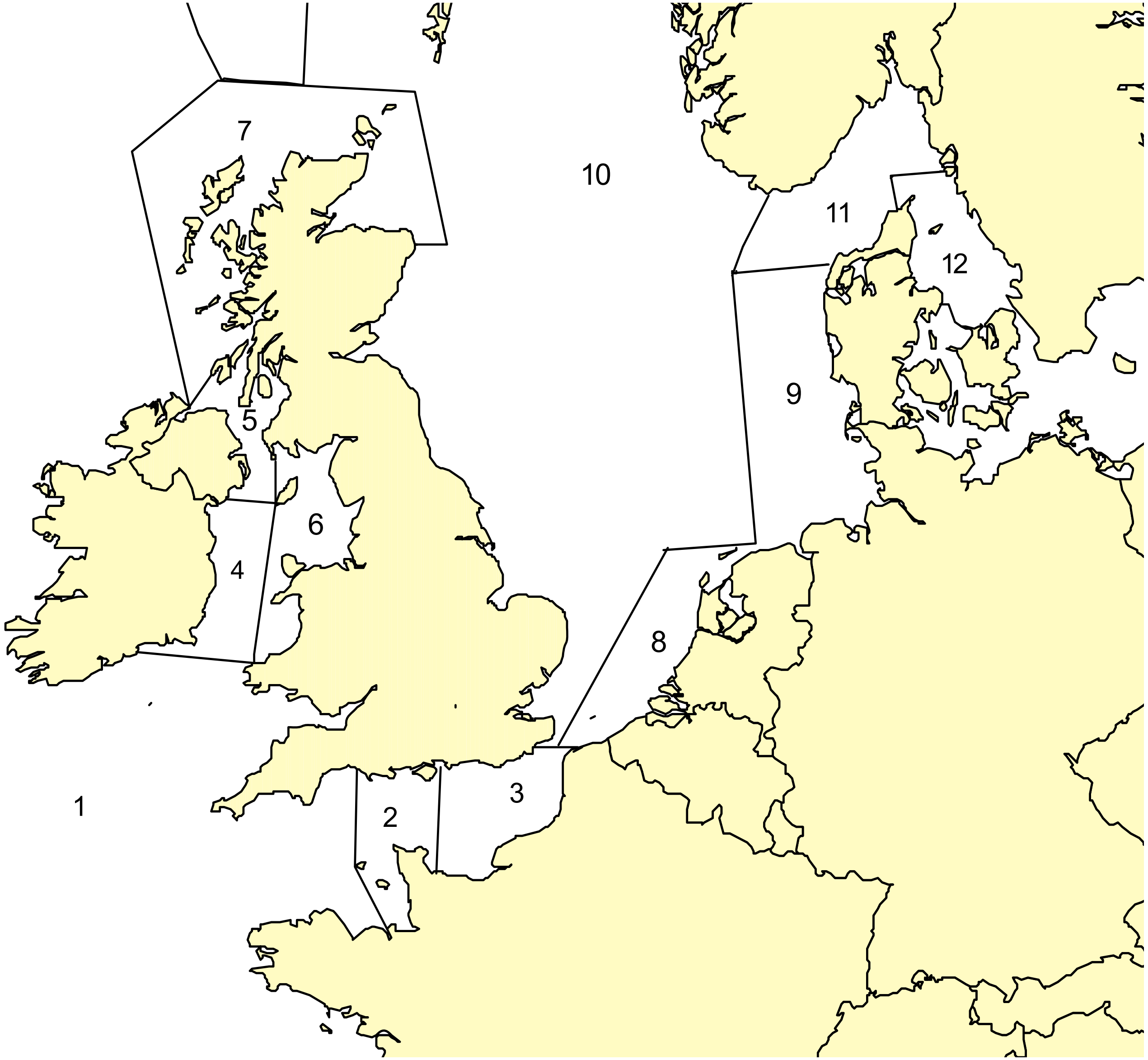
The calculations were carried out for the 7-year period 1995 - 2001 (i.e. 1998 +/- 3 years) which centres the data around 1998 (the "Sintra year"). The baseline period chosen for calculation of environmental baseline values is the same as for the baseline values for discharges.

Map 1: Regions identified for the establishment of baselines on concentrations of radioactive substances



1. Wider Atlantic
2. Cap de la Hague Channel
3. Channel East
4. Irish Sea (Rep. of Ireland)
5. Irish Sea (Northern Ireland)
6. Irish Sea (Sellafield)
7. Scottish waters (Dounreay)
8. North Sea South (Belgian and Dutch coast)
9. German Bight
10. North Sea (NW, SE and Central)
11. North Sea (Skagerrak)
12. Kattegat
13. Norwegian Coastal Current
14. Barents Sea
15. Norwegian, Greenland Seas and Icelandic waters

Map 2: Zoom of the regions identified in the Greater North Sea



1. Wider Atlantic
2. Cap de la Hague Channel
3. Channel East
4. Irish Sea (Rep. of Ireland)
5. Irish Sea (Northern Ireland)
6. Irish Sea (Sellafield)
7. Scottish waters (Dounreay)
8. North Sea South (Belgian and Dutch coast)
9. German Bight
10. North Sea (NW, SE and Central)
11. North Sea (Skagerrak)
12. Kattegat
13 Norwegian Coastal Current
14. Barents Sea
15. Norwegian, Greenland Seas and Icelandic Waters

2.3 Calculation of baseline values

2.3.1 Statistical methods

Baseline values were calculated as mean values of available annual mean concentrations from the baseline period and presented with their respective standard deviations. Standard mathematical functions, as for example in Microsoft EXCEL, were used.

2.3.2 Discussion of the baseline values

The baseline values previously reported in the document 'Baselines for Discharges of Radioactive Substances, their Concentrations in the Marine Environment and Doses to Members of the Public' (RSC Copenhagen 10-14th February 2003; RSC 03/2/1), hereafter referred to as the 'Baseline Document', are presented in Tables 1 and 2. A number of the baseline values reported in the second periodic evaluation have been revised. Where this has occurred, the revised baseline values are identified through the use of footnotes to Tables 1 and 2.

With regard to the baseline values, the following comments and limitations should be borne in mind:

Representativeness of data

a. in geographically subdividing the OSPAR Region, the Group had to compromise between the number of regions and available monitoring data. Too few regions might have meant large areas with large concentration ranges and resulted in large ranges on the baseline values. Too many regions might have meant that a number of regions would not have had any representative monitoring data. With these criteria in mind, a choice of 15 regions was made. Even with the adoption of the chosen 15 regions, it was only possible to calculate around half of the potential 105 baseline values from the existing data. Some baseline values were based on coastal monitoring results from within small areas, while others are derived from much larger marine areas, depending on the available data. Any use of these baseline values in future, need to take this into account. It is also important to note that baseline values have been based only on OSPAR data and not all available data and that environmental concentrations reflect all sources of radionuclides.

Means are based on different sizes of data sets

b. some calculated baseline values were based on long-term regular monitoring programmes, while other values have been derived from short-term or single monitoring campaigns. Some values were based on individual results within a year, whereas others were based on mean annual values which may have been derived from several samples in a year. The numbers of values used in the calculations are included in the tables, but small numbers do not necessarily mean a larger degree of uncertainty;

Monitoring results below detection limits

c. some baseline values were calculated using all or some/most results below analytical detection limits. Where this occurs, such values are identified in the tables (see below for example) through use of italics (all results below detection limits) or bold italics (some/most results below detection limits). The real baseline values may well be less than the values given, but there is no way of knowing on the information available. Values calculated using all or some/most results below detection limits are reported without any component for variability.

Example of data presentation

	Cs-137			Tc-99			Pu-239,240		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
2002	50	2.4	0.6	36	*< 0.1*	-	15	***< 0.0032***	-

- Value for Cs-137 derived from values above detection limits only;
- Value for Tc-99 derived from values below detection limits only;
- Value for Pu-239,240 derived from values above and below detection limits.

The aforementioned comments and limitations are applicable to all data reported for the assessment period.

2.4 Calculation of annual means for the assessment period (2002 to 2005)

Annual means for each year of the assessment period (2002 to 2005) have been calculated, where data is available, as for each annual mean of the baseline period (1995 to 2001) and the baseline values. Monitoring data for the assessment period has been provided by Belgium, Denmark, France, Germany, Ireland, the Netherlands, Norway, Spain, Sweden and the UK. Annual means for each compartment in each region may represent data provided by more than one Contracting Party. In the assessment period where large differences in magnitude occur between data reported above and below detection limits for a radionuclide in the same environmental compartment for the same region, two sets of annual means have been reported for the radionuclides for the applicable years. One mean based only on data above detection limits and one mean based on all available data (i.e. data above and below detection limits). Differences in magnitude between values above and below detection limits may result from differences in sampling and analytical methodologies within and between Contracting Parties.

2.5 Comparison of baseline elements with the assessment period (2002 to 2005)

2.5.1 Simple comparison with the baseline value and baseline 'bracket'

In keeping with the methodology previously used for the comparison of discharge baseline values, the same approach has been adopted for the comparison of environmental baseline values, with annual means from the assessment period compared to the baseline value and the baseline 'bracket', representing the baseline value ±1.96 times the standard deviation. In this approach, environmental data is assumed to be normally distributed around the mean of the reported values and the 'bracket' is therefore calculated as the interval which should contain 95% of all the values. However, in cases where the baseline value has been calculated using all or some/most results below analytical detection limits, the baseline bracket method cannot be employed due to the inability to derive any component for variability on the mean value.

Simple comparisons of annual means from the assessment period with the baseline value and baseline bracket cannot be described as giving 'statistically significant' results. Therefore, where these comparisons can be made, results have only been described as being either higher than, less than or similar to baseline values and upper and lower baseline bracket values. Where the derivation of the lower baseline bracket value produces a negative value, this value is reported as zero as negative environmental concentrations are impossible.

2.5.2 Comparison using statistical tests

Where annual means for the baseline period (1995 to 2001) are available for environmental concentrations and annual means for both the baseline period and assessment period have been derived solely from values above detection limits, more precise statistical methods have been employed. Again, in keeping with methodologies previously used for the comparison of discharge values, two-tailed Student's t-tests (heteroscedastic form) and two-tailed Mann-Whitney tests have been employed where appropriate to qualify conclusions drawn from simple comparisons with the baseline bracket. Where P values of less than 0.050 have been determined using either statistical test, the difference between annual means for the baseline period and assessment period can be said to be 'statistically significant'.

2.6 Limitations to be noted when interpreting and applying the conclusions of this report

In addition to the comments and limitations noted in 2.3.2, the following points should be considered:

a. There may be a time lag involved between changes in discharges and the transport of radionuclides thereafter. This will differ between OSPAR regions and could, for example, amount to years to be observed within the Arctic region and consequently the concentrations of radionuclides will also differ. Furthermore, the detection of radionuclides associated with concentrations may be further delayed in their transport by geochemical reactions;

b. concentrations may also be influenced by, for example, global nuclear fall-out following atmospheric weapons tests, the Chernobyl accident; etc.

c. at present the limited number of data points, and/or differences between sampling and analytical methodologies between Contracting Parties, together with the relatively high number of values below limits of detection, may require caution to be exercised when interpreting the data. Consequently, it was not possible to carry out statistical assessments in all the cases.;

d. some of the data concentrations may be influenced by the remobilisation of radionuclides in sediments from discharges made in the past, for which there has been no discussion but for which scientific evidence exists (Hunt, G. J. & Kershaw, P. J. (1990). Remobilisation of artificial radionuclides from the sediment of the Irish Sea. J. Radiol. Prot. 10 147-151.) (e.g. secondary sources present in the Irish Sea).

OSPAR RSC 2007 has formed a working group on statistics (ICG-Stat.) in order to elaborate a technically appropriate solution to these problems. The work of ICG-Stat., future work on the subject of historical levels and longer time series of data may allow the formation of more accurate and comprehensive conclusions in the next periodic evaluation.

2.7 Considerations towards future monitoring and data collection and storage

During the establishment of baseline values for concentrations in the marine environment, it became clear that the availability of a common database could have made the work easier. The IAEA GLOMARD marine database was used for the MARINA II study, so this could be an alternative to OSPAR developing a new database for marine radioactivity. The European Commission has offered that for this purpose OSPAR could use the REM database (Radioactivity Environmental Monitoring) at their Joint Research Centre in Ispra (Italy).

The data used in calculating baseline values were provided by individual Contracting Parties, and generally their monitoring programmes have not been undertaken for the purposes of the OSPAR Strategy with regard to Radioactive Substances. Furthermore, the monitoring has not been undertaken using any agreed OSPAR-wide approaches such as the Coordinated Environmental Monitoring Programme (CEMP; reference number: 2002-13 as amended from time to time) and guidelines established under the Joint Assessment and Monitoring Programme (JAMP; under revision). These points should be taken into consideration when further compilations of data are carried out, and when monitoring activities to evaluate the changes towards the baseline element for concentrations are developed.[7]

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[7] The 2003 meeting of the Radioactive Substances Committee agreed on intersessional work for the development of coordinated environmental monitoring programme for radioactive substances.

Table 1 - Proposed baseline values on seawater concentrations, based on calculations of the mean concentration for the period 1995-2001

Key to the table:

- n - number of annual means used to derive baseline value (unless otherwise stated); SD - standard deviation.
- Empty box: no data available.
- Baseline seawater value in italic denotes that all measurements on which the value has been based were below the detection limit.
- Baseline seawater value in bold italic denotes that some/most measurements on which the value has been based were below the detection limit.
- Dash: Standard deviation not calculated because baseline seawater value has been based on all or some/most measurements below the detection limit.

	Seawater											
Region	**Tritium (Bq/l)**			**Cs-137 (mBq/l)**			**Tc-99 (mBq/l)**			**Pu-239,240 (µBq/l)**		
	n	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
1. Wider Atlantic Iberian Coast Biscay and Channel West[a]				7[1]	*< 32.2*[2]	-						
2. Channel (Cap de la Hague)	7[1]	***< 13.9***[2]	-	7[1]	***< 30.3***[2]	-						
3. Channel East	5[1]	*< 10.3*[2]	-	7[1]	*< 34.4*[2]	-						
4. Irish Sea (Rep. of Ireland)				7[1]	28	10[2]	7[1]	24	9			
5. Irish Sea (Northern Ireland)				7	28.1[2]	9.3						
6. Irish Sea (Sellafield)	7	***< 15.0***[2]	-	7	175[2]	39	7	357[2]	340			
7. Scottish Waters (Dounreay)	5	***< 1.65***[2]	-	7	***< 53.5***[2]	-						
8. North Sea South (Belgian and Dutch Coast)	7	4.1[3]	0.7	5[1]	4.32	1.04[2]				4[1]	13.1	2.9[2]

Table 1 – Continued

Region	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (µBq/l)		
	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
9. German Bight	6[1]	2.93	0.88[2]	7[1]	5.38	2.02[2]	4[1]	1.67	1.21[2]	5[1]	11.41	4.73[d]
10. North Sea (Northwest, Southeast and Central)	7[1]	< ***0.8***[2]	-	4[1]	7.3	3.3	4[1]	2.8	0.8			
11. North Sea (Skagerrak)[b]				4[1]	14.7	8.4	5[1]	2.3	2.1			
12. Kattegat				7	30.3[4]	10.6	4	1.3[4]	0.5			
13. Norwegian Coastal Current				2	4.4[4]	0.4	5[1]	1.1	0.4			
14. Barents Sea				1[1]	3.5	0.4	3[1]	0.7	0.4			
15. Norwegian, Greenland Seas and Icelandic Waters				46[3]	4.55[6]	0.87						

Footnotes from Baseline Document
a - Surface water (upper 500 m); b - Variability of available data set is too large to derive a representative and sound baseline

Footnotes from RSC-ICG
1 - Value for n was previously reported in the Baseline Document as the total number of individual samples. Value for n is now reported as the number of annual means that were used to derive the baseline value;
2 - Value has been revised from that previously reported in the Baseline Document;
3 - Two baseline seawater values were previously reported in the Baseline Document representing data from the Netherlands (4.0 ±1.3, n=239) and Germany (3.6 ±2.63, n=14). In order to produce a single representative baseline seawater value for tritium in region 8, RSC-ICG made the decision to use only the value derived from data from the Netherlands due to the similarity between the two baseline seawater values and that the baseline seawater value derived from data from the Netherlands was based on a larger sample size. Value derived from data from the Netherlands has been revised;
4 - Baseline value not previously reported in the Baseline Document;
5 - n in this case refers to the total number of samples used to derive the baseline value;
6 - Two baseline seawater values were previously reported in the Baseline Document representing data for Icelandic Polar Water (6.4 ±1.7, n=37) and Icelandic Atlantic Water (2.7 ±0.4, n=9). In order to produce a single representative baseline seawater value for Cs-137 in region 15, RSC-ICG made the decision to use the mean of these two values and the propagated standard deviation.

Note, where standard deviations in the Baseline Document were previously reported for baseline seawater values derived using less than values, these standard deviations have now been removed.

Table 2 - Proposed baseline values on biota concentrations, based on calculations of the mean concentration for the period 1995-2001

Key to the table:

- Type: S - Seaweed (Fucus spp.); F - Fish; M - Molluscs.
- n - number of annual means used to derive baseline value (unless otherwise stated); SD - standard deviation.
- Empty box: no data available.
- Baseline biota value in bold italic denotes that some/most measurements on which the value has been based were below the detection limit.
- Dash: Standard deviation not calculated because baseline biota value has been based on some/most measurements below the detection limit.

	Biota											
Region	**Cs-137 (Bq/kg w.w.)**				**Tc-99 (Bq/kg w.w.)**				**Pu-239,240 (Bq/kg w.w.)**			
	Type	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**
1. Wider Atlantic Iberian Coast Biscay and Channel West	S	7[1]	***< 0.10***	-								
2. Channel (Cap de la Hague)	S	7[1]	***< 0.20***[2]	-	S	7[1]	9.1[2,3]	2.6	M	7[1]	0.017	0.003
3. Channel East	S	7[1]	***< 0.12***[2]	-	S	7[1]	7.3[2,3]	1.0	F[4]	5	***< 0.000046***	-
4. Irish Sea (Rep. of Ireland)	S	7[1]	0.84	0.19	S	7[1]	586	187	M	7[1]	0.13	0.04
5. Irish Sea (Northern Ireland)	F	7	2.7[2]	0.5	S	7	516[2]	280	M	7	0.17[2]	0.03
6. Irish Sea (Sellafield)	M	7	16.3	2.4	S	7	13361[2]	6752	M	7	18.1	1.7
7. Scottish Waters (Dounreay)	S	7	0.64[2]	0.38	S	7	287[2]	80	M	7	0.23[2]	0.14
8. North Sea South (Belgian and Dutch Coast)	F	5[1]	0.510	0.142[2]					M	6[1]	***< 0.04***[2]	-
									F	6[1]	***< 0.02***[2]	

Table 2 – Continued

	Biota											
Region	**Cs-137 (Bq/kg w.w.)**				**Tc-99 (Bq/kg w.w.)**				**Pu-239,240 (Bq/kg w.w.)**			
	Type	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**
9. German Bight	F	7[1]	0.426	0.161[2]					F	6	*< 0.000032*[4]	-
10. North Sea (Northwest, Southeast and Central)	F[a]	7	0.38	0.05	S	7	66.2	28.5	M	4	0.057[2]	0.007
11. North Sea (Skagerrak)												
12. Kattegat	S	7	1.7[4]	0.3	S	7	18.8[4]	10.3				
	F	7	3.0[4]	0.4								
13. Norwegian Coastal Current	S	5[1]	0.118[3]	0.042	S	5[1]	43.6[3]	20.8				
14. Barents Sea	F	6[1]	0.29[2]	0.04								
15. Norwegian, Greenland Seas and Icelandic Waters	S	86[5]	0.046[b,3]	0.016	S	29[5]	0.91[6]	0.39				
	F	19[5]	0.034[b,3]	0.006								

Footnotes from Baseline Document
a - These values are based on UK coastal data; b – Icelandic Coast

Footnotes from RSC-ICG
1 - Value for n was previously reported in the Baseline Document as the total number of individual samples. Value for n is now reported as the number of annual means that were used to derive the baseline value;
2 - Value has been revised from that previously reported in the Baseline Document;
3 - Previously reported values in the Baseline Document were in fact based on dry weight and not wet weight. These values have been converted to wet weight assuming 80% water content;
4 - Baseline value not previously reported in the Baseline Document;
5 - n in this case refers to the total number of samples used to derive the baseline value;
6 - Three dry weight baseline seaweed values were previously reported in the Baseline Document representing data for Iceland South and West Coast (1.6 ±0.3, n=14), Iceland East Coast (8.3 ±1.5, n=6) and Iceland North Coast. (3.8 ±1.2, n=9). In order to produce a single representative baseline seaweed value for Tc-99 in region 15, RSC-ICG made the decision to use the mean of these values as the baseline value with the propagated standard deviation. This value was then converted to wet weight assuming 80% water content.

Note, where standard deviations in the Baseline Document were previously reported for baseline biota values derived using less than values, these have now been removed.

CHAPTER 3 – Baseline Elements for Doses to Members of the Public

3.1 Introduction

According to the agreement between Contracting Parties in Sintra in 1998, the achievement of the OSPAR objective with regards to the radioactive substances should take into account, *inter alia*, the radiological impact on man. The strategy of the Commission includes the identification of radioactive substances which give rise to concern about the impact of discharges, emissions or losses of radioactive substances. This identification should be based upon an evaluation of, *inter alia*, the radiation exposure of humans. This identification should take account of existing methodologies for the scientific assessment of dose.

Doses are an important input to identify those radionuclides which may give rise to concern in the framework of the application of the OSPAR strategy, allowing:

a. quantification of the radiological significance of the measured concentration of each radionuclide included in the concentration baseline.

b. comparison, in terms of doses, of the variations in concentration of various radionuclides within the same region.

The aim of establishing baseline values for doses to members to the public was to recommend:

a. whether and, if so, what statistical techniques (consistent with those for the other baseline elements) are appropriate to be used to establish baselines values centred on 1998 and taking into account the seven years 1995-2001;

b. on the basis of contributions from each Contracting Party, a description of the systems used by the Contracting Parties to assess doses effectively reaching the critical groups for each nuclear installation or other significant source of radioactive discharges or each grouping of such sources;

c. a standard method to assess the doses received by individuals as a result of the concentrations of radionuclides in the marine environment covered by the data to be supplied by Contracting Parties and criteria for defining the areas for which such assessments should be made. These proposals should take into account the work of the European Commission for ensuring realistic assessments of doses to individuals in relation to basic safety standards;

d. if further relevant data exists, how it should be obtained.

3.2 Calculation of baseline values

3.2.1 Objectives

The baseline element for doses to members of the public is a tool to interpret the baseline element for discharges and the baseline element for the concentrations in the environment as it gives the relative radiological significance of the radionuclides discharged into the environment or measured in environmental compartments.

The definition of the baseline element for dose assessment should take into account:

a. the need for consistency with the approaches for establishing the baseline element for discharges and the baseline element for concentration in the environment;

b. the radionuclides and compartments defined for the baseline element for concentrations in the environment;

c. the methods used by EC project MARINA II

3.2.2 Defining the baseline element for doses

The approach for defining the baseline element for doses to members of the public was as follows:

a. a baseline value is defined as the mean of the doses for a several year period; this is consistent with the baseline elements for discharges and for concentrations in the environment;

b. the period for averaging a number of years should be consistent with the baseline elements for discharges and for concentrations in the environment;

c. any underlying trend was not removed; this is consistent with the baseline elements for discharges and for concentrations in the environment;

d. the variability is quantified as the standard deviation; this is consistent with the baseline elements for discharges and for concentrations in the environment;

e. the dose calculation methods were based on those used in the MARINA II project.

f. where doses have been calculated from environmental baseline values that have been derived using all or some/most results below analytical detection limits, these values are identified in the tables through use of italics (all results below detection limits) or bold italics (some/most results below detection limits). Doses calculated using all or some/most results below detection limits are reported without any standard deviation.

3.2.3 Examples of application

The application of a baseline value requires a recommendation for a standard assessment method for doses received by individuals as a result of concentrations of radionuclides in the marine environment. This is further discussed below.

Application to measured concentrations in the environment

In Tables 1 and 2, baseline values are listed for concentrations in seawater and biota (fish, molluscs and seaweed) using data provided by Contracting Parties. Data related to tritium, Cs-137, Tc-99 and Pu-239,240, and baseline values were derived for regions of the OSPAR maritime area. Baseline values for doses were calculated from these baseline values for concentrations in seawater using a simple dose assessment method derived from the MARINA II model. The method is described in Annex 3, with the baseline values for doses from concentrations of radionuclides in seawater shown in Table 3. All standard deviations reported for baseline values are based on the respective standard deviations calculated for the baseline values for concentrations of radionuclides in seawater given Table 1.

In the situation where in chapter 2 baseline values were derived for biota (fish and molluscs), a separate set of calculations was carried out using the simple relationship described in Annex 4. The results are given in Table 4 and enable comparison between the two approaches to be made. The standard deviation values are based on the respective standard deviations calculated for the baseline values for concentrations of radionuclides in biota given in Table 2.

In both approaches, doses were only assessed for ingestion pathways. Both included assessments for consumption of fish and molluscs, whilst the seawater approach also included crustaceans. It is important to note that since the baseline values for concentrations presented in chapter 2 covered the period 1995-2001, the calculated doses are for the same period.

However, the total dose due to discharges can not be inferred from the results shown in Tables 3 and 4. To encompass the total exposure of humans due to discharges, emissions or losses of radioactive substances from nuclear installations of the Contracting parties, impacts of other radionuclides discharged by those installations should be taken into account.

In addition, there are other sources of tritium, Cs-137, Tc-99 and Pu-239,240 to the OSPAR regions, than the present discharges of nuclear installations of the Contracting Parties: nuclear installations of other countries (e.g. discharges in the Baltic Sea or the Mediterranean Sea which result in inputs in the OSPAR area), past discharges, fallout from atmospheric nuclear weapon tests and from accidents such as the Chernobyl accident and non nuclear installations. These sources may increase the concentrations of tritium, Cs-137, Tc-

99 and Pu-239,240 in the OSPAR regions, so that doses shown in tables 3 and 4 may result from more than just the present discharges of the nuclear installations of the Contracting parties.

Furthermore, it is important to note that there are other sources of exposure to humans, such as the dose from natural radionuclides present in seawater. According to UNSCEAR, the order of magnitude of natural exposure of humans is a few millisieverts (mSv) per year, i.e. nearly two orders of magnitude higher than the doses shown in Tables 3 and 4.

3.3 General comments on derived doses

Derived doses in Tables 3 and 4 cover a very large range of values, from < 0.00027 µSv/y to 49.8 µSv/y (nearly 5 orders of magnitude). This confirms the fact that dose can be a powerful tool to discriminate between which radionuclides are of higher or lower concern with regard to the impact of discharges. Doses assessed from concentrations in biota are considered more reliable that those assessed from concentrations in seawater because no concentration factors are required in the assessment model.

However, there are advantages in the derivation of doses from environmental concentrations in seawater. Doses derived from seawater concentrations includes tritium and takes into account three ingestion pathways (fish, molluscs and crustaceans) as opposed to just two (fish and molluscs) in the case of doses derived from biota. As there is more data available for seawater concentrations than seafood concentrations, the doses shown in Table 3 cover more OSPAR regions than the corresponding analysis shown in Table 4.

One should note that, apart from region 9 for doses derived from seawater, none of the regions has a full set of baseline values for all the radionuclides considered. So comparisons between highest and lowest baseline values should be interpreted with this caveat in mind.

3.3.1 Comments on Table 3

Doses shown in Table 3 are derived from concentrations in seawater and cover a wide range of values, from < 0.00081 µSv/y to 9.3 µSv/y. Doses from tritium concentrations are extremely low in all regions, < 0.015 µSv/y and about three orders of magnitude less than the 10µ Sv/y dose (sometimes called the “trivial dose”) considered by the Council of the European Union as a criterion for the exemption of a practice (Directive 96/29/EURATOM of 13 May 1996). The highest values are derived in region 2 (Channel (Cap de la Hague)) and region 6 (Irish Sea (Sellafield)) and the lowest values in region 10 (North Sea (Northwest, Southeast and Central)); there is an 18 fold difference between the lowest and the highest value. The highest value (0.0154 µSv/y) is an upper assessment of the dose from tritium as it has been derived from tritium concentrations which include values below detection limits.

The highest doses are from Cs-137 (up to 9.3 µSv/y). In most of the regions (and in particular in the region with the highest value), the dose assessment has been derived from concentrations above analytical detection limits. The observed dose from Cs-137 declines sharply with distance from the highest value in region 6 (Irish Sea (Sellafield)), with a 50 fold difference between the highest and the lowest doses. The lowest dose from Cs-137 concentrations (0.186 µSv/y) is 12 fold higher than the highest dose from tritium concentrations.

The magnitude of doses from Tc-99 and Pu-239-240 lies between the values from tritium and Cs-137. The highest dose from Tc-99 is 5.53 µSv/y, about half the highest dose from Cs-137. The standard deviation associated with the highest value of the dose from Tc-99 is large (the dose and the standard deviation are nearly equal), which show that the fluctuations of Tc-99 concentrations have been large. Nevertheless, the observed Tc-99 dose, like Cs-137, declines sharply with distance from the highest value in region 6 (Irish Sea (Sellafield)). The highest dose from Pu-239,240 concentrations in seawater is much less (0.127 µSv/y), but no values are available for the regions with the highest value of doses from tritium, Cs-137 and Tc-99 (i.e. regions 2 and 6). Dose assessment for plutonium is available only for two regions and it is difficult to derive any substantial conclusion for this element.

3.3.2 Comments on Table 4

No concentration measurements in biota are available for tritium. Concentrations of Tc-99 have only been measured in seaweed, which is not a significant exposure pathway to humans. Therefore no doses have been assessed for these radionuclides from concentrations in biota.

For Pu-239,240 and Cs-137, concentration data in seafood is available for a number of regions. This data includes measurement of concentrations in either fish or molluscs. No data was collated on concentrations of radionuclides in crustaceans. The doses in Table 4 have then been assessed only for one pathway (fish or mollusc), which makes it difficult to compare them with the doses shown in Table 3. However, as a qualitative conclusion, one notes that in most regions, doses assessed from Cs-137 concentrations in seawater are of the same magnitude as those assessed from concentrations in seafood. This confirms that the order of magnitude of the concentration factors from the MARINA II model is consistent with observations for these radionuclides. Although the same conclusion can be drawn for Pu-239,240 in region 8 (North Sea South (Belgian and Dutch Coast)), the dose assessed from Pu-239,240 measured in biota (< 0.00027 µSv/y) in region 9 (German Bight) is significantly smaller than the dose assessed from the concentration in seawater (0.111 µSv/y), which suggest that the MARINA II dose model for plutonium may include conservative concentration factors in some regions.

Doses for Pu-239,240 cover a very large range of values, with five orders of magnitude between the highest and the lowest doses. Pu-239,240 in molluscs gives rise to the highest dose assessed in the OSPAR baseline. The highest dose from plutonium in seafood is 21 fold higher than the highest dose from Cs-137 in seafood. This situation only occurs in region 6 (Irish Sea (Sellafield), with doses from plutonium in other regions up to two orders of magnitude lower than reciprocal doses from Cs-137.

3.4 Calculation of annual mean doses for the assessment period (2002 to 2005)

Annual mean doses for each year of the assessment period (2002 to 2005) have been calculated, where data is available, as for each annual mean dose of the baseline period (1995 to 2001) and the baseline dose values. Annual mean doses for each compartment in each region may represent data provided by more than one Contracting Party. In the assessment period where large differences in magnitude occur between data reported above and below detection limits for a radionuclide in the same environmental compartment for the same region, two sets of annual mean doses have been reported for the radionuclides for the applicable years. One mean dose based only on data above detection limits and one mean dose based on all available data (i.e. data above and below detection limits). Differences in magnitude between values above and below detection limits may result from differences in sampling and analytical methodologies within and between Contracting Parties.

Table 3 - Baseline doses values assessed from baseline values for concentration of radionuclides in seawater

Key to the table:

- SD: standard deviation.
- Empty box: no data available.
- Baseline dose value in italics denotes that all measurements on which the corresponding baseline seawater value has been based were below the detection limit.
- Baseline dose value in bold italics denotes that some/most measurements on which the corresponding baseline seawater value has been based were below the detection limit.
- Dash: Standard deviation not calculated because the baseline dose value has been derived from a baseline seawater value that has been based on all or some/most measurements below the detection limit.

	Seawater							
Region	**Tritium**		**Cs-137**		**Tc-99**		**Pu-239,240**	
	Dose (µSv/y)	**SD**	**Dose (µSv/y)**	**SD**	**Dose (µSv/y)**	**SD**	**Dose (µSv/y)**	**SD**
1. Wider Atlantic Iberian Coast Biscay and Channel West			*< 1.71*[1]	-				
2. Channel (Cap de la Hague)	***< 0.0143***[1]	-	***< 1.61***[1]	-				
3. Channel East	*< 0.0106*[1]	-	*< 1.83*[1]	-				
4. Irish Sea (Rep. of Ireland)			1.49	1.06	0.369	0.138		
5. Irish Sea (Northern Ireland)			1.49	0.49				
6. Irish Sea (Sellafield)	***< 0.0154***[1]	-	9.30[1]	3.71	5.49[1]	5.23		
7. Scottish Waters (Dounreay)	***< 0.0017***	-	***< 2.84***[1]	-				
8. North Sea South (Belgian and Dutch Coast)	0.0042[2]	0.0007	0.23	0.06[1]			0.127	0.028[1]

Table 3 - Continued

	Seawater							
Region	**Tritium**		**Cs-137**		**Tc-99**		**Pu-239,240**	
	Dose (µSv/y)	**SD**	**Dose (µSv/y)**	**SD**	**Dose (µSv/y)**	**SD**	**Dose (µSv/y)**	**SD**
9. German Bight	0.0030	0.0009[1]	0.286	0.107[1]	0.0257	0.0186[1]	0.111	0.046[b]
10. North Sea (Northwest, Southeast and Central)	< ***0.0008***[2]	-	0.388	0.175	0.0430	0.0123		
11. North Sea (Skagerrak)			0.782	0.447	0.0354	0.0323		
12. Kattegat			1.609[3]	0.562	0.0204[3]	0.0070		
13. Norwegian Coastal Current			0.234[3]	0.023	0.0169	0.0062		
14. Barents Sea			0.186	0.021	0.0108	0.0062		
15. Norwegian, Greenland Seas and Icelandic Waters			0.242[4]	0.046				

Footnotes from RSC-ICG
1 - Value has been revised from that previously reported in the Baseline Document;
2 - Two baseline dose values were previously reported in the Baseline Document derived from baseline seawater values representing data from the Netherlands and Germany. In order to produce a single representative baseline seawater value for tritium in region 8 and hence a single representative baseline dose value, RSC-ICG made the decision to use only the value derived from data from the Netherlands, due to the similarity between the two baseline seawater values and that the baseline seawater value derived from data from the Netherlands was based on a larger sample size. Value derived from data from the Netherlands has been revised;
3 - Baseline value not previously reported in the Baseline Document;
4 - Two baseline dose values were previously reported in the Baseline Document derived from seawater values representing data for Icelandic Polar Water and Icelandic Atlantic Water. In order to produce a single representative baseline seawater value for Cs-137 in region 15, and hence a single representative baseline dose value, RSC-ICG made the decision to use the mean of the two previously reported values and the propagated standard deviation.

Note, where standard deviations in the Baseline Document were previously reported for baseline dose values that had been derived from baseline seawater values that had been derived using less than values, these standard deviations have now been removed.

Table 4 - Baseline doses values assessed from baseline values for concentration of radionuclides in biota

Key to the table:

- Type: F- Fish; M - Molluscs.
- SD: standard deviation.
- Empty box: no data available.

	Biota								
Region	**Cs-137**			**Tc-99**			**Pu-239,240**		
	Type	**Dose (µSv/y)**	**SD**	**Type**	**Dose (µSv/y)**	**SD**	**Type**	**Dose (µSv/y)**	**SD**
1. Wider Atlantic Iberian Coast Biscay and Channel West									
2. Channel (Cap de la Hague)							M	0.047[1]	0.008
3. Channel East							F[2]	***< 0.00039***	-
4. Irish Sea (Rep. of Ireland)							M	0.358	0.110
5. Irish Sea (Northern Ireland)	F	1.19[1]	0.22				M	0.47[1]	0.08
6. Irish Sea (Sellafield)	M	2.33[1]	0.34				M	49.8[1]	4.7
7. Scottish Waters (Dounreay)							M	0.633[1]	0.385
8. North Sea South (Belgian and Dutch Coast)	F	0.225	0.063[1]				M	***< 0.112***[1]	
							F	***< 0.181***[1]	

Table 4 – Continued

	Biota								
Region	**Cs-137**			**Tc-99**			**Pu-239,240**		
	Type	**Dose (µSv/y)**	**SD**	**Type**	**Dose (µSv/y)**	**SD**	**Type**	**Dose (µSv/y)**	**SD**
9. German Bight	F	0.188	0.071[1]				F	< ***0.00027***[2]	-
10. North Sea (Northwest, Southeast and Central)	F	0.170	0.022				M	0.157[1]	0.019
11. North Sea (Skagerrak)									
12. Kattegat	F	1.30[2]	0.20						
13. Norwegian Coastal Current									
14. Barents Sea	F	0.129[1]	0.017						
15. Norwegian, Greenland Seas and Icelandic Waters	F[a]	0.015[3]	0.003						

Footnotes from Baseline Document
a – Icelandic Coast;

Footnotes from RSC-ICG
1 - Value has been revised from that previously reported in the Baseline Document;
2 - Baseline value not previously reported in the Baseline Document;
3 - The baseline dose value previously reported in the Baseline Document was derived from a baseline biota value that was in fact based on dry weight and not wet weight. This baseline biota has been converted to wet weight assuming 80% water content.

Note, where standard deviations in the Baseline Document were previously reported for baseline dose values that had been derived from baseline biota values that had been derived using less than values, these standard deviations have now been removed.

CHAPTER 4 – Radionuclides originating from non-nuclear industries

4.1 Introduction

In 1997, an OSPAR report concerned mainly with the discharges from the phosphate fertiliser industry was published. By 1998, the discharges from the phosphate fertiliser industry had decreased and by 2005, discharges of radioactive discharges from the phosphate fertiliser industry in the OSPAR states had ceased.

OSPAR later agreed that further work was required to identify and quantify discharges of radioactive substances from other sectors of non-nuclear industry into the marine environment. The OSPAR report from 2002 indicates the industrial sectors which are the important sources of radioactive discharges. In order to ensure the application of the Radioactive Substances Strategy to the non-nuclear sectors, OSPAR therefore decided to institute a system for collecting data on these discharges. The priority radionuclides were Tc-99m and I-131 for the medical sector and Ra-226, Ra-228, Th-228 and Pb-210/Po-210 in relation to the oil and gas industry. However, the OSPAR agreement on monitoring of radionuclides in the environment did not include the relevant radionuclides from non-nuclear industries. Currently, these radionuclides are not typically part of national monitoring programmes. Furthermore, baselines for discharges, environmental concentrations and doses have not yet been established for these radionuclides.

4.2 Medical sector: I-131 and Tc-99m

Discharges from the medical sectors are made to the public sewers. It may be assumed that elevated concentrations of I-131 can only be detected near discharge points. Due to its short half-life (~8 days), I-131 will not persist in the environment. However, it is likely that the radionuclide in some cases can be detected in seaweeds and other marine biota in the vicinity of discharge points, but there is a lack of data on environmental concentrations.

The radionuclide Tc-99m decays with a half-life of only ~6 hours into Tc-99 (half-life 213,000 years). Due to the large difference in half-lives, the activity of the resulting technetium-99 activity will be very low – proportional to the ratio between half-lives, 6 hours to 213000 years. Monitoring of Tc-99 is carried out in relation to the discharges from nuclear reprocessing, and in this context the contribution from the medical sector will be insignificant.

4.3 Oil and gas industry: Ra-226, Ra-228, Th-228 and Pb-210/Po-210

Radionuclide discharges from the oil and gas industry are mainly due to discharges of produced water. Produced water is water that is co-extracted during oil and gas exploitation. The water consists of formation water that has been trapped in the reservoirs for millions of years, or a mixture of seawater and formation water, since it is a common practice to inject seawater in the reservoirs. Radium and its daughters may under certain circumstances leak from the formation rock into the formation water. This water is discharged to the marine environment in large volumes and usually contains enhanced levels of Ra-226 and Ra-228 from the naturally occurring uranium and thorium series. Generally, information on radium levels in produced water has been scarce and published data is mainly available only for recent years (2002 to 2005).

During the lifetime of an oil producing well, large quantities of seawater are usually injected into the reservoir to maintain pressure and enhance the production of hydrocarbons. After some time, so called breakthrough occurs, meaning that seawater can be detected in the produced water. Mixing of seawater and formation water creates incompatible solutions, and sulphates (mainly $BaSO_4$ and $SrSO_4$) are precipitated forming scales on production equipment. Due to the similar chemistry between radium and barium, radium will co-precipitate and leading to enhanced radium concentrations in the scales.

The low-radioactive deposits in the production stream represent a considerable waste problem for the industry, as material exceeding the clearance levels must be handled and disposed of as radioactive waste. De-scaling operations of tubing and other equipment are carried out both offshore and at coastal bases resulting in the discharge of radium isotopes to sea, in both dissolved and in particulate forms. Since the formation of scales leads to a slow down in production, scale inhibitors are often employed to reduce this problem.

4.4 Environmental sources and behaviour of radionuclides of the uranium and thorium series

Ra-226 is a long-lived member (half-life ~1600 years) of the uranium-series. It is a source of Pb-210 (half-life ~22.3 years) and Po-210 (half-life ~138 days) through radioactive decay. Ra-228 (half-life 5.75 years) is a decay product of Th-232 in the thorium-series. Ra-228 decays by beta emission into Th-228 (half-life 1.91 years).

Uranium and thorium series radionuclides occur in seawater due to leakage from bottom sediments, in situ radioactive decay and input from ground water, rivers and atmosphere. Their concentrations in the water column vary according to their chemical and geochemical properties and to the properties of the surrounding medium. The chemical and physical characteristics of the sediment, particulate organic and inorganic matter and dissolved salts, all influence the concentration of these radionuclides in the water column.

The major source of radium in seawater is the diffusion from bottom sediments. Radium is produced by decay of the particle reactive thorium-isotopes (Th-230 and Th-232) and can be mobilised to the water column by recoil effects or by direct leaching. Rivers contribute approximately 3-10% of the total oceanic radium, but relatively more in coastal areas affected by fresh-water inputs. Ra-228 is enriched in shallow water regions and has been used as a suitable tracer for advection of shelf water into the open ocean.

Radium-isotopes and their decay products can be taken up in marine biota. Due to the chemical similarities with calcium, levels of radium will be higher in bones and shells than in edible fractions of seafood. Po-210 is of special concern, as more than 90% of radiation doses from seafood intake are due to this radionuclide. After discharge, Po-210 will be produced (via Pb-210) in the environment by decay of Ra-226. It takes about 200 years to reach equilibrium between Ra-226 and Po-210 and about 3-4 years to establish equilibrium between Pb-210 and Po-210. Thus, it is clear that the increases of Po-210 (due to produced water discharges) in the marine environment will occur in the long term through ingrowth from Pb-210 and Ra-226.

4.5 Environmental concentrations.

Table 5 shows the available monitoring and literature data on environmental concentrations of radium isotopes, Pb-210 and Po-210 as averages with standard deviations by OSPAR region. It should be noted that these values are total environmental concentrations i.e. these values reflect natural background concentrations and possible contributions from discharges of these radionuclides from non-nuclear industries. The highest concentrations of radium-isotopes occur in coastal regions. The variability is higher for Ra-228 compared to Ra-226, which can be explained by the difference in half-life. In older water masses in the deep oceans, the concentration of Ra-228 is depleted due to radioactive decay.

The highest concentrations of Ra-226 appear in region 8 near the Dutch coast. These values may be slightly enhanced due to anthropogenic inputs. The enrichment of radium-228 in shallow and coastal areas can be seen in several regions (The Wash Estuary, Irish Sea, Skagerrak and English Channel).

For comparison purposes, doses arising from the marine environmental concentrations of natural radionuclides in Table 5 are shown in Table 6. All doses in Table 6 have been calculated using the same approach (i.e. MARINA II) as for doses derived from environmental concentrations of anthropogenic radionuclides (See Annex 3). Doses from Po-210 in seawater are typically two orders of magnitude greater than doses arising from Ra isotopes and Pb-210.

4.6 Considerations on baselines, future monitoring and reporting

For I-131, it is not relevant to look for long-term changes in environmental concentrations due to its short half-life. For Tc-99m, the contribution to the marine environment is through its decay product Tc-99 and this nuclide is covered by the OSPAR agreement on monitoring in relation to discharges from the nuclear industry. However, information on the relative contribution of Tc-99 from the decay of Tc-99m from the medical sector could be gained by monitoring areas where sewage discharge occurs to the marine environment.

Regarding the naturally occurring radionuclides Ra-226, Ra-228, Pb-210 and Po-210, there is no data available on seawater concentrations in the OSPAR region from the baseline period (1995-2001). However, published data is available from before and after this period and this data can be used as reference values in a similar manner as per the baseline values for anthropogenic radionuclides. Due to the natural variability of these radionuclides, it may be difficult to detect elevated levels originating from non-natural sources (e.g. produced water discharges). However, an efficient monitoring program could provide documentation on actual levels and perhaps improve our knowledge on the seasonal and temporal variability of seawater concentrations of these radionuclides.

Where descaling operations are employed, discharged radionuclides can occur in the form of small particles of varying size. Deposition of these particles may then result in elevated levels of radionuclides in marine sediments. Elevated levels of barium, thought to originate from the offshore oil production in the North Sea, have been found in the Skagerrak area, indicating that small particles can be advected over considerable distances by prevailing currents. Pb-210 and Po-210 are highly particle reactive and sedimentation is probably an important environmental process. Monitoring programmes for radionuclides originating from the oil and gas industry should therefore include sediment sampling and analysis in order to detect any long-term changes in concentrations

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Table 5 - Marine environmental concentrations of naturally occurring radionuclides in OSPAR regions.

Key to the table:

- n - number of observations; SD - standard deviation.
- Empty box: no data available.
- Dash: Standard deviation not calculated because n=1.

		Seawater											
Region	**Year**	**Ra-226 (mBq/l)**			**Ra-228 (mBq/l)**			**Pb-210 (mBq/l)**			**Po-210 (mBq/l)**		
		n	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
1. Wider Atlantic Iberian Coast Biscay and Channel West	1994[1]	7	1.29	0.36	7	0.77	0.45						
2. Channel (Cap de la Hague)	1994[1]	6	1.48	0.20	6	1.92	0.69						
3. Channel East	1994[1]	5	1.19	0.26	5	1.48	0.36						
4. Irish Sea (Rep. of Ireland)	1994[1]	7	1.22	0.24	7	1.09	0.51						
5. Irish Sea (Northern Ireland)	1994[1]	1	1.44	-	1	2.12	-						
6. Irish Sea (Sellafield)	1994[1]	4	1.84	0.33	4	3.58	0.93						
7. Scottish Waters (Dounreay)													
8. North Sea South (Belgian and Dutch Coast)	1985-86[2]	2	5.15	0.21				1	0.8	-	2	0.6	0.14

Table 5 – Continued

		Seawater											
Region	**Year**	**Ra-226 (mBq/l)**			**Ra-228 (mBq/l)**			**Pb-210 (mBq/l)**			**Po-210 (mBq/l)**		
		n	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
9. German Bight													
10. North Sea (Northwest, Southeast and Central)	1976[3]							11	0.89	0.57	11	0.77	0.46
	1986-87[4]	11	2.8	0.7	11	3.8	1.5						
	2004[5]	19	1.7	0.5	10	0.9	1.0				10	1.8	0.5
11. North Sea (Skagerrak)	2004[5]	4	2.1	0.5									
12. Kattegat													
13. Norwegian Coastal Current	1976[3]							1	1.97	-	1	1.49	-
	2005[6]	3	1.37	0.70									
14. Barents Sea	2005[6]	18	1.6	0.5									
15. Norwegian, Greenland Seas and Icelandic Waters													

1 - Schmidt J-L, Reyss F, Landré & Boust D (1998) Distributions and fluxes of ^{226}Ra and ^{228}Ra in the Irish Sea and in the English Channel, in relation to hydrological conditions and sediment interactions. Radiation Protection Dosimetry 75(1-4): 65-67;
2 - Köster HW, Marwitz PA, Berge GW, van Weers AW, Hagel P & Nieuwenhuize J (1992) ^{210}Po, ^{210}Pb, ^{226}Ra in aquatic ecosystems and polders, anthropogenic sources, distribution and enhanced radiation doses in the Netherlands. Radiation Protection Dosimetry 45 (1-4): 715-719;
3 - Spencer DW, Bacon MP & Brewer PG (1980) The distribution of ^{210}Pb and ^{210}Po in the North Sea. Thalassia Jugosl. 16: 125-154;
4 - Plater AJ, Ivanovich M & Dugdale RE (1995) ^{226}Ra contents and ^{228}Ra/^{226}Ra activity ratios of Fenland rivers and the Wash, Eastern England: Spatial and seasonal trends. Chemical Geology 199(1-4): 275-292;
5 - NPRA (2006) Radioactivity in the Marine Environment 2004. Results from the Norwegian National Monitoring programme (RAME). NRPA report 2006:14 Østerås. Norwegian Radiation Protection Authority;
6 - NRPA Unpublished monitoring data.

Table 6 - Doses arising from marine environmental concentrations of naturally occurring radionuclides in OSPAR regions.

Key to the table:

- SD - standard deviation.
- Empty box: no data available.
- Dash: Standard deviation not calculated because n=1.

		Seawater							
Region	Year	Ra-226		Ra-228		Pb-210		Po-210	
		Dose (µSv/y)	SD	Dose (µSv/y)	SD	Dose (µSv/y)	SD	Dose (µSv/y)	SD
1. Wider Atlantic Iberian Coast Biscay and Channel West	1994	10.5	2.9	15.5	9.1				
2. Channel (Cap de la Hague)	1994	12.1	1.6	38.7	13.9				
3. Channel East	1994	9.7	2.1	29.8	7.3				
4. Irish Sea (Rep. of Ireland)	1994	10.0	2.0	22.0	10.3				
5. Irish Sea (Northern Ireland)	1994	11.8	-	42.7	-				
6. Irish Sea (Sellafield)	1994	15.0	2.7	72.1	18.7				
7. Scottish Waters (Dounreay)									
8. North Sea South (Belgian and Dutch Coast)	1985-86	42.1	1.7			16.4	-	1001	234

Table 6 - Continued

		Seawater							
Region	**Year**	**Ra-226**		**Ra-228**		**Pb-210**		**Po-210**	
		Dose (µSv/y)	**SD**	**Dose (µSv/y)**	**SD**	**Dose (µSv/y)**	**SD**	**Dose (µSv/y)**	**SD**
9. German Bight									
10. North Sea (Northwest, Southeast and Central)	1976					18.3	11.7	1284	767
	1986-87	22.9	5.7	76.6	30.2				
	2004	13.9	4.1	18.1	20.1			3002	834
11. North Sea (Skagerrak)	2004	17.2	4.1						
12. Kattegat									
13. Norwegian Coastal Current	1976					40.5	-	2485	-
	2005	11.2	5.7						
14. Barents Sea	2005	13.1	4.1						
15. Norwegian, Greenland Seas and Icelandic Waters									

See footnote for table 5 for references for concentration data on which doses are based.

CHAPTER 5 – Annual mean regional marine environmental concentrations for the assessment period (2002 to 2005)

Key to all tables:

- n - number of observations (unless otherwise stated); SD - standard deviation.
- Type: S - Seaweed (Fucus spp.); F - Fish; M - Molluscs.
- Annual mean environmental concentrations given for each year of baseline period (1995-2001) where available.
- Greyed box: No baseline values available or subsequent sampling not specified under the Agreement on a Monitoring Programme for Concentrations of Radioactive Substances in the Marine Environment or dose not calculated for seaweed.
- Empty box: No data available.
- Value in italic denotes that all measurements on which the value has been based were below the detection limit.
- Value in bold italic denotes that some/most measurements on which the value has been based were below the detection limit.
- Dash: Standard deviation not calculated because either n=1 or value has been based on all or some/most measurements below the detection limit.
- Lower/Upper baseline bracket = Baseline value ±1.96 x SD.
- 0* - Indicates that derived lower baseline bracket is negative, but value is reported as 0.

5.1 Region 1. Wider Atlantic Iberian Coast Biscay and Channel West

5.1.1 Concentrations of radionuclides in seawater

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (μBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
1995				6	*< 24.6*	-						
1996				6	*< 49.7*	-						
1997				10	*< 28.2*	-						
1998				10	*< 33.2*	-						
1999				10	*< 24.9*	-						
2000				10	*< 31.7*	-						
2001				10	*< 33.1*	-						
Baseline				7	*< 32.2*	-						
2002	28	0.51	1.86	7	2.5	0.4	2	*< 0.1*	-			
	37	***< 2.7***	-	40	***< 55.1***	-						
2003	28	0.14	0.03	6	1.6	0.5	2	*< 0.1*	-			
	38	***< 2.6***	-	41	***< 69.0***	-						
2004	27	0.15	0.05	7	2.5	0.7						
	37	***< 2.5***	-	41	***< 75.2***	-						
2005	25	0.15	0.06	4	2.5	1.0						
	35	***< 2.7***	-	38	***< 101.6***	-						

Footnotes to Table
Due to the difference in magnitude between data reported above and below detection limits for tritium and Cs-137 in seawater for 2002 to 2005, two sets of annual means are reported for these radionuclides for these years, one set based only on data above detection limits and one set based on all available data (i.e. data above and below detection limits).

Assessment of concentrations in seawater

Tritium

No baseline value for tritium in seawater has been established for the Wider Atlantic Iberian Coast Biscay and Channel West. Due to a large difference in detection levels in the two sets of data submitted, two sets of annual mean concentrations for the period 2002 to 2005 are reported. Annual means based on all data (i.e. data above and below detection limits) were higher than annual means based only on data above detection limits. This discrepancy may be explained by a difference of metrology capacity or detection limit calculation.

Cs-137

The majority of data for Cs-137 in seawater for the assessment period was below detection limits. Due to a large difference in detection levels in the three sets of data submitted, two sets of annual mean concentrations for the period 2002 to 2005 are reported. Annual mean concentrations based on all data (i.e. data above and below detection limits) were higher than annual mean concentrations based only on data above detection limits. This difference could be explained by a difference of metrology capacity or detection limit calculation. Annual mean concentrations based only on data above detection limits for 2002 to 2005 were less than the baseline value. No baseline bracket could be determined and no statistical analyses could be performed.

Tc-99

No baseline value for Tc-99 in seawater has been established for the Wider Atlantic Iberian Coast Biscay and Channel West. Data for the assessment period was only available for the years 2002 and 2003 with low detection limits reported for both years.

5.1.2 Doses from seawater

	Seawater							
	Tritium		Cs-137		Tc-99		Pu-239,240	
Year	**Dose (µSv/y)**	**SD**	**Dose (µSv/y)**	**SD**	**Dose (µSv/y)**	**SD**	**Dose (µSv/y)**	**SD**
1995			*< 1.31*	-				
1996			*< 2.64*	-				
1997			*< 1.50*	-				
1998			*< 1.77*	-				
1999			*< 1.32*	-				
2000			*< 1.69*	-				
2001			*< 1.76*	-				
Baseline			*< 1.71*	-				
2002	0.00052	0.00191	0.13	0.02	*< 0.002*	-		
	< 0.0028	-	***< 2.93***	-				
2003	0.00014	0.00003	0.09	0.03	*< 0.002*	-		
	< 0.0027	-	***< 3.67***	-				
2004	0.00015	0.00005	0.13	0.04				
	< 0.0026	-	***< 4.00***	-				
2005	0.00015	0.00006	0.13	0.05				
	< 0.0028	-	***< 5.40***	-				

Comment on annual doses from seawater

From the radionuclide data reported, Cs-137 was the largest contributor to dose during the assessment period.

5.1.3 Concentrations of radionuclides in biota

	Biota											
	Cs-137 (Bq/kg w.w.)				**Cs-137 (Bq/kg w.w.)**				**Tc-99 (Bq/kg w.w.)**			
Year	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**
1995	S	36	***< 0.14***	-								
1996	S	31	***< 0.14***	-								
1997	S	36	***< 0.10***	-								
1998	S	33	***< 0.08***	-								
1999	S	36	***< 0.08***	-								
2000	S	12	***< 0.07***	-								
2001	S	12	0.06	0.02								
Baseline	S	7	***< 0.10***	-								
2002	S	15	***< 0.06***	-	F	3	0.23	0.06	S	2	2.16	0.76
2003	S	15	***< 0.06***	-	F	3	0.33	0.12	S	3	1.56	0.27
2004	S	10	0.06	0.02	F	3	0.27	0.06				
2005	S	8	***< 0.06***	-								

Footnotes to Table
Note, no baseline value reported for Pu-239,240 in biota. Cs-137 baseline values reported for both seaweed and fish.

Assessment of concentrations in biota

Cs-137

The majority of the data for Cs-137 in seaweed for the assessment period was above detection limits. Annual mean concentrations for 2002 to 2005 were remarkably similar and less than the baseline value. No baseline bracket could be determined and no statistical analyses could be performed.

No baseline value for Cs-137 in fish has been established for the Wider Atlantic Iberian Coast Biscay and Channel West. Annual mean concentrations from the period 2002 to 2004 were similar in value.

Tc-99

No baseline value for Tc-99 in seaweed has been established for the Wider Atlantic Iberian Coast Biscay and Channel West. Annual mean concentrations from the assessment period were only available for the years 2002 and 2003.

5.1.4 Doses from biota

	Biota								
	Cs-137			**Cs-137**			**Pu-239,240**		
Year	**Type**	**Dose (µSv/y)**	**SD**	**Type**	**Dose (µSv/y)**	**SD**	**Type**	**Dose (µSv/y)**	**SD**
1995									
1996									
1997									
1998									
1999									
2000									
2001									
Baseline									
2002				F	0.10	0.03			
2003				F	0.15	0.05			
2004				F	0.12	0.03			
2005									

Comment on annual doses from biota

Doses from Cs-137 in fish were similar to those based on annual mean concentrations for Cs-137 in seawater that were derived only from data above detection limits. The method for calculation of doses does not include seaweed data.

5.2 Region 2. Channel (Cap de la Hague)

5.2.1 Concentrations of radionuclides in seawater

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (µBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
1995	30	***< 14.9***	-	34	***< 30.9***	-						
1996	30	***< 15.4***	-	34	***< 33.5***	-						
1997	30	***< 14.3***	-	34	***< 29.4***	-						
1998	30	***< 12.8***	-	34	***< 30.4***	-						
1999	29	***< 15.0***	-	33	***< 26.4***	-						
2000	30	***< 12.1***	-	34	***< 30.6***	-						
2001	30	***< 12.8***	-	34	***< 31.0***	-						
Baseline	7	***< 13.9***	-	7	***< 30.3***	-						
2002	12	21.0	12.9	31	***< 28.6***	-						
	31	***< 13.8***	-									
2003	14	14.3	5.6	31	***< 24.0***	-						
	31	***< 11.1***	-									
2004	13	20.3	12.8	29	***< 23.2***	-						
	29	***< 13.7***	-									
2005	16	12.6	3.8	30	***< 23.8***	-						
	30	***< 10.8***	-									

Footnotes to Table
Due to the difference in magnitude between data reported above and below detection limits for tritium in seawater for 2002 to 2005, two sets of annual means are reported for this radionuclide for these years, one set based only on data above detection limits and one set based on all available data (i.e. data above and below detection limits).

Assessment of concentrations in seawater

Tritium

Due to a large difference in the magnitude between data reported above and below detection limits for tritium in seawater, two sets of annual mean concentrations for the period 2002 to 2005 are reported. Annual mean concentrations based on all data (i.e. data above and below detection limits) were lower than annual mean concentrations based only on data above detection limits. Annual mean concentrations based only on data above detection limits for the years 2002 and 2004 were higher than the baseline value, although the data sets for these years showed some variability. Annual mean concentrations for the period 2002 to 2005 that were based on all data were similar to the baseline value. No baseline bracket could be determined and no statistical analyses could be performed.

Cs-137

The majority of the data for Cs-137 in seawater for the assessment period was below detection limits. Annual mean concentrations for 2002 to 2005 were similar and all less than the baseline value. No baseline bracket could be determined and no statistical analyses could be performed.

5.2.2 Doses from seawater

	Seawater							
	Tritium		Cs-137		Tc-99		Pu-239,240	
Year	**Dose (μSv/y)**	**SD**	**Dose (μSv/y)**	**SD**	**Dose (μSv/y)**	**SD**	**Dose (μSv/y)**	**SD**
1995	***< 0.0153***	-	***< 1.64***	-				
1996	***< 0.0158***	-	***< 1.78***	-				
1997	***< 0.0147***	-	***< 1.56***	-				
1998	***< 0.0131***	-	***< 1.62***	-				
1999	***< 0.0154***	-	***< 1.40***	-				
2000	***< 0.0124***	-	***< 1.63***	-				
2001	***< 0.0131***	-	***< 1.65***	-				
Baseline	***< 0.0143***	-	***< 1.61***	-				
2002	0.0215 ***< 0.0142***	0.0132 -	***< 1.52***	-				
2003	0.0147 ***< 0.0114***	0.0057 -	***< 1.28***	-				
2004	0.0208 ***< 0.0141***	0.0131 -	***< 1.23***	-				
2005	0.0129 ***< 0.0111***	0.0039 -	***< 1.27***	-				

Comment on annual doses from seawater

From the radionuclide data reported, Cs-137 was the largest contributor to dose during the assessment period.

5.2.3 Concentrations of radionuclides in biota

	Biota											
	Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**
1995	S	63	***< 0.34***	-	S	12	8.4	4.0	M	16	0.016	0.009
1996	S	60	***< 0.22***	-	S	12	7.1	1.5	M	16	0.017	0.013
1997	S	59	***< 0.25***	-	S	10	8.2	1.7	M	15	0.022	0.033
1998	S	60	***< 0.16***	-	S	12	6.5	1.5	M	16	0.018	0.014
1999	S	64	***< 0.14***	-	S	12	13.9	4.7	M	15	0.018	0.021
2000	S	31	***< 0.14***	-	S	12	11.1	3.3	M	14	0.015	0.010
2001	S	32	***< 0.15***	-	S	4	8.6	3.7	M	16	0.012	0.006
Baseline	S	7	***< 0.20***	-	S	7	9.1	2.6	M	7	0.017	0.003
2002	S	36	***< 0.14***	-	S	6	4.9	3.2	M	17	0.009	0.004
2003	S	33	***< 0.13***	-	S	4	5.6	5.3	M	15	0.010	0.007
2004	S	32	***< 0.11***	-	S	4	3.8	3.9	M	17	0.012	0.009
2005	S	32	***< 0.11***	-	S	3	2.1	2.7	M	17	0.012	0.007

Assessment of concentrations in biota

Cs-137

The majority of the data for Cs-137 in seaweed for the assessment period was below detection limits. Annual mean concentrations for 2002 to 2005 were similar and all less than the baseline value. No baseline bracket could be determined and no statistical analyses could be performed.

Tc-99

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
4.0	14.2	P = 0.003	P = 0.006

Annual mean concentrations of Tc-99 in seaweed for the period 2002 to 2005 were all less than the baseline value, with the annual mean concentrations for 2004 and 2005 below the lower baseline bracket value. The results of the Student's t-test and Mann-Whitney test show that there is a statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2002 to 2005. Thus, there is evidence of a decrease in Tc-99 concentrations in seaweed in region 2. It is worth noting that the data from the UK is lower than data submitted by France.

Pu-239,240

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
0*	0.076	P = 0.002	P = 0.012

Annual mean concentrations of Pu-239,240 in molluscs for the period 2002 to 2005 were all less than the baseline value. The lower baseline bracket value was negative. The results of the Student's t-test and Mann-Whitney test show that there is a statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2002 to 2005. Thus, there is evidence of a decrease in Pu-239,240 concentrations in molluscs in region 2. It is worth noting that the data from the UK is lower than data submitted by France.

5.2.4 Doses from biota

	Biota								
	Cs-137			Tc-99			Pu-239,240		
Year	**Type**	**Dose (µSv/y)**	**SD**	**Type**	**Dose (µSv/y)**	**SD**	**Type**	**Dose (µSv/y)**	**SD**
1995							M	0.044	0.025
1996							M	0.047	0.036
1997							M	0.061	0.091
1998							M	0.050	0.039
1999							M	0.050	0.058
2000							M	0.041	0.028
2001							M	0.033	0.017
Baseline							M	0.047	0.008
2002							M	0.026	0.010
2003							M	0.029	0.020
2004							M	0.034	0.024
2005							M	0.034	0.019

Comment on annual doses from biota

Doses were only available for Pu-239,240 in molluscs and annual mean doses for 2002 to 2005 were all less than the baseline value. The method for calculation of doses does not include seaweed data.

5.3 Region 3. Channel east

5.3.1 Concentrations of radionuclides in seawater

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (μBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
1995				4	*< 8.3*	-						
1996				4	*< 91.8*	-						
1997	4	*< 10.9*	-	4	*< 27.0*	-						
1998	4	*< 10.4*	-	4	*< 25.5*	-						
1999	4	*< 11.0*	-	4	*< 24.5*	-						
2000	4	*< 9.5*	-	4	*< 33.3*	-						
2001	4	*< 9.5*	-	4	*< 30.5*	-						
Baseline	5	*< 10.3*	-	7	*< 34.4*	-						
2002	6	***< 7.3***	-	4	*< 31.3*	-						
2003	6	***< 7.5***	-	4	*< 24.0*	-						
2004	6	***< 7.0***	-	4	*< 26.3*	-						
2005	6	***< 21.6***	-	4	*< 25.5*	-						

Assessment of concentrations in seawater

Tritium

The majority of the data for tritium in seawater for the assessment period was below detection limits. Annual mean concentrations for 2002 to 2004 were similar and all less than the baseline value. The annual mean concentration for 2005 was higher than the baseline value as a result of one data point with an extremely high value. No baseline bracket could be determined and no statistical analyses could be performed.

Cs-137

All data for Cs-137 in seawater for the assessment period was below detection limits. The annual mean concentrations for the period 2002 to 2005 were similar and all less than the baseline value. No baseline bracket could be determined and no statistical analyses could be performed.

5.3.2 Doses from seawater

	Seawater							
	Tritium		Cs-137		Tc-99		Pu-239,240	
Year	**Dose (μSv/y)**	**SD**	**Dose (μSv/y)**	**SD**	**Dose (μSv/y)**	**SD**	**Dose (μSv/y)**	**SD**
1995			*< 0.44*	-				
1996			*< 4.88*	-				
1997	*< 0.0112*	-	*< 1.44*	-				
1998	*< 0.0107*	-	*< 1.36*	-				
1999	*< 0.0113*	-	*< 1.30*	-				
2000	*< 0.0097*	-	*< 1.77*	-				
2001	*< 0.0097*	-	*< 1.62*	-				
Baseline	*< 0.0106*	-	*< 1.83*	-				
2002	***< 0.0075***	-	*< 1.66*	-				
2003	***< 0.0077***	-	*< 1.28*	-				
2004	***< 0.0072***	-	*< 1.40*	-				
2005	***< 0.0222***	-	*< 1.36*	-				

Comment on annual doses from seawater

From the radionuclide data reported, Cs-137 was the largest contributor to dose during the assessment period.

5.3.3 Concentrations of radionuclides in biota

	Biota											
	Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**
1995	S	24	0.26	0.06	S	24	7.3	2.8	F	3	***< 0.000039***	-
1996	S	22	***< 0.22***	-	S	21	6.8	0.9	F	3	0.000048	0.000014
1997	S	24	***< 0.12***	-	S	20	6.5	1.4	F	8	***< 0.000044***	-
1998	S	23	***< 0.10***	-	S	9	6.8	1.1	F	8	***< 0.000073***	-
1999	S	24	***< 0.11***	-	S	8	8.7	2.4	F	1	*< 0.000026*	-
2000	S	8	0.08	0.02	S	7	8.7	2.6				
2001	S	8	0.07	0.02	S	5	6.3	1.4				
Baseline	S	7	***< 0.12***	-	S	7	7.3	1.0	F	5	***< 0.000046***	-
2002	S	8	0.06	0.01	S	6	5.7	1.1				
		9	***< 0.11***	-								
2003	S	8	0.07	0.02	S	3	5.5	0.6				
		9	***< 0.17***	-								
2004	S	8	0.08	0.03	S	5	5.9	1.5				
		9	***< 0.24***	-								
2005	S	8	0.08	0.02	S	3	4.1	1.6				
		9	***< 0.19***	-								

Footnotes to Table
Due to the difference in magnitude between data reported above and below detection limits for Cs-137 in seaweed in 2002 to 2005, two sets of annual means are reported for this radionuclide in these years, one set based only on data above detection limits and one set based on all available data (i.e. data above and below detection limits).

Assessment of concentrations in biota

Cs-137

Due to a large difference in detection levels in the two sets of data submitted, two sets of annual mean concentrations for the period 2002 to 2005 are reported for Cs-137 in seaweed. Annual mean concentrations based on all data (i.e. data above and below detection limits) were higher than annual mean concentrations based only on data above detection limits. This difference could be explained by a difference of metrology capacity or detection limit calculation. Annual mean concentrations based only on data above detection limits for the period 2002 to 2005 were similar and all less than the baseline value. Annual mean concentrations for the period 2002 to 2005 that were based on all data were generally higher than the baseline value. No baseline bracket could be determined and no statistical analyses could be performed.

Tc-99

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
5.3	9.3	P = 0.007	P = 0.006

The annual mean concentrations of Tc-99 in seaweed for the period 2002 to 2005 were similar and all less than the baseline value, with the annual mean concentration for 2005 below the lower baseline bracket value. The results of the Student's t-test and Mann-Whitney test show that there is a statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2002 to 2005. Thus, there is evidence of a decrease in Tc-99 concentrations in seaweed in region 3.

Pu-239,240

No monitoring data was available for the period 2002 to 2005, so no assessment can be made.

5.3.4 Doses from biota

	Biota								
	Cs-137			**Tc-99**			**Pu-239,240**		
Year	**Type**	**Dose (µSv/y)**	**SD**	**Type**	**Dose (µSv/y)**	**SD**	**Type**	**Dose (µSv/y)**	**SD**
1995							F	***< 0.00033***	-
1996							F	0.00041	0.00012
1997							F	***< 0.00037***	-
1998							F	***< 0.00062***	-
1999							F	*< 0.00022*	-
2000									
2001									
Baseline							F	***< 0.00039***	-
2002									
2003									
2004									
2005									

Comment on annual doses from biota

No monitoring data was available for the period 2002 to 2005, so no assessment can be made. The method for calculation of doses does not include seaweed data.

5.4 Region 4. Irish Sea (Rep. of Ireland)

5.4.1 Concentrations of radionuclides in seawater

	Seawater											
	Tritium (Bq/l)			**Cs-137 (mBq/l)**			**Tc-99 (mBq/l)**			**Pu-239,240 (µBq/l)**		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
1995				22	46	21	8	21	6			
1996				27	27	12	19	22	10			
1997				26	29	10	8	43	16			
1998				18	26	10	6	22	11			
1999				13	29	6	8	21	6			
2000				20	28	4	10	20	6			
2001				15	12	4	7	16	7			
Baseline				7	28	10	7	24	9			
2002				29	16	6	18	21	8			
2003				34	11	5	16	18	10			
2004				28	16	5	7	17	7			
2005				32	18	10	7	12	5			

Assessment of concentrations in seawater

Cs-137

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
8.8	47.5	P = 0.013	P = 0.042

The annual mean concentrations for Cs-137 in seawater for the period 2002 to 2005 were all less than the baseline value but not below the lower baseline bracket value. The results of the Student's t-test and Mann-Whitney test show that there is a statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2002 to 2005. Thus, there is evidence of a decrease in Cs-137 concentrations in seawater in region 4.

Tc-99

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
6.3	40.8	P = 0.120	P = 0.109

The annual mean concentrations of Tc-99 in seawater for the period 2002 to 2005 were all less than the baseline value but not below the lower baseline bracket value. The results of the Student's t-test and Mann-Whitney test do not show a statistically significant difference between the annual mean concentrations for from 1995 to 2001 and those from 2002 to 2005. Thus, there is no evidence of any change in Tc-99 concentrations in seawater in region 4.

5.4.2 Doses from seawater

	Seawater							
	Tritium		Cs-137		Tc-99		Pu-239,240	
Year	Dose (µSv/y)	SD	Dose (µSv/y)	SD	Dose (µSv/y)	SD	Dose (µSv/y)	SD
1995			2.45	1.12	0.32	0.09		
1996			1.44	0.64	0.34	0.15		
1997			1.54	0.53	0.66	0.25		
1998			1.38	0.53	0.34	0.17		
1999			1.54	0.32	0.32	0.09		
2000			1.49	0.21	0.31	0.09		
2001			0.64	0.21	0.25	0.11		
Baseline			1.49	0.53	0.37	0.14		
2002			0.85	0.30	0.32	0.12		
2003			0.61	0.27	0.28	0.15		
2004			0.87	0.24	0.27	0.11		
2005			0.95	0.51	0.19	0.08		

Comment on annual doses from seawater

From the radionuclide data reported, Cs-137 was the largest contributor to dose during the assessment period, with a smaller contribution from Pu-239,240.

5.4.3 Concentrations of radionuclides in biota

	Biota											
	Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**
1995	S	15	1.14	0.57	S	12	476	315	M	3	0.11	0.04
1996	S	20	0.83	0.21	S	16	587	215	M	4	0.15	0.03
1997	S	20	0.89	0.24	S	10	852	272	M	4	0.17	0.03
1998	S	22	0.72	0.19	S	14	828	400	M	4	0.20	0.03
1999	S	22	0.77	0.37	S	13	495	274	M	4	0.13	0.04
2000	S	20	0.99	0.36	S	14	508	203	M	4	0.10	0.08
2001	S	17	0.56	0.14	S	13	355	203	M	4	0.08	0.07
Baseline	S	7	0.84	0.19	S	7	586	187	M	7	0.13	0.04
2002	S	18	0.64	0.31	S	11	373	227	M	3	0.05	0.01
2003	S	19	0.64	0.28	S	10	605	436	M	1	0.03	-
2004	S	19	0.65	0.29	S	4	376	187	M	1	0.03	-
2005	S	18	0.67	0. 26	S	4	379	156	M	1	0.03	-

Assessment of concentrations in biota

Cs-137

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
0.47	1.21	P = 0.036	P = 0.073

The annual mean concentrations for Cs-137 in seaweed for the period 2002 to 2005 were all less than the baseline value but not below the lower baseline bracket value. The results of the Mann-Whitney test do not indicate a statistically significant difference between the annual mean concentrations from 1995 to 2001 and 2002 to 2005. However, the Student's t-test indicates a statistically significant difference, providing some evidence of a decrease in Cs-137 concentrations in seaweed in region 4.

Tc-99

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
219	953	P = 0.127	P = 0.315

The annual mean concentration for 2003 was above the baseline value while the values for 2002, 2004 and 2005 were all below the baseline value. However, all values fell within the baseline bracket. The results of the Student's t-test and Mann-Whitney test show that there is no statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2002 to 2005. Thus, there is no evidence of any change in Tc-99 concentrations in seaweed in region 4.

Pu-239,240

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
0.05	0.21	P = 0.001	P = 0.006

The annual mean concentrations for Pu-239,240 in molluscs for the period 2002 to 2005 were all less than the baseline value and with the exception of 2002 all values were below the lower baseline bracket value. The results of the Student's t-test and Mann-Whitney test show that there is a statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2002 to 2005. Thus, there is evidence of a decrease in Pu-239,240 concentrations in molluscs in region 4.

5.4.4 Doses from biota

	Biota								
	Cs-137			Tc-99			Pu-239,240		
Year	Type	Dose (µSv/y)	SD	Type	Dose (µSv/y)	SD	Type	Dose (µSv/y)	SD
1995							M	0.30	0.11
1996							M	0.41	0.08
1997							M	0.47	0.08
1998							M	0.55	0.08
1999							M	0.36	0.11
2000							M	0.28	0.22
2001							M	0.22	0.19
Baseline							M	0.36	0.11
2002							M	0.14	0.03
2003							M	0.08	-
2004							M	0.09	-
2005							M	0.09	-

Comment on annual doses from biota

Annual mean doses for Pu-239,240 in molluscs for the assessment period were all less than the baseline value. The method for calculation of doses does not include seaweed data.

5.5 Region 5. Irish Sea (Northern Ireland)

5.5.1 Concentrations of radionuclides in seawater

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (µBq/l)		
Year	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
1995				12	45.8	11.6						
1996				11	26.6	2.3						
1997				12	28.4	12.5						
1998				12	27.7	4.8						
1999				12	28.8	7.4						
2000				12	25.2	8.1						
2001				12	14.1	3.5						
Baseline				7	28.1	9.3						
2002				12	18.8	6.1						
2003				14	17.4	2.7						
2004				12	16.8	5.3						
2005				14	17.4	6.1						

Assessment of concentrations in seawater

Cs-137

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
9.9	46.3	P = 0.025	P = 0.073

The annual mean concentrations for Cs-137 in seawater for the period 2002 to 2005 were similar and all less than the baseline value but not below the lower baseline bracket value. The results of the Mann-Whitney test do not indicate a statistically significant difference between the annual mean concentrations from 1995 to 2001 and 2002 to 2005. However, the Student's t-test indicates a statistically significant difference, providing some evidence of a decrease in Cs-137 concentrations in seawater in region 5.

5.5.2 Doses from seawater

	Seawater							
	Tritium		Cs-137		Tc-99		Pu-239,240	
Year	Dose (µSv/y)	SD	Dose (µSv/y)	SD	Dose (µSv/y)	SD	Dose (µSv/y)	SD
1995			2.44	0.62				
1996			1.41	0.12				
1997			1.51	0.66				
1998			1.47	0.26				
1999			1.53	0.39				
2000			1.34	0.43				
2001			0.75	0.19				
Baseline			1.49	0.49				
2002			1.00	0.32				
2003			0.93	0.14				
2004			0.89	0.28				
2005			0.93	0.32				

Comment on annual doses from seawater

From the radionuclide data reported, only doses from Cs-137 could be determined. In comparison with the baseline value for this radionuclide, doses were lower in each of the subsequent years.

5.5.3 Concentrations of radionuclides in biota

	Biota											
	Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	Type	n	Mean	SD	Type	n	Mean	SD	Type	n	Mean	SD
1995	F	6	3.1	0.6	S	1	309	-	M	2	0.22	0.05
1996	F	4	3.2	0.7	S	1	408	-	M	2	0.17	0.02
1997	F	4	2.5	0.7	S	1	617	-	M	1	0.20	-
1998	F	3	2.3	0.8	S	1	397	-	M	1	0.16	-
1999	F	4	2.7	1.4	S	1	495	-	M	1	0.16	-
2000	F	4	2.9	0.7	S	1	1100	-	M	1	0.16	-
2001	F	4	1.9	1.0	S	1	289	-	M	1	0.15	-
Baseline	F	7	2.7	0.5	S	7	516	280	M	7	0.17	0.03
2002	F	5	2.4	0.7	S	4	269	289	M	2	0.13	0.04
2003	F	6	1.4	0.4	S	4	255	268	M	2	0.38	0.36
2004	F	6	1.7	0.4	S	4	304	322	M	2	0.19	0
2005	F	6	1.5	0.7	S	4	173	172	M	2	0.13	0.05

Assessment of concentrations in biota

Cs-137

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
1.7	3.7	P = 0.019	P = 0.024

The annual mean concentrations for Cs-137 in fish for the period 2002 to 2005 were all less than the baseline value, with the annual mean concentrations for 2003 and 2005 below the lower baseline bracket value. The results of the Student's t-test and Mann-Whitney test show that there is a statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2002 to 2005. Thus, there is evidence of a decrease in Cs-137 concentrations in fish in region 5.

Tc-99

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
0*	1065	P = 0.046	P = 0.012

The annual mean concentrations for Tc-99 in seaweed for the period 2002 to 2005 were all less than the baseline value. The lower baseline bracket value was negative. The overall tendency has been for Tc-99 concentrations to decrease with time, with some scatter between years presumably due to water circulation. The results of the Student's t-test and Mann-Whitney test show that there is a statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2002 to 2005. Thus, there is evidence of a decrease in Tc-99 concentrations in seaweed in region 5.

Pu-239,240

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
0.11	0.23	P = 0.619	P = 0.788

The annual mean concentrations of Pu-239,240 in molluscs for the period 2002 to 2005 were either higher or lower than the baseline value, with all values below the baseline upper bracket value, with the exception of the annual mean concentrations for 2003. The results of the Student's t-test and Mann-Whitney test show that there is no statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2002 to 2005. Thus, there is no evidence of any change in Pu-239,240 concentrations in molluscs in region 5. It is possible that the differences between the baseline value and annual mean concentrations in period 2002 to 2005 data may be due to environmental scatter from remobilisation from sediments.

5.5.4 Doses from biota

	Biota								
	Cs-137			Tc-99			Pu-239,240		
Year	**Type**	**Dose (µSv/y)**	**SD**	**Type**	**Dose (µSv/y)**	**SD**	**Type**	**Dose (µSv/y)**	**SD**
1995	F	1.37	0.27				M	0.61	0.14
1996	F	1.41	0.31				M	0.47	0.06
1997	F	1.11	0.31				M	0.55	-
1998	F	1.02	0.35				M	0.44	-
1999	F	1.19	0.62				M	0.44	-
2000	F	1.28	0.31				M	0.44	-
2001	F	0.84	0.44				M	0.41	-
Baseline	F	1.19	0.22				M	0.47	0.08
2002	F	1.06	0.30				M	0.36	0.10
2003	F	0.64	0.17				M	1.05	0.98
2004	F	0.75	0.17				M	0.53	0.00
2005	F	0.67	0.33				M	0.36	0.13

Comment on annual doses from biota

From the radionuclide data reported, Cs-137 was the largest contributor to dose during the assessment period, with a smaller contribution from Pu-239,240. In comparison with the baseline values, annual mean doses for Cs-137 were lower in each of the subsequent years, whereas values for Pu-239,240 were only lower in 2002 and 2005. The observed scatter observed for doses with time is assumed to be due to remobilisation from sediments. The method for calculation of doses does not include seaweed data.

5.6 Region 6. Irish Sea (Sellafield)

5.6.1 Concentrations of radionuclides in seawater

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (µBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
1995	15	12.3	9.4	6	221	131	4	480	245			
1996	18	11.7	7.7	6	219	99	4	1070	1276			
1997	15	***< 16.2***	-	6	200	92	4	278	39			
1998	14	***< 14.5***	-	6	158	78	4	112	57			
1999	14	***< 11.7***	-	6	142	64	4	160	85			
2000	14	***< 16.3***	-	6	168	75	4	113	22			
2001	14	***< 22.4***	-	6	118	62	4	288	244			
Baseline	7	***< 15.0***	-	7	175	39	7	357	340			
2002	18	***< 21.7***	-	6	97	70	4	256	174			
2003	41	***< 12.9***	-	29	73	50	4	230	136			
2004	16	***< 18.1***	-	6	147	73	4	104	54			
2005	40	***< 11.7***	-	28	78	48	2	73	30			

Assessment of concentrations in seawater

Tritium

The annual mean concentrations of tritium were below detection limits throughout the period 2002 to 2005 and were similar to the baseline value. No statistical analyses could be performed.

Cs-137

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
99	251	P = 0.012	P = 0.024

The annual mean concentrations for Cs-137 in seawater for the period 2002 to 2005 were all less than the baseline value and with the exception of the 2004 value, were all below the lower baseline bracket value. The results of the Student's t-test and Mann-Whitney test show that there is a statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2002 to 2005. Thus, there is evidence of a decrease in Cs-137 concentrations in seawater in region 6.

Tc-99

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
0*	1023	P = 0.203	P = 0.164

The annual mean concentrations for Tc-99 in seawater for the period 2002 to 2005 were all less than the baseline value. The lower baseline bracket value was negative. The results of the Student's t-test and Mann-Whitney test show that there is no statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2002 to 2005. Thus, there is no evidence of any change in Tc-99 concentrations in seawater in region 6.

5.6.2 Doses from seawater

	Seawater							
	Tritium		Cs-137		Tc-99		Pu-239,240	
Year	Dose (µSv/y)	SD	Dose (µSv/y)	SD	Dose (µSv/y)	SD	Dose (µSv/y)	SD
1995	0.013	0.010	11.75	6.97	7.38	3.77		
1996	0.012	0.008	11.64	5.26	16.5	19.6		
1997	***< 0.017***	-	10.63	4.89	4.27	0.60		
1998	***< 0.015***	-	8.40	4.15	1.72	0.88		
1999	***< 0.012***	-	7.55	3.40	2.46	1.31		
2000	***< 0.017***	-	8.93	3.99	1.74	0.34		
2001	***< 0.023***	-	6.27	3.30	4.43	3.75		
Baseline	***< 0.015***	-	9.30	2.07	5.49	5.23		
2002	***< 0.022***	-	5.17	3.71	3.94	2.67		
2003	***< 0.013***	-	3.90	2.64	3.54	2.09		
2004	***< 0.019***	-	7.83	3.89	1.60	0.83		
2005	***< 0.012***	-	4.12	2.55	1.13	0.46		

Comment on annual doses from seawater

From the radionuclide data reported, Cs-137 was the largest contributor to dose during the assessment period, with a smaller contribution from Tc-99. Annual mean doses from these radionuclides were all lower than their respective baseline value. Some scatter is observed for the dose from Cs-137 with time (assumed to be from remobilisation to the water column from sediments), whilst the tendency for dose from Tc-99 is to decrease with time.

5.6.3 Concentrations of radionuclides in biota

	Biota											
	Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**
1995	M	4	20.9	9.4	S	4	20518	12236	M	4	21.0	7.3
1996	M	4	16.7	5.9	S	4	23775	10547	M	4	18.6	7.1
1997	M	4	17.2	8.8	S	4	15700	5754	M	4	17.2	8.7
1998	M	4	15.3	6.8	S	4	7748	4446	M	4	17.0	7.3
1999	M	4	15.4	4.1	S	4	9815	2614	M	4	17.2	3.7
2000	M	4	14.6	7.7	S	4	6180	1452	M	4	16.4	9.3
2001	M	4	13.6	7.1	S	4	9795	2147	M	4	19.6	13.6
Baseline	M	7	16.3	2.4	S	7	13361	6752	M	7	18.1	1.7
2002	M	20	4.3	5.5	S	10	6525	4997	M	8	9.7	11.8
2003	M	20	3.7	4.0	S	10	6386	4664	M	8	9.4	11.5
2004	M	20	3.8	3.6	S	9	2339	1518	M	8	7.2	6.5
2005	M	20	3.8	4.3	S	10	2279	1948	M	8	10.4	12.9

Assessment of concentrations in biota

Cs-137

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
11.6	21.0	P = <0.001	P = 0.006

The annual mean concentrations for Cs-137 in molluscs for the period 2002 to 2005 were similar and all less than the baseline value and the lower baseline bracket value. The results of the Student's t-test and Mann-Whitney test show that there is a statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2002 to 2005. Thus, there is evidence of a decrease in Cs-137 concentrations in molluscs in region 6.

Tc-99

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
127	26595	P = 0.013	P = 0.024

The annual mean concentrations for Tc-99 in seaweed for the period 2002 to 2005 were all less the baseline value and showed a decrease over time. The lower baseline bracket value was negative. The results of the Student's t-test and Mann-Whitney test show that there is a statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2002 to 2005. Thus, there is evidence of a decrease in Tc-99 concentrations in seaweed in region 6.

Pu-239,240

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
14.8	21.4	P = <0.001	P = 0.006

The annual mean concentrations for Pu-239,240 in molluscs for the period 2002 to 2005 were similar and all less than the baseline value and the lower baseline bracket value. The results of the Student's t-test and Mann-Whitney test show that there is a statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2002 to 2005. Thus, there is evidence of a decrease in Pu-239,240 concentrations in molluscs in region 6.

5.6.4 Doses from biota

	Biota								
	Cs-137			Tc-99			Pu-239,240		
Year	**Type**	**Dose (µSv/y)**	**SD**	**Type**	**Dose (µSv/y)**	**SD**	**Type**	**Dose (µSv/y)**	**SD**
1995	M	2.99	1.34				M	57.8	20.1
1996	M	2.39	0.84				M	51.2	19.5
1997	M	2.46	1.26				M	47.3	23.9
1998	M	2.19	0.97				M	46.8	20.1
1999	M	2.20	0.59				M	47.3	10.2
2000	M	2.09	1.10				M	45.1	25.6
2001	M	1.94	1.02				M	53.9	37.4
Baseline	M	2.33	0.34				M	49.8	4.7
2002	M	0.61	0.79				M	26.7	32.5
2003	M	0.53	0.57				M	25.9	31.6
2004	M	0.54	0.51				M	19.8	17.9
2005	M	0.54	0.62				M	28.6	35.5

Comment on annual doses from biota

From the radionuclide data reported, Pu-239,240 was the largest contributor to dose during the assessment period, with a minor contribution from Cs-137. Annual mean doses from these radionuclides were all lower than their respective baseline value. From 2002 to 2005, values for both Pu-239,240 and Cs-137 were reasonably consistent. The small scatter observed for doses with time is assumed to be due to remobilisation from sediments. The method for calculation of doses does not include seaweed data.

5.7 Region 7. Scottish Waters (Dounreay)

5.7.1 Concentrations of radionuclides in seawater

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (µBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
1995				4	25.6	9.2						
1996				4	23.7	11.2						
1997	4	*< 1.59*	-	3	*< 50*	-						
1998	2	2.40	0.28	3	*< 50*	-						
1999	4	*< 1.38*	-	4	*< 50*	-						
2000	4	*< 1.25*	-	4	*< 75*	-						
2001	4	***< 1.66***	-	3	*< 100*	-						
Baseline	5	***< 1.65***	-	7	***< 53.5***	-						
2002	6	*< 1.16*	-	2	4.6	0.4						
				6	***< 68***	-						
2003	4	***< 1.08***	-	4	*< 100*	-						
2004	6	*< 1.15*	-	2	3.5	1.3						
				6	***< 68***	-						
2005	4	*< 1.00*	-	4	*< 100*	-						

Footnotes to Table

Due to the difference in magnitude between data reported above and below detection limits for Cs-137 in seawater for 2002 and 2004, two sets of annual means are reported for this radionuclide in these years, one set based only on data above detection limits and one set based on all available data (i.e. data above and below detection limits).

Assessment of concentrations in seawater

Tritium

The annual mean concentrations of tritium were below detection limits throughout the period 2002 to 2005 and were similar to the baseline value. No baseline bracket could be determined and no statistical analyses could be performed.

Cs-137

The majority of the data for Cs-137 in seawater for the assessment period was below detection limits. A few data points above detection levels were provided for 2002 and 2004 and annual mean concentrations derived from this data were lower than the baseline value. Data above detection levels was reasonably consistent and low. No baseline bracket could be determined and no statistical analyses could be performed.

5.7.2 Doses from seawater

	Seawater							
	Tritium		Cs-137		Tc-99		Pu-239,240	
Year	**Dose (µSv/y)**	**SD**	**Dose (µSv/y)**	**SD**	**Dose (µSv/y)**	**SD**	**Dose (µSv/y)**	**SD**
1995			1.36	0.49				
1996			1.26	0.60				
1997	*< 0.0016*	-	*< 2.66*	-				
1998	0.0025	0.0003	*< 2.66*	-				
1999	*< 0.0014*	-	*< 2.66*	-				
2000	*< 0.0013*	-	*< 3.99*	-				
2001	***< 0.0017***	-	*< 5.32*	-				
Baseline	***< 0.0017***	-	***< 2.84***	-				
2002	*< 0.0012*	-	0.24	0.02				
			< 3.63	-				
2003	***< 0.0011***	-	*< 5.32*	-				
2004	*< 0.0012*	-	0.19	0.07				
			< 3.60	-				
2005	*< 0.0010*	-	*< 5.32*	-				

Comment on annual doses from seawater

From the radionuclide data reported, Cs-137 was the largest contributor to dose during the assessment period. In comparison with the baseline value, the doses for Cs-137 were lower in each of the years that data above detection levels was observed. Dose values from 2002 to 2005 that were larger than the baseline value were due to higher detection limits and therefore not relevant.

5.7.3 Concentrations of radionuclides in biota

	Biota											
	Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**
1995	S	8	1.19	0.31	S	4	250	19	M	2	0.39	0.01
1996	S	8	1.19	0.49	S	1	345	-	M	2	0.46	0.02
1997	S	8	0.40	0.18	S	3	220	84	M	2	0.22	0.01
1998	S	8	0.37	0.13	S	4	424	335	M	2	0.20	0.01
1999	S	8	0.53	0.26	S	4	313	119	M	2	0.10	0.00
2000	S	14	0.31	0.16	S	6	268	159	M	3	0.12	0.06
2001	S	16	0.48	0.26	S	4	190	46	M	3	0.11	0.04
Baseline	S	7	0.64	0.38	S	7	287	80	M	7	0.23	0.14
2002	S	14	0.20	0.08	S	6	158	72	M	3	0.07	0.03
2003	S	16	0.21	0.10	S	6	238	124	M	3	0.12	0.04
2004	S	16	0.21	0.15	S	6	170	113	M	3	0.09	0.03
2005	S	14	0.17	0.10	S	6	194	101	M	3	0.11	0.07

Assessment of concentrations in biota

Cs-137

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
0*	1.38	P = 0.023	P = 0.006

The annual mean concentrations for Cs-137 in seaweed for the period 2002 to 2005 were all less than the baseline value. The lower baseline bracket value was negative. Following the reduction from the baseline value, a reasonably consistent value for Cs-137 has been observed. The results of the Student's t-test and Mann-Whitney test show that there is a statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2002 to 2005. Thus, there is evidence of a decrease in Cs-137 concentrations in seaweed in region 7.

Tc-99

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
130	444	P = 0.022	P = 0.042

The annual mean concentrations for Tc-99 in seaweed for the period 2002 to 2005 were all less than the baseline value, but not below the lower baseline bracket value. Following the reduction from the baseline value, some scatter was observed for Tc-99 concentrations with time, presumably due to the episodic flushing and water circulation from the Irish Sea between years. The results of the Student's t-test and Mann-Whitney test show that there is a statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2002 to 2005. Thus, there is evidence of a decrease in Tc-99 concentrations in seaweed in region 7.

Pu-239,240

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
0*	0.50	P = 0.055	P = 0.073

The annual mean concentrations for Pu-239,240 in molluscs for the period 2002 to 2005 were all less than the baseline value. The lower baseline bracket value was negative. Following the reduction from the baseline value, a reasonably consistent value for Pu-239,240 has been observed, with some environmental scatter between years. The results of the Student's t-test and Mann-Whitney test show that there is no statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2002 to 2005. Thus, there is no evidence of any change in Pu-239,240 concentrations in molluscs in region 7.

5.7.4 Doses from biota

	Biota								
	Cs-137			Tc-99			Pu-239,240		
Year	Type	Dose (µSv/y)	SD	Type	Dose (µSv/y)	SD	Type	Dose (µSv/y)	SD
1995							M	1.07	0.03
1996							M	1.27	0.06
1997							M	0.61	0.03
1998							M	0.55	0.03
1999							M	0.28	0.00
2000							M	0.33	0.17
2001							M	0.30	0.11
Baseline							M	0.63	0.39
2002							M	0.19	0.08
2003							M	0.32	0.11
2004							M	0.24	0.08
2005							M	0.29	0.20

Comment on annual doses from biota

Annual mean doses for Pu-239,240 in molluscs in the assessment period were all less than the baseline value. From 2002 to 2005 the values were reasonably consistent, with some environmental scatter. The small scatter observed for doses with time is assumed to be due to remobilisation from sediments. The method for calculation of doses does not include seaweed data.

5.8 Region 8. North Sea South (Belgian and Dutch Coast)

5.8.1 Concentrations of radionuclides in seawater

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (µBq/l)		
Year	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
1995	34	3.0	1.2									
1996	41	3.8	1.1	21	5.5	1.1						
1997	42	4.5	1.2	29	5.0	0.9				23	11.9	3.8
1998	40	4.3	1.5	15	4.6	1.0				2	16.6	4.2
1999	39	4.8	1.2	22	3.5	0.3				13	9.9	1.8
2000	40	4.8	1.1	34	3.0	0.8				23	14.1	3.7
2001	39	3.3	1.7									
Baseline	7	4.1	0.7	5	4.3	1.0				4	13.4	2.9
2002	23	3.7	1.1	3	3.0	0.5						
				23	< ***89***	-						
2003	20	3.7	0.9	15	*< 107*	-						
2004	22	5.0	1.1	2	2.4	0.7						
				22	< ***94***							
2005	20	2.0	1.4	15	*< 117*	-				15	*<* ***373***	-

Footnote to Table

Due to the difference in magnitude between data reported above and below detection limits for Cs-137 in seawater in 2002 and 2004, two sets of annual means are reported for this radionuclide in these years, one set based only on data above detection limits and one set based on all available data (i.e. data above and below detection limits).

Assessment of concentrations in seawater

Tritium

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
2.7	5.5	P = 0.522	P = 0.648

The annual mean concentrations for tritium in seawater from 2002, 2003 and 2005 were all less than the baseline value, with the annual mean concentration from 2005 below the lower baseline bracket value. The annual mean concentration from 2004 was above the baseline value but below the upper baseline bracket value. The results of the Student's t-test and Mann-Whitney test show that there is no statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2002 to 2005. Thus, there is no evidence of any change in tritium concentrations in seawater in region 8.

Cs-137

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
2.3	6.4	-	-

The majority of data for Cs-137 in seawater in the assessment period was below detection limits. The annual means for 2002 and 2004, based on samples where Cs-137 was detected, were less than the baseline value, but not below the lower baseline bracket value. No statistical analyses could be performed.

Pu-239,240

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
7.8	19.1	-	-

Monitoring data was only available for one year (2005) from the period 2002 to 2005 and measurement results were mostly below high detection limits. Therefore, comparisons with the baseline can not be made.

5.8.2 Doses from seawater

	Seawater							
	Tritium		Cs-137		Tc-99		Pu-239,240	
Year	Dose (µSv/y)	SD	Dose (µSv/y)	SD	Dose (µSv/y)	SD	Dose (µSv/y)	SD
1995	0.0031	0.0012						
1996	0.0039	0.0011	0.29	0.06				
1997	0.0046	0.0012	0.26	0.05			0.12	0.04
1998	0.0044	0.0015	0.24	0.05			0.16	0.04
1999	0.0049	0.0012	0.18	0.01			0.10	0.02
2000	0.0049	0.0011	0.16	0.02			0.14	0.04
2001	0.0034	0.0017						
Baseline	0.0042	0.0007	0.23	0.06			0.13	0.03
2002	0.0038	0.0011	0.16	0.03				
			< 4.75	-				
2003	0.0038	0.0009	*< 5.71*	-				
2004	0.0051	0.0011	0.13	0.04				
			< 5.01	-				
2005	0.0021	0.0014	*< 6.22*	-			***3.62***	-

Comment on annual doses from seawater

From the radionuclide data reported, Cs-137 was the largest contributor to dose during the assessment period. Real estimates for doses from Cs-137 exist only for 2002 and 2004 and these were within the baseline bracket. Tritium doses were generally lower by more than an order of magnitude. The plutonium baseline value was only slightly lower than for Cs-137, indicating that plutonium concentrations should be taken into account in dose estimates.

5.8.3 Concentrations of radionuclides in biota

	Biota											
	Cs-137 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**
1995	F	1	0.44	-								
1996	F	4	0.64	0.33	M	9	***< 0.02***	-	F	25	***< 0.02***	-
1997	F	2	0.34	0.10	M	9	0.04	0.03	F	25	***< 0.02***	-
1998	F	2	0.45	0.13	M	9	***< 0.05***	-	F	21	***< 0.03***	-
1999	F	1	0.68	-	M	9	***< 0.04***	-	F	17	***< 0.02***	-
2000					M	9	0.07	0.02	F	24	***< 0.02***	-
2001					M	9	0.04	0.01	F	25	***< 0.02***	-
Baseline	F	5	0.51	0.14	M	6	***< 0.04***	-	F	6	***< 0.02***	-
2002	F	25	***< 0.15***	-	M	6	***< 0.19***	-				
2003	F	25	***< 0.15***	-	M	4	*< 0.25*	-				
2004	F	25	***< 0.13***	-	M	3	*< 0.22*	-				
2005	F	24	***< 0.22***	-	M	4	*< 0.13*	-	F	24	***< 0.03***	-

Footnotes to Table

Note, no baseline value reported for Tc-99 in biota. Pu-239,240 baseline values reported for both molluscs and fish.

Assessment of concentrations in biota

Cs-137

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
0.24	0.78	-	-

The annual mean concentrations of Cs-137 in fish for the period 2002 to 2005 were all less than baseline value and the lower baseline bracket value. However, as the annual mean concentrations for the period 2002 to 2005 were based partly on values below detection limits, no statistical analyses could be performed.

Pu-239,240

The annual mean concentrations of Pu-239,240 in molluscs for the period 2002 to 2005 produced values with detection limits higher than the baseline value. No baseline bracket could be determined and no statistical analyses could be performed. However, the data shows that plutonium concentrations in molluscs were below detection limits, thus providing some information about the level of contamination.

Monitoring data for plutonium in fish was only available for 2005, and the underlying data set contains data both above and below detection limits. The data indicates a similar concentration in 2005 compared to the baseline value. No baseline bracket could be determined and no statistical analyses could be performed.

5.8.4 Doses from biota

	Biota								
	Cs-137			Pu-239,240			Pu-239,240		
Year	**Type**	**Dose (µSv/y)**	**SD**	**Type**	**Dose (µSv/y)**	**SD**	**Type**	**Dose (µSv/y)**	**SD**
1995	F	0.19	-						
1996	F	0.28	0.15	M	***< 0.06***	-	F	***< 0.17***	-
1997	F	0.15	0.05	M	0.10	0.07	F	***< 0.15***	-
1998	F	0.20	0.06	M	***< 0.12***	-	F	***< 0.21***	-
1999	F	0.30	-	M	***< 0.12***	-	F	***< 0.19***	-
2000				M	0.15	0.05	F	***< 0.19***	-
2001				M	0.18	0.05	F	***< 0.17***	-
Baseline	F	0.23	0.06	M	***< 0.12***	-	F	***< 0.18***	-
2002	F	***< 0.07***	-	M	***< 0.53***	-			
2003	F	***< 0.07***	-	M	*0.69*	-			
2004	F	***< 0.06***	-	M	*0.60*	-			
2005	F	***< 0.10***	-	M	*0.34*	-	F	***< 0.23***	-

Comment on annual doses from biota

From the radionuclide data reported, Pu-239,240 in molluscs was the largest contributor to dose during the assessment period. The sum of the baseline doses for Cs-137 in fish and Pu-230,240 in fish and molluscs is 0.53 µSv/y, which is similar to the sum of doses from 2005 (0.67 µSv/y). Conclusions on any potential reduction of doses can not be drawn on the basis of this data set.

5.9 Region 9. German Bight

5.9.1 Concentrations of radionuclides in seawater

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (µBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
1995	9	2.8	0.5	46	8.8	4.4				30	19.4	5.5
1996	13	1.4	0.1	34	7.4	2.1						
1997	18	3.2	0.4	37	5.3	1.5	7	1.03	0.46	19	7.4	2.0
1998	11	4.0	0.7	45	4.5	1.7	1	0.70	-	19	11.3	2.4
1999	13	2.7	0.8	50	4.9	1.9	11	1.53	1.00	17	8.4	2.6
2000	13	3.4	0.9	42	3.6	1.2	1	3.40	-	14	10.5	2.6
2001				38	3.2	0.9						
Baseline	6	2.9	0.9	7	5.4	2.0	4	1.67	1.21	5	11.4	4.7
2002	7	***< 2.8***	-	22	3.4	1.0				8	6.0	2.6
2003	4	4.1	0.8	24	3.7	0.7				7	7.5	1.5
2004	6	4.3	1.5	24	2.9	0.6				10	12.6	3.7
2005	4	4.3	1.1	24	2.6	0.4						

Assessment of concentrations in seawater

Tritium

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
1.1	4.7	P = 0.015	P = 0.024

The annual mean concentrations of tritium in seawater for the period 2002 to 2005 were all higher than the baseline value, with the exception of the 2002 value (below detection limits), but below the upper baseline bracket value. The results of the Student's t-test and Mann-Whitney test show that there is a statistically significant difference between the annual mean concentrations from 1995 to 2000 and those from 2003 to 2005. Thus, there is evidence of an increase in tritium concentrations in seawater in region 9.

Cs-137

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
1.4	9.3	P = 0.028	P = 0.042

The annual mean concentrations of Cs-137 in seawater for the period 2002 to 2005 were all less than the baseline value, but not below the lower baseline bracket value. There is a tendency for Cs-137 concentrations to decrease over the entire period of 1995 to 2005. The results of the Student's t-test and Mann-Whitney test show that there is a statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2002 to 2005. Thus, there is evidence of a decrease in Cs-137 concentrations in seawater in region 9.

Tc-99

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
0*	4.04	-	-

No monitoring data was available for the period 2002 to 2005, so no assessment can be made.

Pu-239,240

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
2.2	20.6	P = 0.390	P = 0.571

Monitoring data was only available for the years 2002 to 2004 of the assessment period. The annual mean concentrations of Pu-239,240 in seawater from 2002 and 2003 were less than the baseline value while the annual mean concentration from 2005 was higher than the baseline value. However, all values from 2002 to 2004 fell within the baseline bracket. The results of the Student's t-test and Mann-Whitney test show that there is no statistically significant difference between the annual mean concentrations from 1995 to 2000 and those from 2002 to 2004. Thus, there is no evidence of any change in Pu-239,240 concentrations in seawater in region 9.

5.9.2 Doses from seawater

	Seawater							
	Tritium		Cs-137		Tc-99		Pu-239,240	
Year	Dose (µSv/y)	SD	Dose (µSv/y)	SD	Dose (µSv/y)	SD	Dose (µSv/y)	SD
1995	0.0029	0.0005	0.47	0.23			0.19	0.05
1996	0.0015	0.0001	0.39	0.11				
1997	0.0032	0.0004	0.28	0.08	0.016	0.007	0.07	0.02
1998	0.0041	0.0007	0.24	0.09	0.011	-	0.11	0.02
1999	0.0028	0.0008	0.26	0.10	0.024	0.015	0.08	0.02
2000	0.0035	0.0009	0.19	0.06	0.052	-	0.10	0.03
2001			0.17	0.05				
Baseline	0.0030	0.0009	0.29	0.11	0.026	0.019	0.11	0.05
2002	***< 0.0029***	-	0.18	0.05			0.06	0.03
2003	0.0042	0.0008	0.20	0.04			0.07	0.01
2004	0.0044	0.0015	0.16	0.03			0.12	0.04
2005	0.0044	0.0011	0.14	0.02				

Comment on annual doses from seawater

From the radionuclide data reported, Cs-137 was the largest contributor to dose during the assessment period, with a smaller contribution from Pu-239,240.

5.9.3 Concentrations of radionuclides in biota

	Biota											
	Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	Type	n	Mean	SD	Type	n	Mean	SD	Type	n	Mean	SD
1995	F	6	0.60	0.17					F	4	*< 0.000028*	-
1996	F	9	0.57	0.29					F	6	**< 0.000044**	-
1997	F	7	0.53	0.34								
1998	F	6	0.47	0.26					F	1	*< 0.000030*	-
1999	F	4	0.40	0.31					F	2	**< 0.000032**	-
2000	F	3	0.21	0.07					F	2	**< 0.000039**	-
2001	F	1	0.21	-					F	1	0.000022	-
Baseline	F	7	0.43	0.16					F	6	**< 0.000032**	-
2002	F	2	0.29	0.01					F	1	*< 0.000046*	-
2003	F	2	0.33	0.17								
2004	F	1	0.12	-					F	1	*< 0.000032*	-
2005	F	4	0.18	0.09								

Assessment of concentrations in biota

Cs-137

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
0.12	0.74	P = 0.033	P = 0.073

The annual mean concentrations of Cs-137 in fish for the period 2002 to 2005 were all less than the baseline value, but not below the lower baseline bracket value. Overall, the annual mean concentrations in fish suggest a slight decrease has occurred over the entire period of 1995 and 2005. The results of the Mann-

Whitney test do not indicate a statistically significant difference between the annual mean concentrations from 1995 to 2001 and 2002 to 2005. However, the Student's t-test indicates a statistically significant difference, providing some evidence of a decrease in Cs-137 concentrations in fish in region 9.

Pu-239,240

Monitoring data was only available for the years 2002 to 2004 of the assessment period. Data for Pu-239,240 in fish for 2002 and 2004 was below detection limits. No baseline bracket could be determined and no statistical analyses could be performed. Therefore, it is difficult to make any assessment. As the corresponding seawater concentrations did not show any trend and one would expect a similar trend for fish as for seawater, one can at least conclude that the results from fish data do not contradict the data obtained for seawater.

5.9.4 Doses from biota

	Biota								
	Cs-137			**Tc-99**			**Pu-239,240**		
Year	**Type**	**Dose (µSv/y)**	**SD**	**Type**	**Dose (µSv/y)**	**SD**	**Type**	**Dose (µSv/y)**	**SD**
1995	F	0.26	0.07				F	*< 0.00024*	-
1996	F	0.25	0.13				F	***< 0.00037***	-
1997	F	0.23	0.15						
1998	F	0.21	0.11				F	*< 0.00026*	-
1999	F	0.18	0.14				F	***< 0.00027***	-
2000	F	0.09	0.03				F	***< 0.00033***	-
2001	F	0.09	-				F	0.00019	-
Baseline	F	0.19	0.07				F	***< 0.00027***	-
2002	F	0.13	0.01				F	*< 0.00039*	-
2003	F	0.15	0.08						
2004	F	0.05	-				F	*< 0.00027*	-
2005	F	0.08	0.04						

Comment on annual doses from biota

From the radionuclide data reported, Cs-137 was the largest contributor to dose during the assessment period.

5.10 Region 10. North Sea (Northwest, Southeast and Central)

5.10.1 Concentrations of radionuclides in seawater

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (μBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
1995	5	***< 1.0***	-	2	11.9	1.0						
1996	6	***< 1.3***	-	13	7.0	3.0	14	3.2	2.6			
1997	6	*< 1.0*	-	12	5.9	3.0	15	2.3	1.6			
1998	6	***< 0.6***	-									
1999	2	0.9	0.5				3	3.6	1.1			
2000	4	***< 0.7***	-									
2001	4	***< 0.5***	-	23	4.3	3.9	23	2.0	1.8			
Baseline	7	***< 0.8***	-	4	7.3	3.3	4	2.8	0.8			
2002	37	***< 1.9***	-	30	4.5	1.7						
2003	9	***< 1.9***	-	1	4.2	-						
2004	36	***< 1.5***	-	29	4.5	1.4						
2005	9	***< 1.2***	-	6	4.2	0.9						

Assessment of concentrations in seawater

Tritium

The majority of the data for tritium in seawater from the assessment period was below detections limits. Annual mean concentrations from the period 2002 to 2005 were higher than the baseline value. No baseline bracket could be determined and no statistical analyses could be performed.

Cs-137

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
0.8	13.8	P = 0.173	P = 0.114

The annual mean concentrations of Cs-137 in seawater for the period 2002 to 2005 were similar and all less than the baseline value, but not below the lower baseline bracket value. The results of the Student's t-test and Mann-Whitney test show that there is no statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2002 to 2005. Thus, there is no evidence of any change in Cs-137 concentrations in seawater in region 10.

Tc-99

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
1.2	4.4	-	-

No monitoring data was available for the period 2002 to 2005, so no assessment can be made.

5.10.2 Doses from seawater

	Seawater							
	Tritium		Cs-137		Tc-99		Pu-239,240	
Year	Dose (µSv/y)	SD	Dose (µSv/y)	SD	Dose (µSv/y)	SD	Dose (µSv/y)	SD
1995	***< 0.0010***	-	0.63	0.05				
1996	***< 0.0013***	-	0.37	0.16	0.049	0.040		
1997	*< 0.0010*	-	0.31	0.16	0.035	0.025		
1998	***< 0.0006***	-						
1999	0.0009	0.0005			0.055	0.017		
2000	***< 0.0007***	-						
2001	***< 0.0005***	-	0.23	0.21	0.031	0.028		
Baseline	***< 0.0008***	-	0.39	0.18	0.043	0.012		
2002	***< 0.0019***	-	0.24	0.09				
2003	***< 0.0019***	-	0.22	-				
2004	***< 0.0015***	-	0.24	0.07				
2005	***< 0.0012***	-	0.22	0.05				

Comment on annual doses from seawater

From the radionuclide data reported, Cs-137 was the largest contributor to dose during the assessment period. In comparison with the baseline values for this radionuclide, doses were lower in each of the subsequent years and have remained constant with time.

5.10.3 Concentrations of radionuclides in biota

	Biota											
	Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	Type	n	Mean	SD	Type	n	Mean	SD	Type	n	Mean	SD
1995	F	2	0.38	0.07	S	1	30.4	-				
1996	F	2	0.38	0.06	S	1	55.5	-				
1997	F	2	0.41	0.02	S	1	97.5	-				
1998	F	2	0.41	0.06	S	1	110	-	M	1	0.052	-
1999	F	2	0.44	0.12	S	1	57.9	-	M	1	0.049	-
2000	F	2	0.35	0.01	S	1	43.7	-	M	1	0.062	-
2001	F	2	0.29	0.10	S	1	68.6	-	M	1	0.063	-
Baseline	F	7	0.38	0.05	S	7	66.2	28.5	M	4	0.057	0.007
2002	F	11	0.48	0.22	S	3	43.4	56.0	M	1	0.083	-
2003	F	17	0.36	0.17	S	3	25.2	19.5	M	1	0.079	-
2004	F	16	0.34	0.21	S	3	23.8	35.3	M	1	0.079	-
2005	F	13	0.35	0.26	S	3	73.6	78.3	M	1	0.058	-

Assessment of concentrations in biota

Cs-137

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
0.28	0.48	P = 0.950	P = 0.648

Annual mean concentrations of Cs-137 in fish from 2003 to 2005 were similar and comparable to the baseline value, while the annual mean for 2002 was comparable to the upper baseline bracket value. The results of the Student's t-test and Mann-Whitney test show that there is no statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2002 to 2005. Thus, there is no evidence of any change in Cs-137 concentrations in fish in region 10.

Tc-99

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
10.3	122.1	P = 0.157	P = 0.164

The annual mean concentrations of Tc-99 in seaweed for the period 2002 to 2005 were all less than the baseline value, with the exception of the value for 2005. All annual mean concentrations fell within the baseline bracket. Following the reduction from the baseline value, some scatter is observed for Tc-99 concentrations with time, presumably due to the episodic flushing and water circulation from the Irish Sea between years. The results of the Student's t-test and Mann-Whitney test show that there is no statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2002 to 2005. Thus, there is no evidence of any change in Tc-99 concentrations in seaweed in region 10.

Pu-239,240

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
0.043	0.071	P = 0.041	P = 0.114

The annual mean concentrations of Pu-239,240 in molluscs for the period 2002 to 2005 were all higher than the baseline value, with the values for 2002 to 2004 above the upper baseline bracket value. The results of the Mann-Whitney test do not indicate a statistically significant difference between the annual mean concentrations from 1995 to 2001 and 2002 to 2005. However, the Student's t-test indicates a statistically significant difference, providing some evidence of an increase in Pu-239,240 concentrations in molluscs in region 10. It is possible that the increase from the baseline to subsequent years is due to remobilisation from sediments.

5.10.4 Doses from biota

	Biota								
	Cs-137			Tc-99			Pu-239,240		
Year	**Type**	**Dose (µSv/y)**	**SD**	**Type**	**Dose (µSv/y)**	**SD**	**Type**	**Dose (µSv/y)**	**SD**
1995	F	0.17	0.03						
1996	F	0.17	0.03						
1997	F	0.18	0.01						
1998	F	0.18	0.03				M	0.14	-
1999	F	0.19	0.05				M	0.13	-
2000	F	0.15	0.00				M	0.17	-
2001	F	0.13	0.04				M	0.17	-
Baseline	F	0.17	0.02				M	0.16	0.02
2002	F	0.21	0.10				M	0.23	-
2003	F	0.16	0.08				M	0.22	-
2004	F	0.15	0.09				M	0.22	-
2005	F	0.15	0.11				M	0.16	-

Comment on annual doses from biota

From the radionuclide data reported, both Pu-239,240 and Cs-137 contribute to dose during the assessment period. In comparison with the baseline values for these radionuclides, doses were slightly elevated on a number of occasions in subsequent years. From 2002 to 2005 the values were reasonably consistent for both Pu-239,240 and Cs-137. The small scatter observed for doses with time is assumed to be due to remobilisation from sediments. The method for calculation of doses does not include seaweed data.

5.11 Region 11. North Sea (Skagerrak)

5.11.1 Concentrations of radionuclides in seawater

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (μBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
1995				1	25.2	-						
1996				3	9.5	9.2	2	1.2	0.5			
1997				5	17.1	20.2	2	1.7	0			
1998												
1999							2	6.0	1.8			
2000							9	1.2	0.2			
2001				4	6.7	5.9	9	1.2	0.4			
Baseline				4	14.7	8.4	5	2.3	2.1			
2002							2	1.7	0.6			
2003				1	6.6	-	2	1.5	0.4			
2004				2	10.0	2.0	2	2.3	1.8			
2005				2	8.6	0.6	2	1.2	0.4			

Assessment of concentrations in seawater

Cs-137

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
0*	31.2	P = 0.241	P = 0.400

The concentrations of Cs-137 in the Skagerrak area typically show a large degree of variability. This is mainly due to the variable outflow of low saline water from the Baltic Sea that has been affected by Chernobyl fallout. As a result, a very large standard deviation has been derived for the baseline value. Annual mean concentrations for 2003 to 2005 were all less than the baseline value. The lower baseline bracket value was negative. The results of Student's t-test and Mann-Whitney test show no statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2003 to 2005. Thus, there is no evidence of any change in Cs-137 concentrations in seawater in region 11.

Tc-99

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
0*	6.4	P = 0.578	P = 0.730

The annual mean concentrations of Tc-99 in seawater for the period 2002 to 2005 were equal to or less than the baseline value. The lower baseline bracket value was negative. However, the results of Student's t-test and Mann-Whitney test show no statistically significant difference between the annual mean concentrations from 1996 to 2001 and those from 2002 to 2005. Thus, there is no evidence of any change in Tc-99 concentrations in seawater in region 11.

Tc-99 discharges from Sellafield were significantly reduced in 2004, but as the transport time from the discharge point in the Irish Sea to the Skagerrak is approximately 3 years, reductions in concentrations are not expected to occur before the year 2007 or later.

5.11.2 Doses from seawater

	Seawater							
	Tritium		Cs-137		Tc-99		Pu-239,240	
Year	Dose (µSv/y)	SD	Dose (µSv/y)	SD	Dose (µSv/y)	SD	Dose (µSv/y)	SD
1995			1.34	-				
1996			0.51	0.49	0.018	0.008		
1997			0.91	1.07	0.026	0.000		
1998								
1999					0.092	0.028		
2000					0.018	0.003		
2001			0.36	0.31	0.018	0.006		
Baseline			0.78	0.45	0.035	0.032		
2002					0.026	0.009		
2003			0.35	-	0.023	0.006		
2004			0.53	0.11	0.035	0.028		
2005			0.46	0.03	0.018	0.006		

Comment on annual doses from seawater

From the radionuclide data reported, Cs-137 was the largest contributor to dose during the assessment period. As for the concentration data, the values obtained for Cs-137 and Tc-99 for the period 2002 to 2005 were equal to or less than the baseline values.

5.11.3 Concentrations of radionuclides in biota

	Biota											
	Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	Type	n	Mean	SD	Type	n	Mean	SD	Type	n	Mean	SD
Baseline												
2002	S	1	6.0	-	S	1	89	-				
2003	S	1	2.8	-	S	1	126	-				
2004	S	1	3.8	-	S	1	119	-				
2005	S	1	3.7	-	S	1	132	-				

Assessment of concentrations in biota

Cs-137

No baseline value for Cs-137 in seaweed has been established for the North Sea (Skagerrak). A higher concentration of Cs-137 was observed for 2002 compared to later years.

Tc-99

No baseline value for Tc-99 in seaweed has been established for the North Sea (Skagerrak). For Tc-99, no clear trend can be seen, but the highest concentration value was observed in 2005.

5.11.4 Doses from biota

Data was only available for Cs-137 and Tc-99 in seaweed. The method for calculation of doses does not include seaweed data.

5.12 Region 12. Kattegat

5.12.1 Concentrations of radionuclides in seawater

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (µBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
1995				20	44.5	10.8						
1996				16	30.1	14.0						
1997				20	41.6	16.3						
1998				20	28.3	17.2	14	1.5	1.2			
1999				31	23.2	15.9	14	1.9	1.1			
2000				27	13.4	12.1	8	1.1	0.3			
2001				20	30.9	15.0	8	0.8	0.4			
Baseline				7	30.3	10.6	4	1.3	0.5			
2002	4	*< 3.1*	-	14	***< 60.1***	-	4	0.5	0.3			
2003	4	***< 2.3***	-	14	53.7	26.0	4	0.6	0.2			
2004	4	***< 2.9***	-	14	45.0	31.0	4	0.5	0.1			
2005	4	*< 2.3*	-	14	48.1	28.4	3	0.5	0.2			

Assessment of concentrations in seawater

Tritium

No baseline value for tritium in seawater has been established for the Kattegat. Monitoring data available from the period 2002 to 2005 was mostly below detection limits.

Cs-137

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
9.6	51.0	P = 0.004	P = 0.017

The annual mean concentrations of Cs-137 in seawater for the period 2002 to 2005 were all higher than the baseline value and similar to the upper baseline bracket value. The results of the Student's t-test and Mann-Whitney test show that there is a statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2003 to 2005. Thus, there is evidence of an increase in Cs-137 concentrations in seawater in region 12. The relatively high standard deviations indicate a large variability in the concentration of Cs-137 in the area, which may be expected due to temporal and geographical variability in the water exchange between Baltic water with high Cs-137 concentrations due to Chernobyl fallout and North Sea waters with lower concentrations. It must be noted that monitoring data from the assessment period contained data based on samples collected close to Ringhals NPP, which was not the case for the baseline period.

Tc-99

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
0.4	2.2	P = 0.045	P = 0.029

The annual mean concentrations of Tc-99 in seawater for the period 2002 to 2005 were all less than the baseline value but not below the lower baseline bracket value. The results of the Student's t-test and Mann-Whitney test show that there is a statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2002 to 2005. Thus, there is evidence of a decrease in Tc-99 concentrations in seawater in region 12.

5.12.2 Doses from seawater

	Seawater							
	Tritium		**Cs-137**		**Tc-99**		**Pu-239,240**	
Year	**Dose (µSv/y)**	**SD**	**Dose (µSv/y)**	**SD**	**Dose (µSv/y)**	**SD**	**Dose (µSv/y)**	**SD**
1995			2.37	0.57				
1996			1.60	0.74				
1997			2.21	0.87				
1998			1.50	0.92	0.023	0.018		
1999			1.23	0.85	0.029	0.018		
2000			0.71	0.65	0.017	0.004		
2001			1.64	0.80	0.013	0.006		
Baseline			1.61	0.56	0.020	0.007		
2002	*< 0.0031*	-	***< 3.20***	-	0.008	0.005		
2003	***< 0.0024***	-	2.86	1.38	0.009	0.003		
2004	***< 0.0029***	-	2.39	1.65	0.008	0.002		
2005	*< 0.0023*	-	2.56	1.51	0.008	0.003		

Comment on annual doses from seawater

From the radionuclide data reported, Cs-137 was the largest contributor to dose during the assessment period.

5.12.3 Concentrations of radionuclides in biota

	Biota											
	Cs-137 (Bq/kg w.w.)				**Cs-137 (Bq/kg w.w.)**				**Tc-99 (Bq/kg w.w.)**			
Year	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**
1995	S	5	2.3	0.5	F	6	2.5	3.0	S	2	3.7	1.4
1996	S	3	1.9	0.6	F	3	3.3	2.3	S	3	8.5	2.8
1997	S	3	1.7	0.4	F	3	3.2	1.8	S	3	14.9	3.5
1998	S	4	1.6	0.4	F	3	3.6	3.8	S	4	20.7	7.2
1999	S	5	1.7	0.5	F	3	2.7	1.5	S	4	28.0	7.1
2000	S	4	1.4	0.5	F	3	2.9	1.4	S	4	32.5	7.3
2001	S	4	1.5	0.4	F	3	2.4	0.8	S	4	22.9	5.0
Baseline	S	7	1.7	0.3	F	7	3.0	0.4	S	7	18.8	10.3
2002	S	4	1.3	0.8	F	9	7.1	3.9	S	4	23.1	7.1
2003	S	4	1.3	0.3	F	9	6.1	3.3	S	4	24.7	9.6
2004	S	4	1.2	0.3	F	9	5.7	3.1	S	4	23.4	7.2
2005	S	4	1.2	0.4	F	9	5.4	2.8				

Footnote to Table
Note, no baseline value reported for Pu-239,240 in biota. Cs-137 baseline values reported for both seaweed and fish.

Assessment of concentrations in biota

Cs-137

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
Seaweed			
1.2	2.3	P = 0.005	P = 0.006
Fish			
2.1	3.8	P = 0.002	P = 0.006

The annual mean concentrations of Cs-137 in seaweed for the period 2002 to 2005 were all less than the baseline value but not below the lower baseline bracket value. The results of the Student's t-test and Mann-Whitney test show that there is a statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2002 to 2005. Thus, there is evidence of a decrease in Cs-137 concentrations in seaweed in region 12.

The annual mean concentrations of Cs-137 in fish for the period 2002 to 2005 were all higher than the baseline value and the upper baseline bracket value. The results of the Student's t-test and Mann-Whitney test show that there is a statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2002 to 2005. Thus, there is evidence of an increase in Cs-137 concentrations in fish in region 12. It must be noted that as for seawater, monitoring data from the assessment period contained data based on samples collected close to Ringhals NPP, which was not the case for the baseline period. Generally, standard deviations for the annual mean concentrations of Cs-137 in fish were lower than those for seawater data suggesting that in this area, fish data may be more useful for trend monitoring.

Tc-99

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
0*	39.0	P = 0.252	P = 0.383

The annual mean concentrations of Tc-99 in seaweed for the period 2002 to 2005 were similar and were all higher than the baseline value but below the upper baseline bracket value. The results of the Student's t-test and Mann-Whitney test show that there is no statistically significant difference between the annual mean concentrations from 1995 to 2001 and those from 2002 to 2005. Thus, there is no evidence of any change in Tc-99 concentrations in seaweed in region 12.

5.12.4 Doses from biota

	Biota								
	Cs-137			Cs-137			Tc-99		
Year	**Type**	**Dose (µSv/y)**	**SD**	**Type**	**Dose (µSv/y)**	**SD**	**Type**	**Dose (µSv/y)**	**SD**
1995				F	1.11	1.33			
1996				F	1.46	1.00			
1997				F	1.42	0.78			
1998				F	1.61	1.67			
1999				F	1.20	0.68			
2000				F	1.27	0.63			
2001				F	1.07	0.37			
Baseline				F	1.30	0.20			
2002				F	3.14	1.72			
2003				F	2.70	1.46			
2004				F	2.52	1.37			
2005				F	2.39	1.24			

Comment on annual doses from biota

The doses calculated from annual mean concentrations of Cs-137 in fish for each year of the period 2002 to 2005 were similar to doses calculated from seawater data. The method for calculation of doses does not include seaweed data.

5.13 Region 13. Norwegian Coastal Current

5.13.1 Concentrations of radionuclides in seawater

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (µBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
1995				13	4.1	1.7						
1996												
1997							6	0.6	0.1			
1998							11	1.0	0.4			
1999							10	1.5	0.3			
2000				13	4.7	2.2	9	1.3	0.3			
2001							12	1.2	0.3			
Baseline				2	4.4	0.4	5	1.1	0.4			
2002				2	4.5	1.8	12	1.0	0.2			
2003				4	3.1	0.6	12	0.8	0.1			
2004				3	2.1	0.7	12	0.8	0.1			
2005				2	3.0	0.2	12	0.9	0.1			

Assessment of concentrations in seawater

Cs-137

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
3.6	5.2	P = 0.102	P = 0.267

The annual mean concentrations of Cs-137 in seawater for the years 2003, 2004 and 2005 were all less than the baseline value and the lower baseline bracket value, while the value for 2002 was similar to the baseline value. The results of Student's t-test and Mann-Whitney test show no statistically significant difference between the annual mean concentrations from 1995 and 2000 and those from 2002 to 2005. Thus, there is no evidence of any change in Cs-137 concentrations in seawater in region 13, although it is worth noting that the baseline value for Cs-137 in seawater for this region has been derived from only two annual mean concentrations.

Tc-99

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
0.3	1.9	P = 0.187	P = 0.190

The annual mean concentrations of Tc-99 in seawater for the period 2002 to 2005 were all slightly less than the baseline value, but not below the lower baseline bracket value. The results of Student's t-test and Mann-Whitney test show no statistically significant difference between the annual mean concentrations from 1997 and 2001 and those from 2002 to 2005. Thus, there is no evidence of any change in Tc-99 concentrations in seawater in region 13.

5.13.2 Doses from seawater

	Seawater							
	Tritium		Cs-137		Tc-99		Pu-239,240	
Year	**Dose (µSv/y)**	**SD**	**Dose (µSv/y)**	**SD**	**Dose (µSv/y)**	**SD**	**Dose (µSv/y)**	**SD**
1995			0.22	0.09				
1996								
1997					0.009	0.002		
1998					0.015	0.006		
1999					0.023	0.005		
2000			0.25	0.12	0.020	0.005		
2001					0.018	0.005		
Baseline			0.23	0.02	0.017	0.006		
2002			0.24	0.10	0.015	0.003		
2003			0.16	0.03	0.012	0.002		
2004			0.11	0.04	0.012	0.002		
2005			0.16	0.01	0.014	0.002		

Comment on annual doses from seawater

From the radionuclide data reported, Cs-137 was the largest contributor to dose during the assessment period, with a smaller contribution from Tc-99.

5.13.3 Concentrations of radionuclides in biota

	Biota											
	Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**
1995												
1996												
1997	S	4	0.09	0.06	S	4	16.4	3.8				
1998	S	11	0.11	0.04	S	10	27.6	6.2				
1999	S	9	0.12	0.01	S	10	46.4	9.4				
2000	S	10	0.09	0.03	S	11	63.6	7.2				
2001	S	6	0.19	0.18	S	12	64.2	13.6				
Baseline	S	5	0.12	0.04	S	5	43.7	21.4				
2002	S	16	0.16	0.09	S	16	61.6	20.6				
2003	S	15	0.15	0.14	S	15	51.8	14.2				
2004	S	14	0.14	0.14	S	16	51.0	13.9				
2005	S	15	0.15	0.15	S	16	52.5	14.0				

Assessment of concentrations in biota

Cs-137

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
0.04	0.20	P = 0.188	P = 0.190

The annual mean concentrations of Cs-137 in seaweed for the period 2002 to 2005 were all higher than the baseline value, but below the upper baseline bracket value. The results of Student's t-test and Mann-Whitney test show no statistically significant difference between the annual mean concentrations from 1997 and 2001 and those from 2002 to 2005. Thus, there is no evidence of any change in Cs-137 concentrations in seaweed in region 13.

Tc-99

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
1.8	85.6	P = 0.333	P = 0.730

The annual mean concentrations of Tc-99 in seaweed for the period 2002 to 2005 were all higher than the baseline value, but below the upper baseline bracket value. The results of Student's t-test and Mann-Whitney test show no statistically significant difference between the annual mean concentrations from 1997 and 2001 and those from 2002 to 2005. Thus, there is no evidence of any change in Tc-99 concentrations in seaweed in region 13.

5.13.4 Doses from biota

Radionuclide data was only reported for Cs-137 and Tc-99 in seaweed. The method for calculation of doses does not include seaweed data.

5.14 Region 14. Barents Sea

5.14.1 Concentrations of radionuclides in seawater

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (μBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
1995												
1996												
1997												
1998												
1999				7	3.5	0.4	7	0.7	0.4			
2000							3	1.2	0.2			
2001							2	0.16	0.03			
Baseline				1	3.5	0.4	3	0.7	0.4			
2002							1	0.18	-			
2003							1	0.05	-			
2004							1	0.19	-			
2005							1	0.19	-			

Assessment of concentrations in seawater

Cs-137

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
2.7	4.3	-	-

No monitoring data was available for the period 2002 to 2005, so no assessment can be made.

Tc-99

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
0*	1.5	P = 0.219	P = 0.400

The annual mean concentrations of Tc-99 in seawater for the period 2002 to 2005 were all less than the baseline value. The lower baseline bracket value was negative. The results of Student's t-test and Mann-Whitney test show no statistically significant difference between the annual mean concentrations from 1999 and 2001 and those from 2002 to 2005. Thus, there is no evidence of any change in Tc-99 concentrations in seawater in region 14.

5.14.2 Doses from seawater

	Seawater							
	Tritium		Cs-137		Tc-99		Pu-239,240	
Year	Dose (µSv/y)	SD	Dose (µSv/y)	SD	Dose (µSv/y)	SD	Dose (µSv/y)	SD
1995								
1996								
1997								
1998								
1999			0.19	0.02	0.011	0.006		
2000					0.018	0.003		
2001					0.002	0.000		
Baseline			0.19	0.02	0.011	0.006		
2002					0.003	-		
2003					0.001	-		
2004					0.003	-		
2005					0.003	-		

Comment on annual doses from seawater

The baseline values indicate that Cs-137 is the most important contributor to dose in this region. Annual mean doses for Tc-99 in the assessment period were all less than the baseline value.

5.14.3 Concentrations of radionuclides in biota

	Biota											
	Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	Type	n	Mean	SD	Type	n	Mean	SD	Type	n	Mean	SD
1995												
1996	F	12	0.30	0.03								
1997	F	11	0.33	0.05								
1998	F	6	0.34	0.09								
1999	F	32	0.24	0.10								
2000	F	7	0.29	0.07								
2001	F	17	0.25	0.06								
Baseline	F	6	0.29	0.04								
2002	F	8	0.17	0.08	S	2	47.5	17.7				
2003	F	21	0.23	0.08	S	2	34.0	7.1				
2004	F	16	0.28	0.05	S	2	31.0	9.9				
2005	F	7	0.27	0.04	S	2	34.5	9.2				

Assessment of concentrations in biota

Cs-137

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
0.21	0.37	P = 0.121	P = 0.114

The annual mean concentrations of Cs-137 in fish for the period 2002 to 2005 were all less than the baseline value, with the value for 2002 below the lower baseline bracket value. The results of Student's t-test and Mann-Whitney test show no statistically significant difference between the annual mean concentrations from

1996 and 2001 and those from 2002 to 2005. Thus, there is no evidence of any change in Cs-137 concentrations in fish in region 14.

Tc-99

No baseline value for Tc-99 in biota has been established for the Barents Sea. Annual mean concentrations for Tc-99 in seaweed for the period 2002 to 2005 appear to have been relatively constant over this time period.

5.14.4 Doses from biota

	Biota								
	Cs-137			Tc-99			Pu-239,240		
Year	**Type**	**Dose (µSv/y)**	**SD**	**Type**	**Dose (µSv/y)**	**SD**	**Type**	**Dose (µSv/y)**	**SD**
1995									
1996	F	0.13	0.01						
1997	F	0.15	0.02						
1998	F	0.15	0.04						
1999	F	0.11	0.04						
2000	F	0.13	0.03						
2001	F	0.11	0.03						
Baseline	F	0.13	0.02						
2002	F	0.08	0.04						
2003	F	0.10	0.04						
2004	F	0.12	0.02						
2005	F	0.12	0.02						

Comment on annual doses from seawater

Annual mean doses for Cs-137 in fish in the assessment period were similar to the baseline value. The method for calculation of doses does not include seaweed data.

5.15 Region 15. Norwegian Sea, Greenland Sea and Icelandic Waters

5.15.1 Concentrations of radionuclides in seawater

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (µBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
Baseline				46[1]	4.6	0.9						
2002				3	4.0	1.6	4	0.13	0.08			
2003				3	3.5	1.4	3	0.14	0.06			
2004				3	3.4	1.4	3	0.14	0.05			
2005				3	2.4	1.2	3	0.12	0.06			

Footnote to Table
1 - n in this case refers to the total number of samples used to derive the baseline value.
Baseline data for Cs-137 in seawater has only been reported as a mean for the whole baseline period and not as individual annual means.

Assessment of concentrations in seawater

Cs-137

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
2.8	6.4	-	-

The annual mean concentrations of Cs-137 in seawater for the period 2002 to 2005 were all less than the baseline value, with the value for 2005 below the lower baseline bracket value. However, due to a lack of annual mean data for the baseline period, no statistical analyses could be performed to determine if this difference was statistically significant.

Tc-99

No baseline value for Tc-99 in seawater has been established for the Norwegian Sea, Greenland Sea and Icelandic waters. The annual mean concentrations of Tc-99 in seawater for the period 2002 to 2005 were all very similar, and there is no indication of any reductions over this 4 year period.

5.15.2 Doses from seawater

	Seawater							
	Tritium		Cs-137		Tc-99		Pu-239,240	
Year	Dose (µSv/y)	SD	Dose (µSv/y)	SD	Dose (µSv/y)	SD	Dose (µSv/y)	SD
Baseline			0.24	0.05				
2002			0.21	0.09	0.002	0.001		
2003			0.19	0.07	0.002	0.001		
2004			0.18	0.07	0.002	0.001		
2005			0.13	0.06	0.002	0.001		

Comment on annual doses from seawater

From the radionuclide data reported, Cs-137 was the largest contributor to dose during the assessment period, with only minor contributions from Tc-99.

5.15.3 Concentrations of radionuclides in biota

	Biota											
	Cs-137 (Bq/kg w.w.)				Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)			
Year	Type	n	Mean	SD	Type	n	Mean	SD	Type	n	Mean	SD
Baseline	S	86[1]	0.05	0.02	F	19[1]	0.03	0.01				
2002	S	1	*< 0.20*	-					S	1	2	-
2003	S	1	0.11	-					S	1	10	-
2004												
2005												

Footnotes to Table
1 - n in this case refers to the total number of samples used to derive the baseline value.
Baseline data for Cs-137 in seaweed and fish has only been reported as means for the whole baseline period and not as individual annual means. Note, no baseline value reported for Pu-239,240 in biota. Cs-137 baseline values reported for both seaweed and fish.

Assessment of concentrations in biota

Cs-137

Baseline lower bracket	Baseline upper bracket	Student's t-test probability	Mann-Whitney probability
Seaweed			
0.01	0.09	-	-
Fish			
0.01	0.05	-	-

Monitoring data for Cs-137 in seaweed was available only for 2002 and 2003. For 2002, the concentration was below detection limits. In 2003, the concentration of Cs-137 was higher than the upper baseline bracket value. More data and statistical analyses are required in order to draw any conclusions.

No monitoring data for the period 2002 to 2005 was available for Cs-137 in fish, so no assessment can be made.

Tc-99

No baseline value for Tc-99 in biota has been established for the Norwegian Sea, Greenland Sea and Icelandic waters. Concentrations of Tc-99 in seaweed for 2002 and 2003 were given. More data and statistical analyses are required in order to draw any conclusions.

5.15.4 Doses from biota

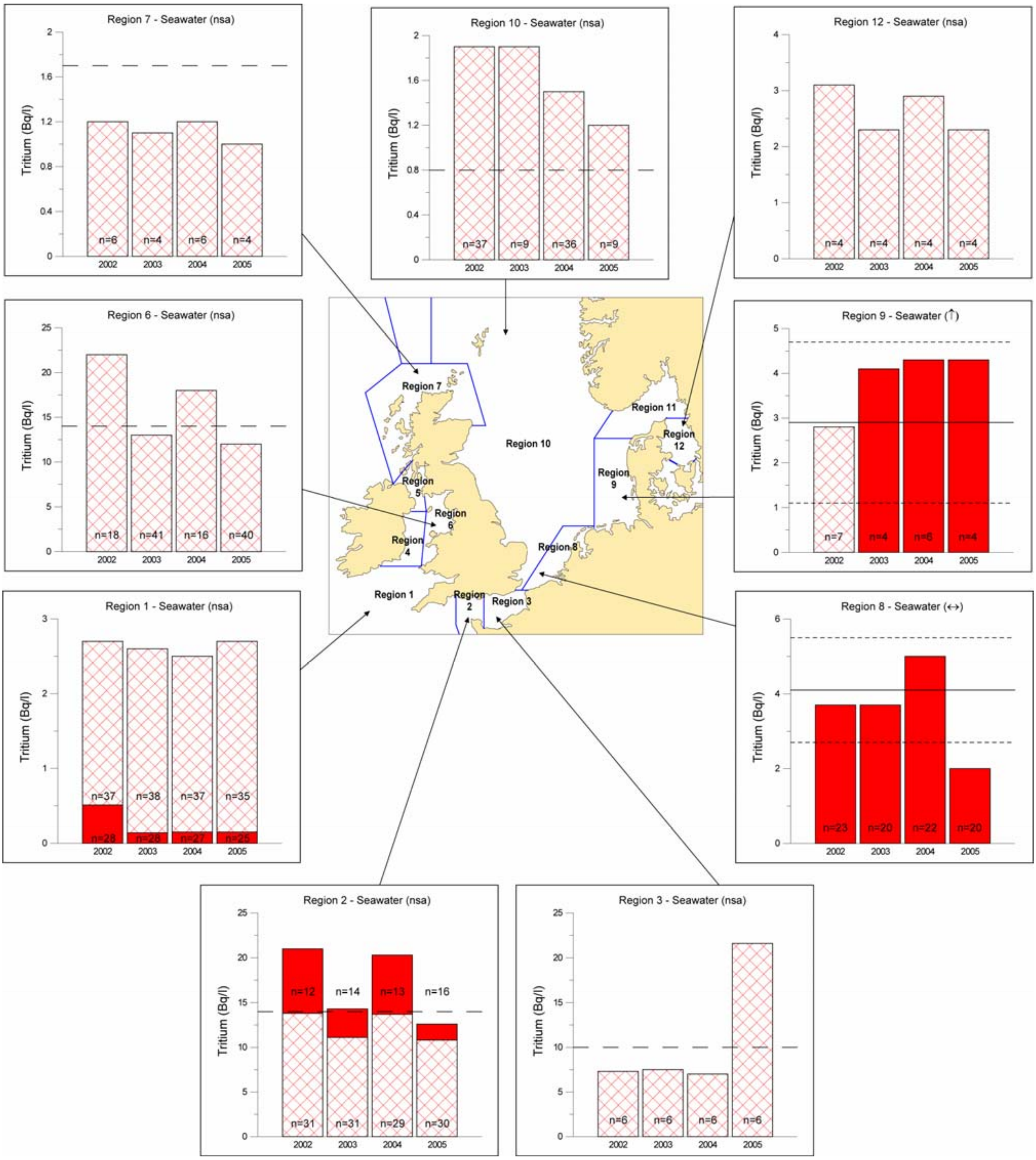
	Biota								
	Cs-137			Cs-137			Tc-99		
Year	Type	Dose (µSv/y)	SD	Type	Dose (µSv/y)	SD	Type	Dose (µSv/y)	SD
Baseline				F	0.015	0.003			
2002									
2003									
2004									
2005									

Comment on annual doses from biota

The only information available was the baseline dose calculated from Cs-137 concentrations in fish. Hence no conclusions regarding potential changes with time can be made. The method for calculation of doses does not include seaweed data.

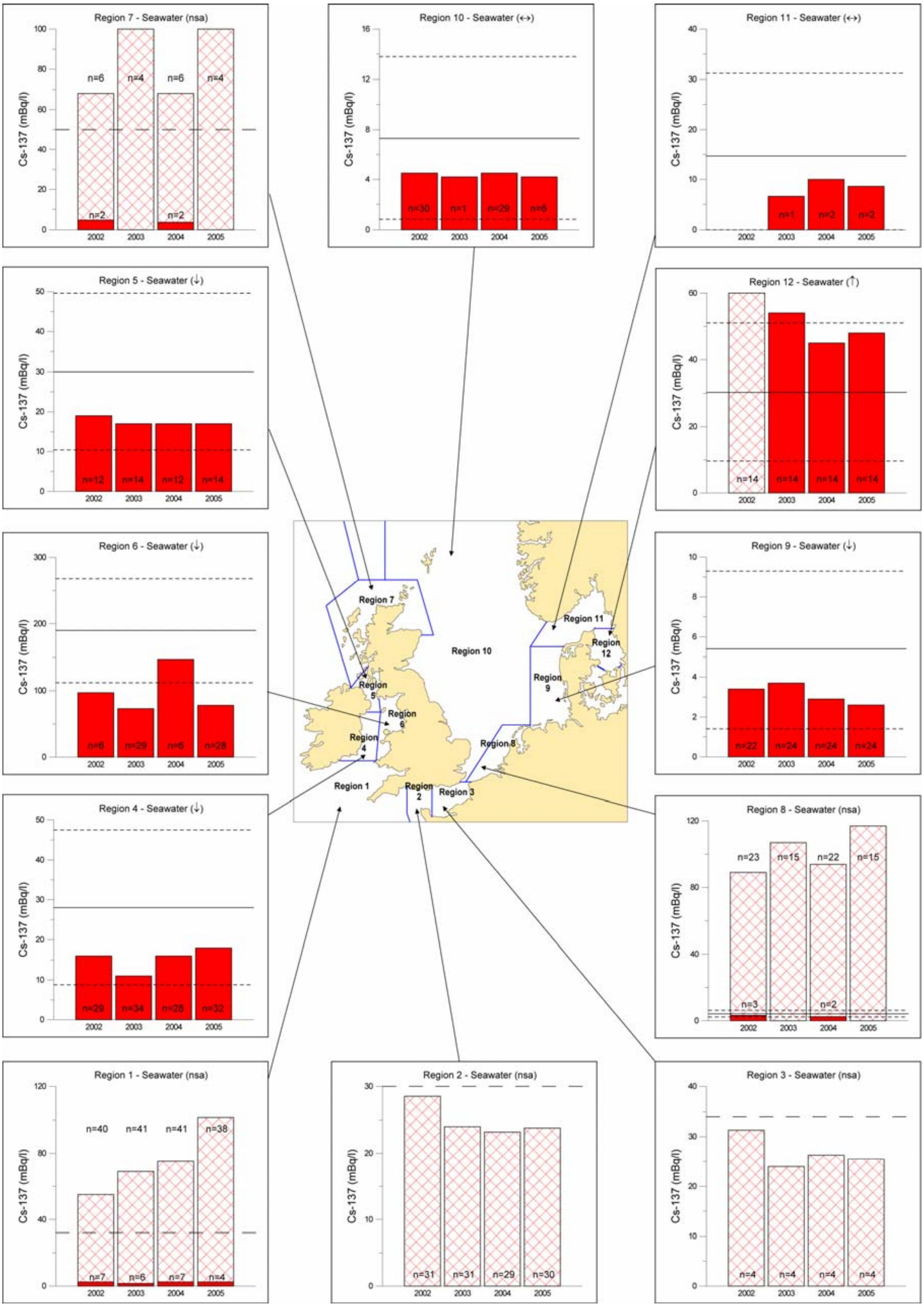
5.16 Graphical Summary

5.16.1 Tritium in seawater - North Sea and surrounding waters



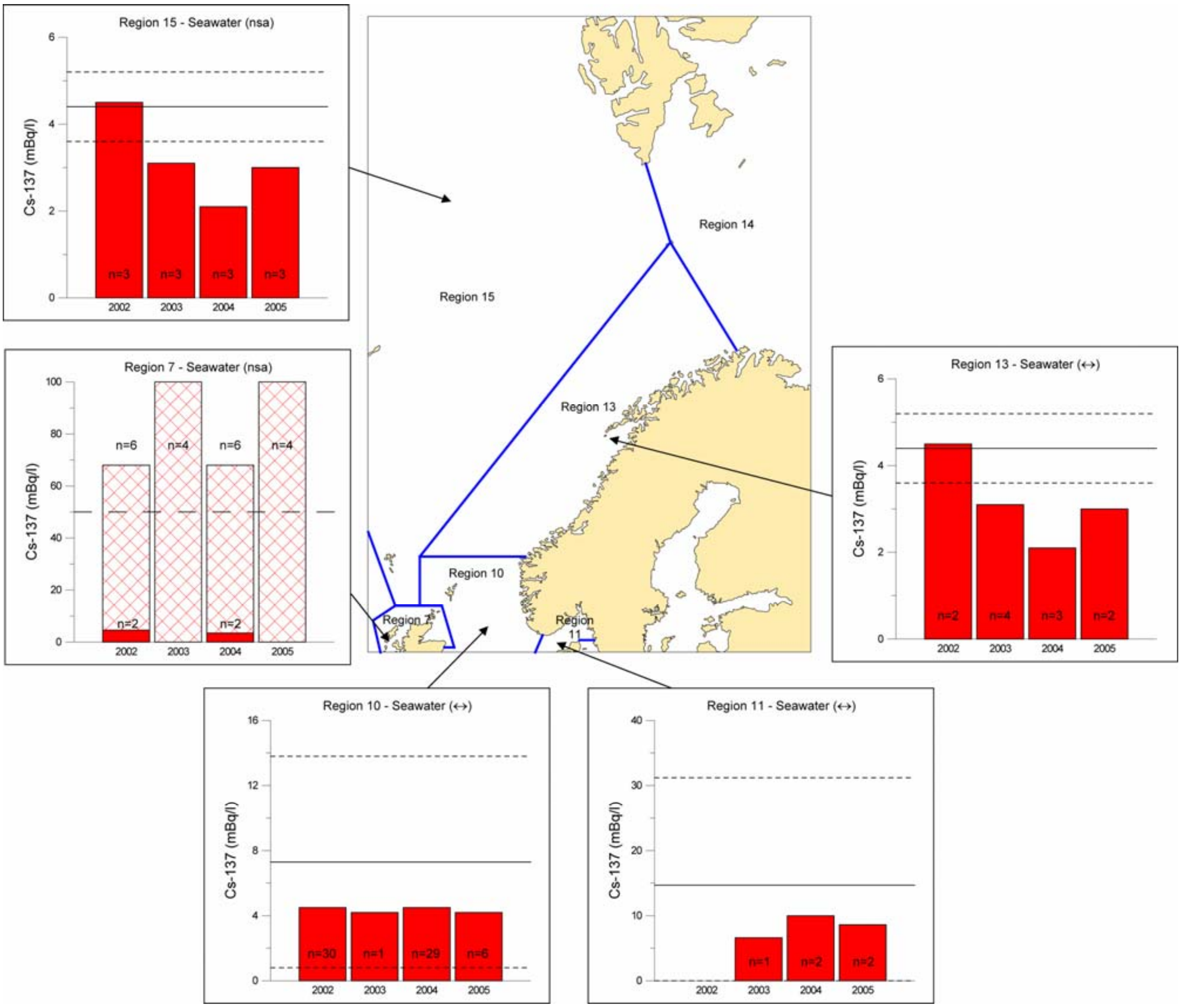
Note, concentration scales on vertical axes may vary in magnitude. Annual averages based on data above detection limits represented by solid bars; annual averages based on some/most or all data below detection limits represented by hatched bars; where available, baseline value is represented by a solid line (value above detection level) or large dashed line (value below detection level); where available, upper and lower baseline bracket values are represented by small dashed lines; where derived lower baseline bracket is negative, value is reported as 0. Evidence from statistical analyses of changes in concentrations in assessment period compared to baseline period indicated by symbol in parentheses; ↓ - decrease; ↑ - increase; ↔ - no change; nsa – no statistical analyses could be performed.

5.16.2 Cs-137 in seawater - North Sea and surrounding waters



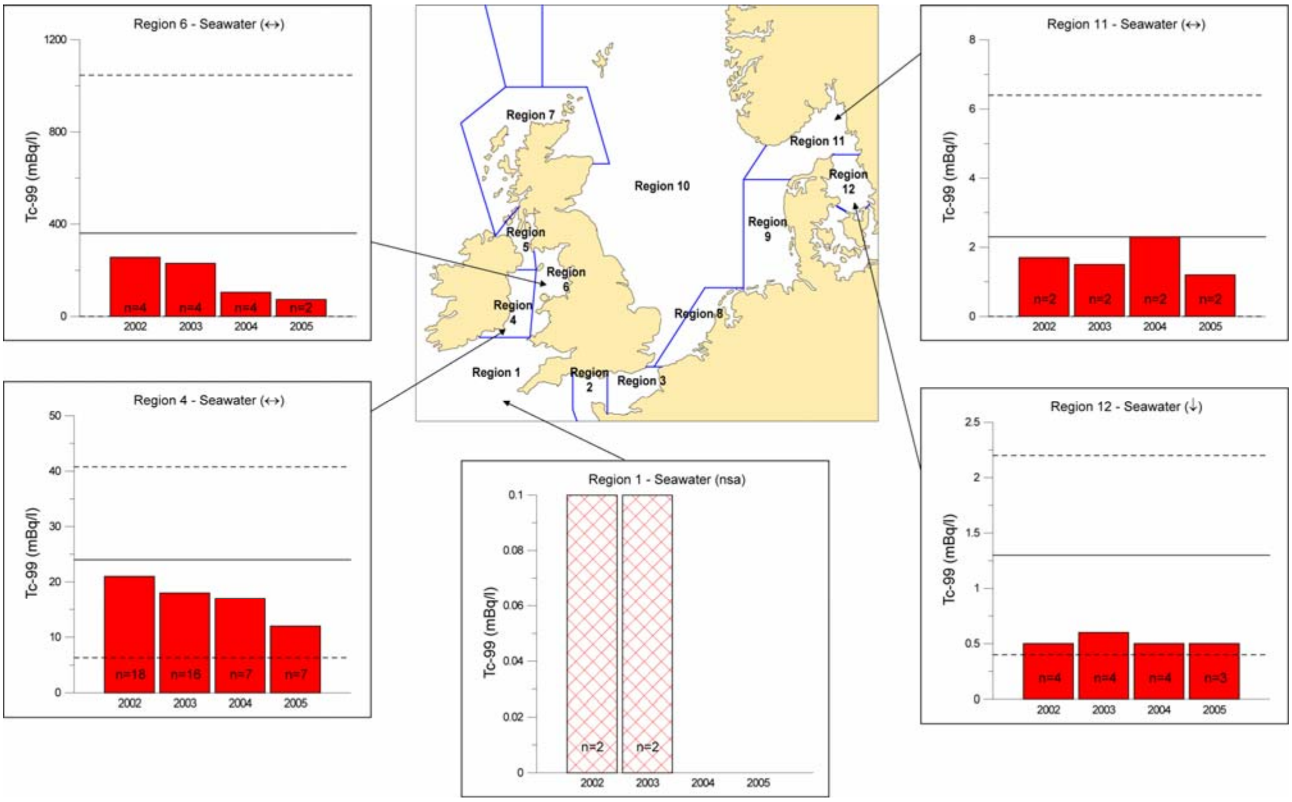
Note, concentration scales on vertical axes may vary in magnitude. Annual averages based on data above detection limits represented by solid bars; annual averages based on some/most or all data below detection limits represented by hatched bars; where available, baseline value is represented by a solid line (value above detection level) or large dashed line (value below detection level); where available, upper and lower baseline bracket values are represented by small dashed lines; where derived lower baseline bracket is negative, value is reported as 0. Evidence from statistical analyses of changes in concentrations in assessment period compared to baseline period indicated by symbol in parentheses; ↓ - decrease; ↑ - increase; ↔ - no change; nsa – no statistical analyses could be performed.

5.16.3 Cs-137 in seawater - Norwegian Sea and surrounding waters



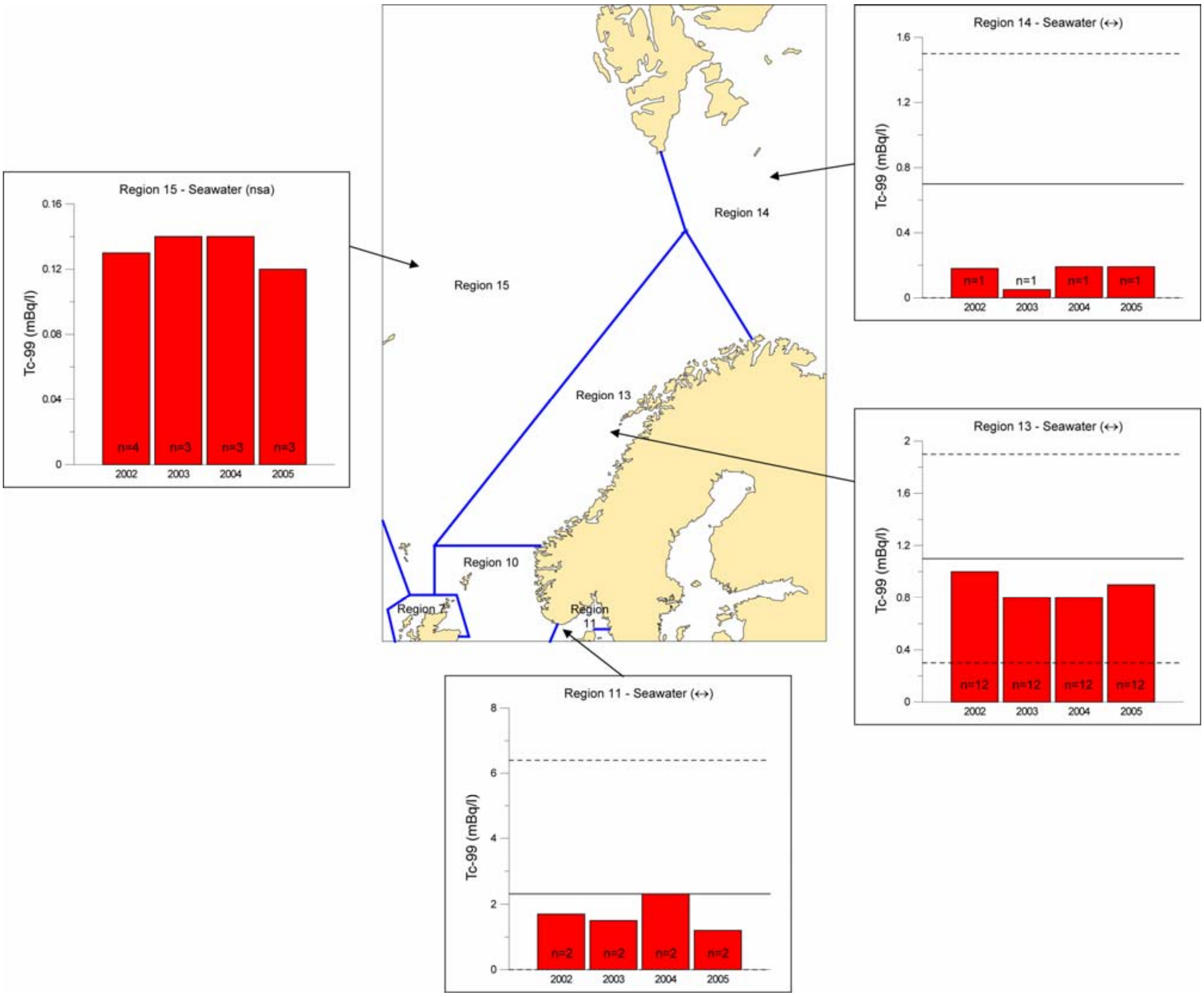
Note, concentration scales on vertical axes may vary in magnitude. Annual averages based on data above detection limits represented by solid bars; annual averages based on some/most or all data below detection limits represented by hatched bars; where available, baseline value is represented by a solid line (value above detection level) or large dashed line (value below detection level); where available, upper and lower baseline bracket values are represented by small dashed lines; where derived lower baseline bracket is negative, value is reported as 0. Evidence from statistical analyses of changes in concentrations in assessment period compared to baseline period indicated by symbol in parentheses; ↓ - decrease; ↑ - increase; ↔ - no change; nsa – no statistical analyses could be performed.

5.16.4 Tc-99 in seawater - North Sea and surrounding waters



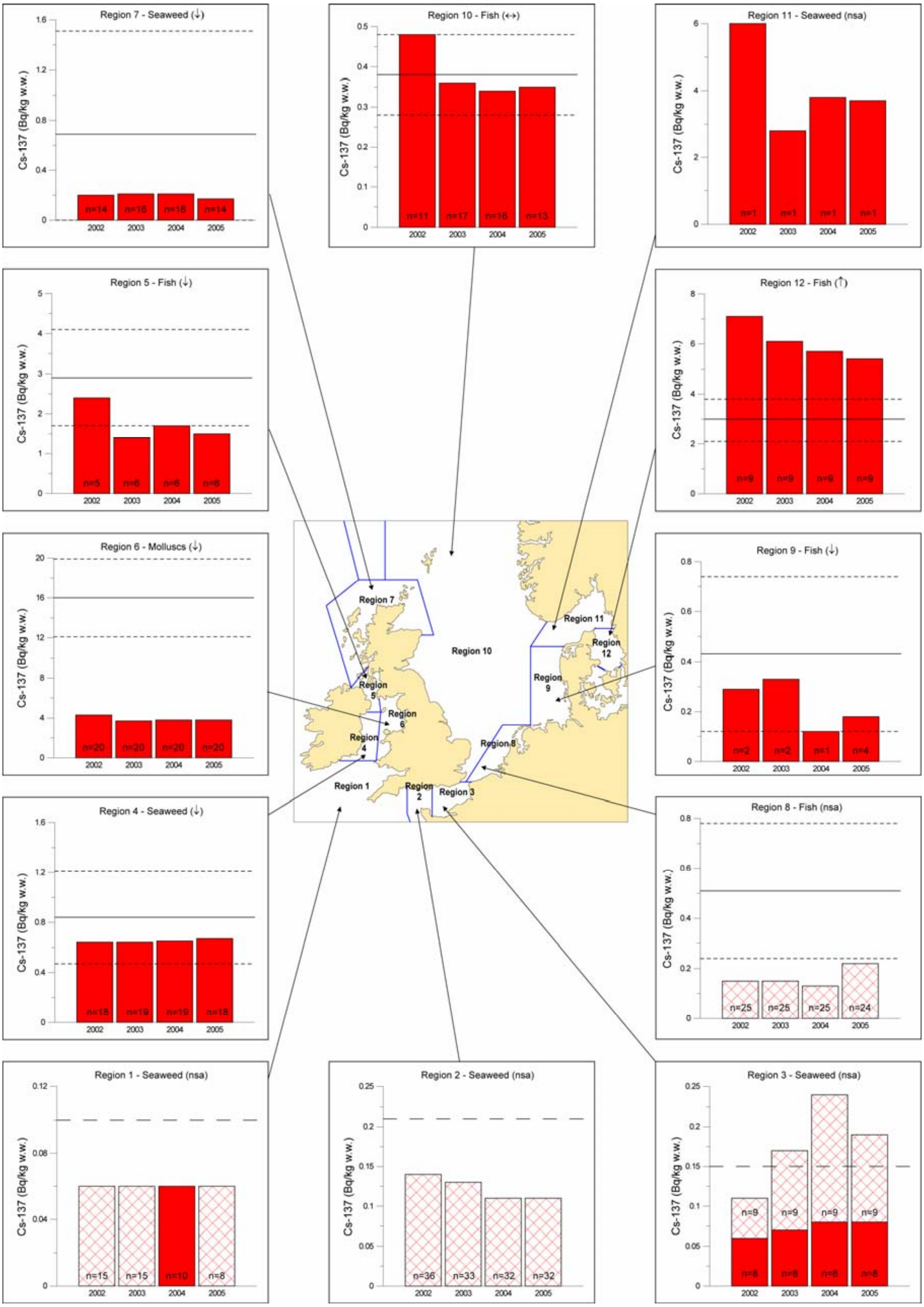
Note, concentration scales on vertical axes may vary in magnitude. Annual averages based on data above detection limits represented by solid bars; annual averages based on some/most or all data below detection limits represented by hatched bars; where available, baseline value is represented by a solid line (value above detection level) or large dashed line (value below detection level); where available, upper and lower baseline bracket values are represented by small dashed lines; where derived lower baseline bracket is negative, value is reported as 0. Evidence from statistical analyses of changes in concentrations in assessment period compared to baseline period indicated by symbol in parentheses; ↓ - decrease; ↑ - increase; ↔ - no change; nsa – no statistical analyses could be performed.

5.16.5 Tc-99 in seawater - Norwegian Sea and surrounding waters



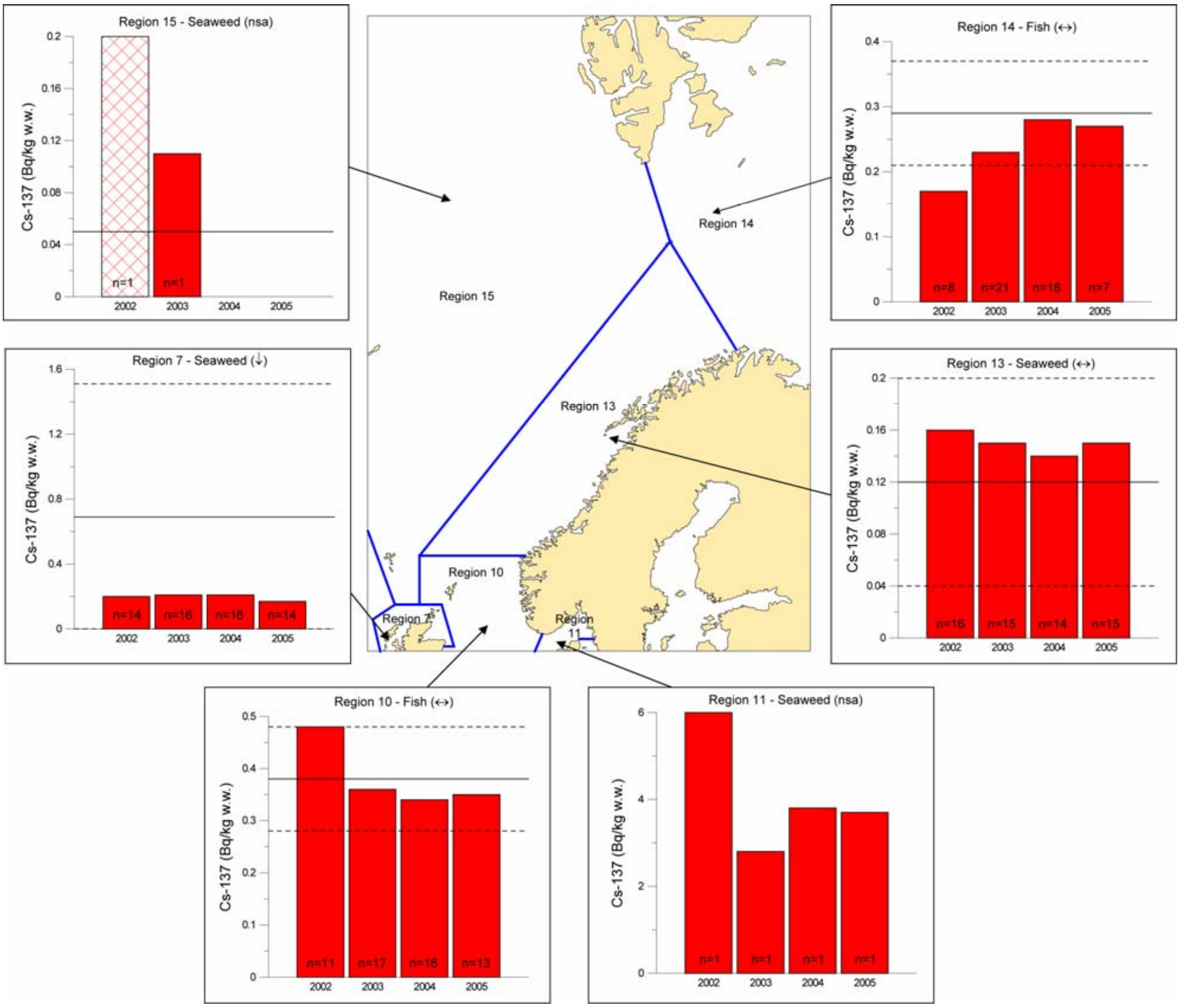
Note, concentration scales on vertical axes may vary in magnitude. Annual averages based on data above detection limits represented by solid bars; annual averages based on some/most or all data below detection limits represented by hatched bars; where available, baseline value is represented by a solid line (value above detection level) or large dashed line (value below detection level); where available, upper and lower baseline bracket values are represented by small dashed lines; where derived lower baseline bracket is negative, value is reported as 0. Evidence from statistical analyses of changes in concentrations in assessment period compared to baseline period indicated by symbol in parentheses; ↓ - decrease; ↑ - increase; ↔ - no change; nsa – no statistical analyses could be performed.

5.16.6 Cs-137 in biota - North Sea and surrounding waters



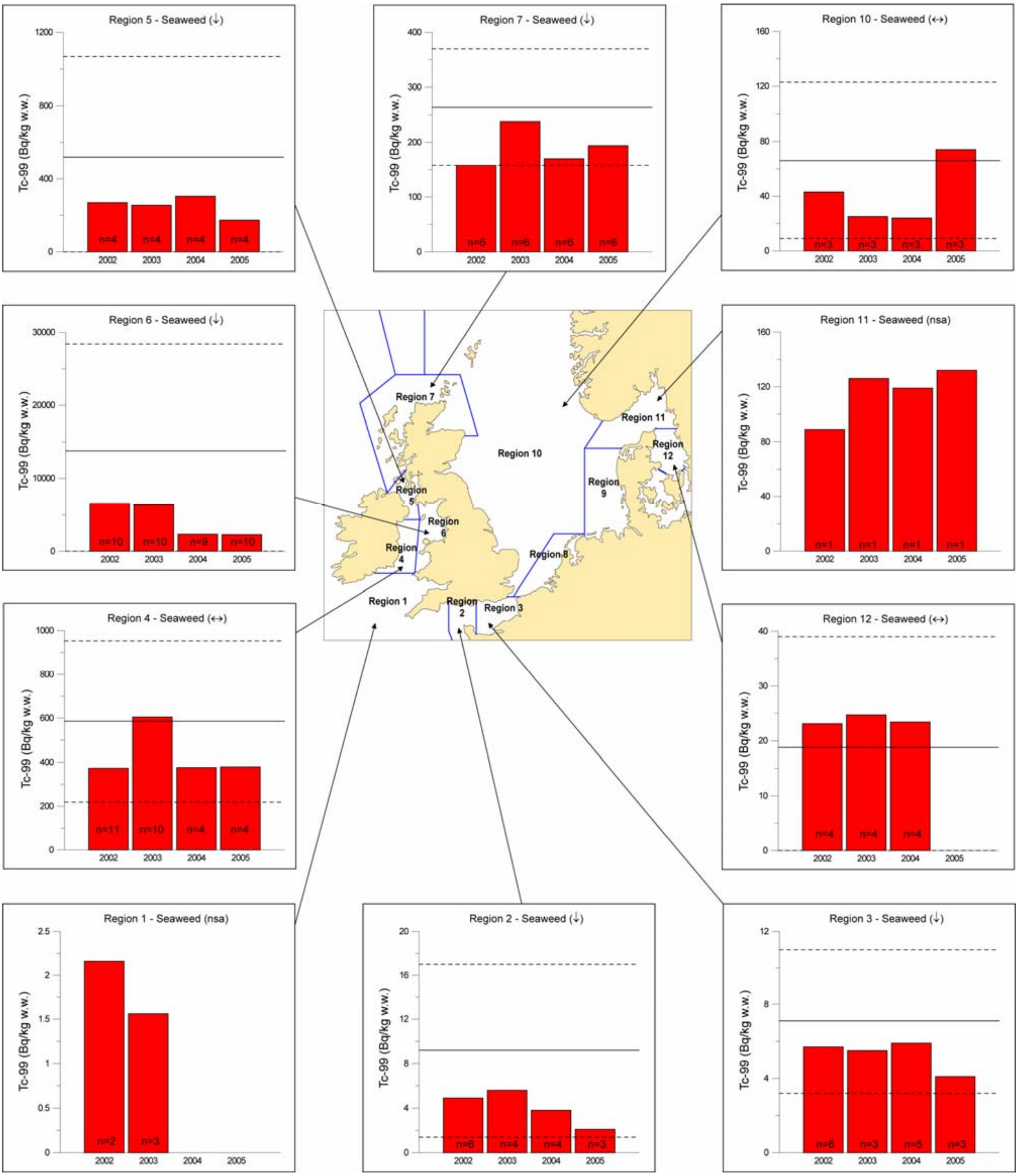
Note, concentration scales on vertical axes may vary in magnitude. Annual averages based on data above detection limits represented by solid bars; annual averages based on some/most or all data below detection limits represented by hatched bars; where available, baseline value is represented by a solid line (value above detection level) or large dashed line (value below detection level); where available, upper and lower baseline bracket values are represented by small dashed lines; where derived lower baseline bracket is negative, value is reported as 0. Evidence from statistical analyses of changes in concentrations in assessment period compared to baseline period indicated by symbol in parentheses; ↓ - decrease; ↑ - increase; ↔ - no change; nsa – no statistical analyses could be performed.

5.16.7 Cs-137 in biota - Norwegian Sea and surrounding waters



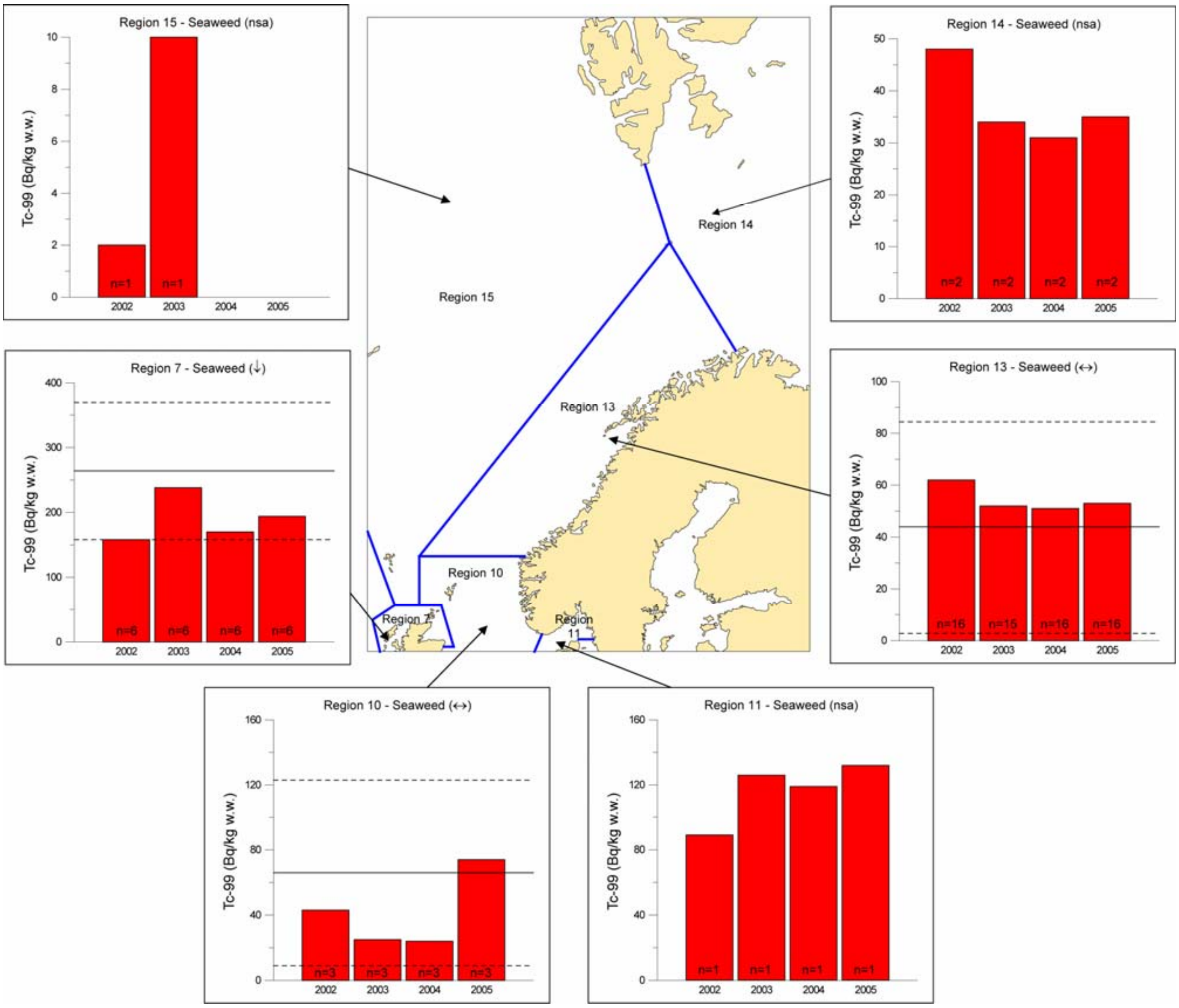
Note, concentration scales on vertical axes may vary in magnitude. Annual averages based on data above detection limits represented by solid bars; annual averages based on some/most or all data below detection limits represented by hatched bars; where available, baseline value is represented by a solid line (value above detection level) or large dashed line (value below detection level); where available, upper and lower baseline bracket values are represented by small dashed lines; where derived lower baseline bracket is negative, value is reported as 0. Evidence from statistical analyses of changes in concentrations in assessment period compared to baseline period indicated by symbol in parentheses; ↓ - decrease; ↑ - increase; ↔ - no change; nsa – no statistical analyses could be performed.

5.16.8 Tc-99 in biota - North Sea and surrounding waters



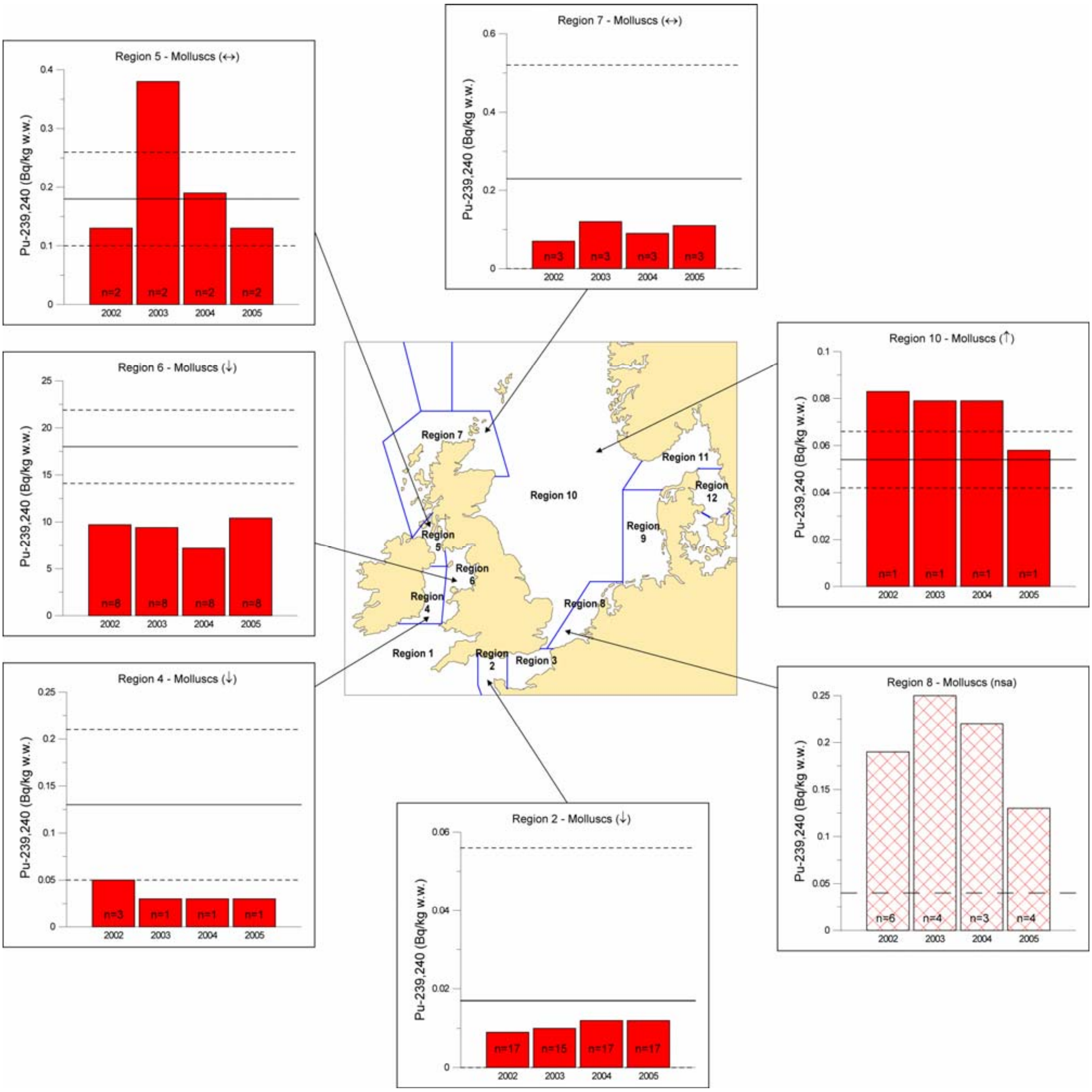
Note, concentration scales on vertical axes may vary in magnitude. Annual averages based on data above detection limits represented by solid bars; annual averages based on some/most or all data below detection limits represented by hatched bars; where available, baseline value is represented by a solid line (value above detection level) or large dashed line (value below detection level); where available, upper and lower baseline bracket values are represented by small dashed lines; where derived lower baseline bracket is negative, value is reported as 0. Evidence from statistical analyses of changes in concentrations in assessment period compared to baseline period indicated by symbol in parentheses; ↓ - decrease; ↑ - increase; ↔ - no change; nsa – no statistical analyses could be performed.

5.16.9 Tc-99 in biota - Norwegian Sea and surrounding waters



Note, concentration scales on vertical axes may vary in magnitude. Annual averages based on data above detection limits represented by solid bars; annual averages based on some/most or all data below detection limits represented by hatched bars; where available, baseline value is represented by a solid line (value above detection level) or large dashed line (value below detection level); where available, upper and lower baseline bracket values are represented by small dashed lines; where derived lower baseline bracket is negative, value is reported as 0. Evidence from statistical analyses of changes in concentrations in assessment period compared to baseline period indicated by symbol in parentheses; ↓ - decrease; ↑ - increase; ↔ - no change; nsa – no statistical analyses could be performed.

5.16.10 Pu-239,240 in biota - North Sea and surrounding waters



Note, concentration scales on vertical axes may vary in magnitude. Annual averages based on data above detection limits represented by solid bars; annual averages based on some/most or all data below detection limits represented by hatched bars; where available, baseline value is represented by a solid line (value above detection level) or large dashed line (value below detection level); where available, upper and lower baseline bracket values are represented by small dashed lines; where derived lower baseline bracket is negative, value is reported as 0. Evidence from statistical analyses of changes in concentrations in assessment period compared to baseline period indicated by symbol in parentheses; ↓ - decrease; ↑ - increase; ↔ - no change; nsa – no statistical analyses could be performed.

CHAPTER 6 – General Conclusions

Key to all tables:

- LBB - Lower baseline bracket; UBB - Upper baseline bracket.
- Lower/Upper baseline bracket = Baseline value ±1.96 x SD.
- Dash: No data available.
- Value in italic denotes that all measurements on which the value has been based were below the detection limit.
- Value in bold italic denotes that some/most measurements on which the value has been based were below the detection limit.
- 0* - Indicates that derived lower baseline bracket is negative, but value is reported as 0.
- Type: S - Seaweed (Fucus spp.); F - Fish; M - Molluscs.

6.1 Regional conclusions

6.1.1 Region 1. Wider Atlantic Iberian Coast Biscay and Channel West

Summary of data

	Baseline Value	LBB	UBB	Range (2002 to 2005)		Student's t-test Probability	Mann-Whitney Probability
				Concentration	Dose (µSv/y)		
Seawater							
Tritium (Bq/l)	-	-	-	0.14 - 0.51 ***< 2.5 - < 2.7***	0.00014 - 0.00052 < ***0.0026*** - < ***0.0028***	-	-
Cs-137 (mBq/l)	*< 32.2*	-	-	1.6 - 2.5 ***< 55.1 - < 101.6***	0.09 - 0.13 ***< 2.93 - < 5.40***	-	-
Tc-99 (mBq/l)	-	-	-	*< 0.1*[a]	*< 0.002*	-	-
Pu-239,240 (µBq/l)	-	-	-	-	-	-	-
Biota (Type) : All Bq/kg (w.w.)							
Cs-137 (S)	***< 0.10***	-	-	< ***0.06*** - 0.06	-	-	-
Cs-137 (F)	-	-	-	0.23 - 0.33[b]	0.10 - 0.15	-	-
Tc-99 (S)	-	-	-	1.56 - 2.16[a]	-	-	-

Due to the difference in magnitude between data reported above and below detection limits for tritium and Cs-137 in seawater for 2002 to 2005, two sets of annual means are reported for these radionuclides for these years, one set based only on data above detection limits and one set based on all available data (i.e. data above and below detection limits). Note, no baseline value reported for Pu-239,240 in biota. Cs-137 baseline values reported for both seaweed and fish. a – Data from only 2002 and 2003; b – Data from only 2002 to 2004.

For seawater in this region, data is available for tritium, Cs-137 and Tc-99. Comparison of both tritium and Cs-137 data sets reveals a difference in measurement methodologies used by the relevant Contracting Parties. Consequently, the annual mean concentrations based only on data above detection limits were lower than the annual mean concentrations based on all data. The data sets submitted by the relevant contracting parties could be reported separately in order to produce more meaningful values. For tritium, annual mean concentrations based only on data above detection limits were similar for each year of the assessment period, as was the case for annual mean concentrations based on all data. For Cs-137, it is difficult to make any assessment due to the heterogeneity of values reported. No baseline value for tritium and Tc-99 has been established.

For biota in this region, data is available for Cs-137 in seaweed and fish and Tc-99 in seaweed. Annual mean concentrations for Cs-137 in seaweed for the assessment period were below the baseline value. No baseline value for Cs-137 in fish and Tc-99 in seaweed has been established.

Overall the lack of baseline values for this region makes it difficult to assess any changes in seawater and biota concentrations.

The sum of the doses from all available data (i.e. including data based on less than values) for the assessment radionuclides (tritium and Cs-137) in seawater for each year of the period 1995 to 2005 ranged from (<)1.31 to (<)5.4 µSv/y. Where data was available for tritium and Cs-137 in seawater, the dose from Cs-137 was the dominant contributor (99.9%). For comparison purposes only and based on the limited data available in the scientific literature, the doses from environmental concentrations of the natural radionuclides Ra-226 and Ra-228 in seawater in region 1 (no data available for Pb-210 and Po-210) from a similar time period were 10.5 µSv/y and 15.5 µSv/y respectively.

6.1.2 Region 2. Channel (Cap de la Hague)

Summary of data

	Baseline Value	LBB	UBB	Range (2002 to 2005)		Student's t-test Probability	Mann-Whitney Probability
				Concentration	Dose (µSv/y)		
Seawater							
Tritium (Bq/l)	*< 13.9*	-	-	12.6 - 21.0 *< 10.8 - < 13.8*	0.0129 - 0.0215 *< 0.0111 - < 0.0142*	-	-
Cs-137 (mBq/l)	*< 30.3*	-	-	*< 23.2 - < 28.6*	*< 1.23 - < 1.52*	-	-
Tc-99 (mBq/l)	-	-	-	-	-	-	-
Pu-239,240 (µBq/l)	-	-	-	-	-	-	-
Biota (Type) : All Bq/kg (w.w.)							
Cs-137 (S)	*< 0.20*	-	-	*< 0.11 - < 0.14*	-	-	-
Tc-99 (S)	9.1	4.0	14.2	2.1 - 5.6	-	0.003	0.006
Pu-239,240 (M)	0.017	0*	0.076	0.009 – 0.012	0.026 - 0.034	0.002	0.012

Due to the difference in magnitude between data reported above and below detection limits for tritium in seawater for 2002 to 2005, two sets of annual means are reported for this radionuclide for these years, one set based only on data above detection limits and one set based on all available data (i.e. data above and below detection limits).

For seawater in this region, data is available for tritium and Cs-137. Comparison of tritium data sets reveals a difference in measurement methodologies used by the relevant Contracting Parties. Annual mean concentrations based only on data above detection limits were similar or higher than the annual mean concentrations based on all data and the baseline value. For Cs-137, the majority of seawater data for the assessment period was below detection limits. Annual mean concentrations were similar and less than the baseline value.

For biota in this region, data is available for Cs-137 in seaweed, Tc-99 in seaweed and Pu-239,240 in molluscs. The majority of the data for Cs-137 in seaweed for the assessment period was below detection limits. Annual mean concentrations for 2002 to 2005 were similar and all less than the baseline value. Statistical analyses reveal that there is evidence of a decrease in Tc-99 concentrations in seaweed and Pu-239,240 concentrations in molluscs in the assessment period compared to the baseline period.

Environmental concentrations may be influenced by historical levels, which may require further study.

The sum of the doses from all available data (i.e. including data based on less than values) for the assessment radionuclides (tritium and Cs-137) in seawater for each year of the period 1995 to 2005 ranged from (<)1.24 to (<)1.80 µSv/y. Where data was available for tritium and Cs-137 in seawater, the dose from Cs-137 was the dominant contributor (98.9 to 99.1%). For comparison purposes only and based on the limited data available in the scientific literature, the doses from environmental concentrations of the natural radionuclides Ra-226 and Ra-228 in seawater in region 2 (no data available for Pb-210 and Po-210) from a similar time period were 12.1 µSv/y and 38.7 µSv/y respectively.

6.1.3 Region 3. Channel east

Summary of data

	Baseline Value	LBB	UBB	Range (2002 to 2005)		Student's t-test Probability	Mann-Whitney Probability
				Concentration	Dose (µSv/y)		
Seawater							
Tritium (Bq/l)	*< 10.3*	-	-	***< 7.0 - < 21.6***	***< 0.0072 - < 0.0222***	-	-
Cs-137 (mBq/l)	*< 34.4*	-	-	*< 24.0 - < 31.3*	*< 1.28 - < 1.66*	-	-
Tc-99 (mBq/l)	-	-	-	-	-	-	-
Pu-239,240 (µBq/l)	-	-	-	-	-	-	-
Biota (Type) : All Bq/kg (w.w.)							
Cs-137 (S)	***< 0.12***	-	-	0.06 - 0.08 ***< 0.11 - < 0.24***	-	-	-
Tc-99 (S)	7.3	5.3	9.3	4.1 - 5.9	-	0.007	0.006
Pu-239,240 (F)	***< 0.000046***	-	-	-	-	-	-

Due to the difference in magnitude between data reported above and below detection limits for Cs-137 in seaweed for 2002 to 2005, two sets of annual means are reported for this radionuclide for these years, one set based only on data above detection limits and one set based on all available data (i.e. data above and below detection limits).

For seawater in this region, data is available for tritium and Cs-137. The majority of the monitoring data for tritium and Cs-137 was below detection levels, with annual mean concentrations of both radionuclides in the assessment period comparable to their respective baseline values.

For biota in this region, data is available for Cs-137 and Tc-99 in seaweed and Pu-239,240 in fish. The majority of the monitoring data for Cs-137 in seaweed was above detection levels, although there was a difference in detection limit between the data sets that were submitted. Consequently, values below detection limits were higher than those above detection limits and conclusions on comparisons with the baseline value are completely different depending on which data is selected (annual means based on only data above detection limits or all data). Data sets submitted by different Contracting Parties could be collected separately in order to produce more meaningful values. Statistical analyses reveal that there is evidence of a decrease in Tc-99 concentrations in seaweed in the assessment period compared to the baseline period. No monitoring data was available for Pu-239,240 in fish for the assessment period.

The sum of the doses from all available data (i.e. including data based on less than values) for the assessment radionuclides (tritium and Cs-137) in seawater for each year of the period 1995 to 2005 ranged from (<)0.44 to (<)4.88 µSv/y. Where data was available for tritium and Cs-137 in seawater, the dose from Cs-137 was the dominant contributor (98.4 to 99.6%). For comparison purposes only and based on the limited data available in the scientific literature, the doses from environmental concentrations of the natural radionuclides Ra-226 and Ra-228 in seawater in region 3 (no data available for Pb-210 and Po-210) from a similar time period were 9.7 µSv/y and 29.8 µSv/y respectively.

6.1.4 Region 4. Irish Sea (Rep. of Ireland)

Summary of data

	Baseline Value	LBB	UBB	Range (2002 to 2005)		Student's t-test Probability	Mann-Whitney Probability
				Concentration	Dose (µSv/y)		
Seawater							
Tritium (Bq/l)	-	-	-	-	-	-	-
Cs-137 (mBq/l)	28	8.8	47.5	11 - 18	0.61 - 0.95	0.013	0.042
Tc-99 (mBq/l)	24	6.3	40.8	12 - 21	0.19 - 0.32	0.120	0.109
Pu-239,240 (µBq/l)	-	-	-	-	-	-	-
Biota (Type) : All Bq/kg (w.w.)							
Cs-137 (S)	0.84	0.47	1.21	0.64 - 0.67	-	0.036	0.073
Tc-99 (S)	586	219	953	373 - 605	-	0.127	0.315
Pu-239,240 (M)	0.13	0.05	0.21	0.03 - 0.05	0.08 - 0.14	0.001	0.006

The biggest influence on the radionuclide concentrations in this region is discharges from Sellafield. The initial dispersion of radionuclides from Sellafield is influenced by a number of factors including variations in the discharge rate, the chemical form of the radionuclides in the effluent, local hydrographic conditions and the distribution and composition of bottom sediments. Those radionuclides that are (relatively) soluble in seawater (e.g., Tc-99, Cs-137 and tritium) are advected principally in a northerly direction, associated with the mean flow of water currents, leaving the Irish Sea via the North Channel, with a mean transit time of about one year. In contrast, the non-conservative radionuclide plutonium is quickly removed from the water column by direct precipitation or by absorption on suspended particulate matter. The behaviour and distribution of plutonium is closely linked to that of fine-grained seabed sediments.

The trends observed in the discharge data, reported in the first periodic evaluation, may not necessarily be observed in the concentration data.

For seawater in this region, data is available for Cs-137 and Tc-99. Statistical analyses reveal that there is evidence of a decrease in Cs-137 concentrations but no evidence of any change in Tc-99 concentrations in the assessment period compared to the baseline period.

For biota in this region, data is available for Tc-99 and Cs-137 in seaweed and for Pu-239,240 in molluscs. Statistical analyses reveal that while there is evidence of a decrease in Cs-137 concentrations in seaweed (Student's t-test only) and Pu-239,240 concentrations in molluscs, there is no evidence of any change in Tc-99 concentrations in seaweed in the assessment period compared to the baseline period.

The sum of the doses from all available data for the assessment radionuclides (Cs-137 and Tc-99) in seawater for each year of the period 1995 to 2005 ranged from 0.89 to 2.77 µSv/y. Where data was available for Cs-137 and Tc-99 in seawater, the dose from Cs-137 was the dominant contributor (68.5 to 88.4%). For comparison purposes only and based on the limited data available in the scientific literature, the doses from environmental concentrations of the natural radionuclides Ra-226 and Ra-228 in seawater in region 4 (no data available for Pb-210 and Po-210) from a similar time period were 10.0 µSv/y and 22.0 µSv/y respectively.

6.1.5 Region 5. Irish Sea (Northern Ireland)

Summary of data

	Baseline Value	LBB	UBB	Range (2002 to 2005)		Student's t-test Probability	Mann-Whitney Probability
				Concentration	Dose (µSv/y)		
Seawater							
Tritium (Bq/l)	-	-	-	-	-	-	-
Cs-137 (mBq/l)	28.1	9.9	46.3	16.8 - 18.8	0.89 - 1.00	0.025	0.073
Tc-99 (mBq/l)	-	-	-	-	-	-	-
Pu-239,240 (µBq/l)	-	-	-	-	-	-	-
Biota (Type) : All Bq/kg (w.w.)							
Cs-137 (F)	2.7	1.7	3.7	1.4 - 2.4	0.64 - 1.06	0.019	0.024
Tc-99 (S)	516	0*	1065	173 - 304	-	0.046	0.012
Pu-239,240 (M)	0.17	0.11	0.23	0.13 - 0.38	0.36 - 1.05	0.619	0.788

For seawater in this region, data is only available for Cs-137. Statistical analyses reveal that there is evidence of a decrease in Cs-137 concentrations (Student's t-test only) in the assessment period compared to the baseline period.

For biota in this region, data is available for Cs-137 in fish, Tc-99 in seaweed and for Pu-239,240 in molluscs. Statistical analyses reveal that while there is evidence of a decrease in Cs-137 concentrations in fish and Tc-99 concentrations in seaweed, there is no evidence of any change in Pu-239,240 concentrations in molluscs in the assessment period compared to the baseline period.

The doses from Cs-137 in seawater for each year of the period 1995 to 2005 ranged from 0.89 to 2.44 µSv/y. For comparison purposes only and based on the limited data available in the scientific literature, the doses from environmental concentrations of the natural radionuclides Ra-226 and Ra-228 in seawater in region 5 (no data available for Pb-210 and Po-210) from a similar time period were 11.8 µSv/y and 42.7 µSv/y respectively.

6.1.6 Region 6. Irish Sea (Sellafield)

Summary of data

	Baseline Value	LBB	UBB	Range (2002 to 2005)		Student's t-test Probability	Mann-Whitney Probability
				Concentration	Dose (µSv/y)		
Seawater							
Tritium (Bq/l)	***< 15***	-	-	***< 12 - < 22***	***< 0.012 - < 0.022***	-	-
Cs-137 (mBq/l)	175	99	251	73 - 147	3.90 - 7.83	0.012	0.024
Tc-99 (mBq/l)	357	0*	1023	73 - 256	1.13 - 3.94	0.203	0.164
Pu-239,240 (µBq/l)	-	-	-	-	-	-	-
Biota (Type) : All Bq/kg (w.w.)							
Cs-137 (M)	16.3	11.6	21.0	3.7 - 4.3	0.53 - 0.61	<0.001	0.006
Tc-99 (S)	13361	127	26595	2279 - 6525	-	0.013	0.024
Pu-239,240 (M)	18.1	14.8	21.4	7.2 - 10.4	19.8 - 28.6	<0.001	0.006

For seawater in this region, data is available for tritium, Cs-137 and Tc-99. Statistical analyses reveal that while there is evidence of a decrease in Cs-137 concentrations, there is no evidence of any change in Tc-99 concentrations in the assessment period compared to the baseline period. No statistical analyses could be performed for tritium, as annual mean concentrations were derived partly from data below detection limits.

For biota in this region, data is available for Cs-137 and Pu-239,240 in molluscs and Tc-99 in seaweed. Statistical analyses reveal that there is evidence of a decrease in the concentrations of all three radionuclides in their respective biota in the assessment period compared to the baseline period.

The sum of the doses from all available data (i.e. including data based on less than values) for the assessment radionuclides (tritium, Cs-137 and Tc-99) in seawater for each year of the period 1995 to 2005 ranged from 5.3 to 28.2 µSv/y. Where data was available for tritium, Cs-137 and Tc-99 in seawater, the doses from Cs-137 and Tc-99 were the dominant contributors (41.3 to 82.9% and 17.0 to 58.6%). For comparison purposes only and based on the limited data available in the scientific literature, the doses from environmental concentrations of the natural radionuclides Ra-226 and Ra-228 in seawater in region 6 (no data available for Pb-210 and Po-210) from a similar time period were 15.0 µSv/y and 72.1 µSv/y respectively.

6.1.7 Region 7. Scottish Waters (Dounreay)

Summary of data

	Baseline Value	LBB	UBB	Range (2002 to 2005)		Student's t-test Probability	Mann-Whitney Probability
				Concentration	Dose (μSv/y)		
Seawater							
Tritium (Bq/l)	***< 1.65***	-	-	*< 1.00 - < 1.16*	*< 0.0010 - < 0.0012*	-	-
Cs-137 (mBq/l)	***< 53.5***	-	-	3.5 - 4.6[a] ***< 68*** - *< 100*	0.19 - 0.24 ***< 3.60*** - *< 5.32*	-	-
Tc-99 (mBq/l)	-	-	-	-	-	-	-
Pu-239,240 (μBq/l)	-	-	-	-	-	-	-
Biota (Type) : All Bq/kg (w.w.)							
Cs-137 (S)	0.64	0*	1.38	0.17 - 0.21	-	0.023	0.006
Tc-99 (S)	287	130	444	158 - 238	-	0.022	0.042
Pu-239,240 (M)	0.23	0*	0.50	0.07 - 0.12	0.19 - 0.32	0.055	0.073

Due to the difference in magnitude between data reported above and below detection limits for Cs-137 in seawater for 2002 and 2004, two sets of annual means are reported for this radionuclide in these years, one set based only on data above detection limits and one set based on all available data (i.e. data above and below detection limits). a – Data from only 2002 and 2004.

For seawater in this region, data is available for tritium and Cs-137. The majority of Cs-137 data and all of the tritium data for the assessment period were below detection limits. For Cs-137, the few data points above detection limits were reasonably consistent and low. Dose estimates were restrictive because of the lack of data above detection limits. The limited evidence available supports the view that there has been little change in seawater concentrations of either radionuclide between the assessment period and the baseline period.

For biota in this region, data is available for Cs-137 and Tc-99 in seaweed and Pu-239,240 in molluscs. Annual mean concentrations of Cs-137 and Tc-99 in seaweed and Pu-239,240 in molluscs appear to have been reasonably consistent throughout the assessment period, with some observed environmental scatter. Statistical analyses reveal that while there is evidence of decreases in Cs-137 and Tc-99 concentrations in seaweed, there is no evidence of any change in Pu-239,240 concentrations in molluscs in the assessment period compared to the baseline period.

The sum of the doses from all available data (i.e. including data based on less than values) for the assessment radionuclides (tritium and Cs-137) in seawater for each year of the period 1995 to 2005 ranged from 1.26 to (<)5.32 μSv/y. Where data was available for tritium and Cs-137 in seawater, the dose from Cs-137 was the dominant contributor (99.9%). No data was available for environmental concentrations of Pb-210, Po-210, Ra-226 and Ra-228 in seawater for region 7 from a similar time period for comparison purposes.

6.1.8 Region 8. North Sea South (Belgian and Dutch Coast)

Summary of data

	Baseline Value	**LBB**	**UBB**	**Range (2002 to 2005)**		**Student's t-test Probability**	**Mann-Whitney Probability**
				Concentration	**Dose (µSv/y)**		
Seawater							
Tritium (Bq/l)	4.1	2.7	5.5	2.0 - 5.0	0.0021 - 0.0051	0.522	0.648
Cs-137 (mBq/l)	4.3	2.3	6.4	2.4 - 3.0[a] ***< 89*** - *< 117*	0.13 - 0.16 ***< 4.75*** - *< 6.22*	-	-
Tc-99 (mBq/l)	-	-	-	-	-	-	-
Pu-239,240 (µBq/l)	13.4	7.8	19.1	***< 373***[b]	***< 3.62***	-	-
Biota (Type) : All Bq/kg (w.w.)							
Cs-137 (F)	0.51	0.24	0.78	***< 0.13 - < 0.22***	***< 0.06*** - ***< 0.10***	-	-
Pu-239,240 (M)	***< 0.04***	-	-	*< 0.13 - < 0.25*	*< 0.34 - < 0.69*	-	-
Pu-239,240 (F)	***< 0.02***	-	-	***< 0.03***[b]	***< 0.23***	-	-

Due to the difference in magnitude between data reported above and below detection limits for Cs-137 in seawater for 2002 and 2004, two sets of annual means are reported for this radionuclide in these years, one set based only on data above detection limits and one set based on all available data (i.e. data above and below detection limits). Note, no baseline value reported for Tc-99 in biota. Pu-239,240 baseline values reported for both molluscs and fish. a – Data from only 2002 and 2004; b – Data from only 2005.

For seawater in this region, data is available for tritium, Cs-137 and Pu-239,240. Statistical analyses reveal that there is no evidence of any change in tritium concentrations in the assessment period compared to the baseline period. For Cs-137, annual mean concentrations based on data reported above detection levels were lower than the baseline value, but no statistical analyses could be performed to validate the significance of this observation. For Pu-239,240, "the less than detection" limit given is far higher than the baseline value and so consequently no conclusions regarding potential reductions can be made. In order to detect trends in the future, monitoring methods should be improved to ensure that Cs-137 and Pu-239,240 can be detected in environmental samples.

For biota in this region, data is available for Cs-137 and Pu-239,240 in fish and Pu-239,240 in molluscs. There is an indication that annual mean concentrations of Cs-137 in fish have declined over the period 2002 to 2005 compared to the baseline, although no statistical analyses could be performed to validate the significance of this observation. It appears that monitoring methods for 2002 to 2005 were different from the data used for baseline calculation and it is possible that this has some influence on the result. For Pu-239, 240 in fish, data was only available for 2005, with a value that was comparable to the baseline value. Dose calculations based on fish measurements indicates that Pu-239,240 contributes more to dose than Cs-137 in this area.

The sum of the doses from all available data (i.e. including data based on less than values) for the assessment radionuclides (tritium, Cs-137 and Pu-239,240) in seawater for each year of the period 1995 to 2005 ranged from 0.0031 to (<)9.84 µSv/y. Where data was available for tritium, Cs-137 and Pu-239,240 in seawater, the dose from Cs-137 and Pu-239,240 were the dominant contributors (63.1 to 67.6% and 31.2 to 35.1%). No data was available for environmental concentrations of Pb-210, Po-210, Ra-226 and Ra-228 in seawater for region 8 from a similar time period for comparison purposes.

6.1.9 Region 9. German Bight

Summary of data

	Baseline Value	LBB	UBB	Range (2002 to 2005)		Student's t-test Probability	Mann-Whitney Probability
				Concentration	Dose (µSv/y)		
Seawater							
Tritium (Bq/l)	2.9	1.1	4.7	< ***2.8*** - 4.3	< ***0.0029*** - 0.0044	0.015	0.024
Cs-137 (mBq/l)	5.4	1.4	9.3	2.6 - 3.7	0.14 - 0.20	0.028	0.042
Tc-99 (mBq/l)	1.67	0*	4.04	-	-	-	-
Pu-239,240 (µBq/l)	11.4	2.2	20.6	6.0 - 12.6[a]	0.06 - 0.12	0.390	0.571
Biota (Type) : All Bq/kg (w.w.)							
Cs-137 (F)	0.43	0.12	0.74	0.12 - 0.33	0.05 - 0.15	0.033	0.073
Tc-99	-	-	-	-	-	-	-
Pu-239,240 (F)	< ***0.000032***	-	-	< *0.000032* - < *0.000046*[b]	< *0.00027* - < *0.00039*	-	-

a – Data from only 2002 to 2004; b – Data from only 2002 and 2004.

For seawater in this region, data is available for tritium, Cs-137, Tc-99 and Pu-239,240. Statistical analyses reveal that while there is evidence of an increase in tritium concentrations and a decrease in Cs-137 concentrations, there is no evidence of any change in Pu-239,240 concentrations in the assessment period compared to the baseline period. No monitoring data for Tc-99 was available for the assessment period.

For biota in this region, data is available for Cs-137 and Pu-239,240 in fish. Statistical analyses reveal that there is evidence of a decrease in Cs-137 concentrations in fish (Student's t-test only) in the assessment period compared to the baseline period. Reported concentrations of Pu-239,240 in fish were below detection limits.

The sum of the doses from all available data (i.e. including data based on less than values) for the assessment radionuclides (tritium, Cs-137, Tc-99 and Pu-239,240) in seawater for each year of the period 1995 to 2005 ranged from 0.14 to 0.66 µSv/y. Where data was available for tritium, Cs-137, Tc-99 and Pu-239,240 in seawater, the dose from Cs-137 was the dominant contributor (55.0 to 75.8%) followed by the dose from Pu-239,240 (19.0 to 28.9%). No data was available for environmental concentrations of Pb-210, Po-210, Ra-226 and Ra-228 in seawater for region 9 from a similar time period for comparison purposes.

6.1.10 Region 10. North Sea (Northwest, Southeast and Central)

Summary of data

	Baseline Value	LBB	UBB	Range (2002 to 2005)		Student's t-test Probability	Mann-Whitney Probability
				Concentration	Dose (µSv/y)		
Seawater							
Tritium (Bq/l)	*< 0.8*	-	-	*< 1.2 - < 1.9*	*< 0.0012 - < 0.0019*	-	-
Cs-137 (mBq/l)	7.3	0.8	13.8	4.2 - 4.5	0.22 - 0.24	0.173	0.114
Tc-99 (mBq/l)	2.8	1.2	4.4	-	-	-	-
Pu-239,240 (µBq/l)	-	-	-	-	-	-	-
Biota (Type) : All Bq/kg (w.w.)							
Cs-137 (F)	0.38	0.28	0.48	0.34 - 0.48	0.15 - 0.21	0.950	0.648
Tc-99 (S)	66.2	10.3	122.1	23.8 - 73.6	-	0.157	0.164
Pu-239,240 (M)	0.057	0.043	0.071	0.058 - 0.083	0.16 - 0.23	0.041	0.114

For seawater in this region, data is available for tritium, Cs-137 and Tc-99. Statistical analyses reveal that there is no evidence of any change in Cs-137 concentrations in the assessment period compared to the baseline period. No statistical analyses could be performed for tritium, as annual mean concentrations were derived partly from data below detection limits. No monitoring data for Tc-99 was available for the assessment period.

For biota in this region, data is available for Cs-137 in fish, Tc-99 in seaweed and Pu-239,240 in molluscs. Statistical analyses reveal that while there is evidence of an increase in Pu-239,240 concentrations in molluscs (Student's t-test only), there is no evidence of any change in Cs-137 concentrations in fish and Tc-99 concentrations in seaweed in the assessment period compared to the baseline period. It is possible that the observed increase in Pu-239,240 concentrations from the baseline to subsequent years is due to long term remobilisation from sediments.

The sum of the doses from all available data (i.e. including data based on less than values) for the assessment radionuclides (tritium, Cs-137 and Tc-99) in seawater for each year of the period 1995 to 2005 ranged from (<)0.006 to 6.3 µSv/y. Where data was available for tritium, Cs-137 and Tc-99 in seawater, the dose from Cs-137 was the dominant contributor (88.0%) followed by the dose from Tc-99 (11.7 to 11.9%). For comparison purposes only and based on the limited data available in the scientific literature, the doses from environmental concentrations of the natural radionuclides Po-210, Ra-226 and Ra-228 in seawater in region 10 (no data available for Pb-210) from a similar time period were 3002 µSv/y, 13.9 µSv/y and 18.1 µSv/y respectively.

6.1.11 Region 11. North Sea (Skagerrak)

Summary of data

	Baseline Value	LBB	UBB	Range (2002 to 2005)		Student's t-test Probability	Mann-Whitney Probability
				Concentration	Dose (µSv/y)		
Seawater							
Tritium (Bq/l)	-	-	-	-	-	-	-
Cs-137 (mBq/l)	14.7	0*	31.2	6.6 - 10.0[a]	0.35 - 0.53	0.241	0.400
Tc-99 (mBq/l)	2.3	0*	6.4	1.2 - 2.3	0.018 - 0.035	0.578	0.730
Pu-239,240 (µBq/l)	-	-	-	-	-	-	-
Biota (Type) : All Bq/kg (w.w.)							
Cs-137 (S)	-	-	-	2.8 - 6.0	-	-	-
Tc-99 (S)	-	-	-	89 - 132	-	-	-
Pu-239,240	-	-	-	-	-	-	-

a – Data from only 2003 to 2005.

Water from the Channel and the North Sea flow into the Skagerrak area along the Danish coast, and further into the Kattegat. The Norwegian coast is affected by the outflow of low salinity water from the Baltic Sea. The degree of outflow can vary depending on weather conditions and in some years the bottom water of the Baltic Sea can be replaced by saline waters from the North Sea, resulting in a larger outflow of Baltic seawater into the Norwegian Coastal Current. The Baltic seawater is contaminated with Chernobyl fallout, giving relatively high concentrations of Cs-137, especially following episodes of major water exchange. Such episodes occurred in 1993, 1997 and 2003. Information on salinity is important for the interpretation of the observed radionuclide concentrations. The concentrations of radionuclides may therefore vary considerably both geographically and over relatively short time intervals in this area.

For seawater in this region, data is available for Cs-137 and Tc-99. Statistical analyses reveal that there is no evidence of any change in Cs-137 and Tc-99 concentrations in the assessment period compared to the baseline period. The potential for variations in the concentrations of radionuclides in this region is reflected in the very large standard deviation of the baselines for both Cs-137 and Tc-99 in seawater.

For biota in this region, data is available for Cs-137 and Tc-99 in seaweed. However, no baseline values have been established for either radionuclide, so no assessment can be made.

The sum of the doses from all available data for the assessment radionuclides (Cs-137 and Tc-99) in seawater for each year of the period 1995 to 2005 ranged from 0.37 to 1.34 µSv/y. Where data was available for Cs-137 and Tc-99 in seawater, the dose from Cs-137 was the dominant contributor (93.8 to 97.2%). For comparison purposes only and based on the limited data available in the scientific literature, the dose from environmental concentrations of the natural radionuclide Ra-226 in seawater in region 11 (no data available for Pb-210, Po-210 and Ra-228) from a similar time period was 17.2 µSv/y.

6.1.12 Region 12. Kattegat

Summary of data

	Baseline Value	**LBB**	**UBB**	**Range (2002 to 2005)**		**Student's t-test Probability**	**Mann-Whitney Probability**
				Concentration	**Dose (µSv/y)**		
Seawater							
Tritium (Bq/l)	-	-	-	< ***2.3*** - < *3.1*	-	-	-
Cs-137 (mBq/l)	30.3	9.6	51.0	45 - < ***60***	2.39 - < ***3.20***	0.004	0.017
Tc-99 (mBq/l)	1.3	0.4	2.2	0.5 - 0.6	0.008 - 0.009	0.045	0.029
Pu-239,240 (µBq/l)	-	-	-	-	-	-	-
Biota (Type) : All Bq/kg (w.w.)							
Cs-137 (S)	1.7	1.2	2.3	1.2 - 1.3	-	0.005	0.006
Cs-137 (F)	3.0	2.1	3.8	5.4 - 7.1	2.39 - 3.14	0.002	0.006
Tc-99 (S)	18.8	0*	39.0	23.1 - 24.7[a]	-	0.252	0.383

a – Data from only 2002 to 2004. Note, no baseline value reported for Pu-239,240 in biota. Cs-137 baseline values reported for both seaweed and fish.

In the Kattegat area, low salinity Baltic water is mixed with inflowing currents from the North Sea. For seawater in this region, data is available for tritium, Cs-137 and Tc-99. Statistical analyses reveal that there is evidence of an increase in Cs-137 concentrations and a decrease in Tc-99 concentrations in the assessment period compared to the baseline period. In the case of Cs-137, it must be noted that monitoring data from the assessment period contained data based on samples collected close to Ringhals NPP, which was not the case for the baseline period. No baseline value for tritium has been established, so no assessment can be made. Tritium monitoring data from the assessment period is mostly below detection limits.

For biota in this region, data is available for Cs-137 in fish and seaweed and Tc-99 in seaweed. Statistical analyses reveal that while there is evidence of an increase in Cs-137 concentrations in fish and a decrease in Cs-137 concentrations in seaweed, there is no evidence of any change in Tc-99 concentrations in seaweed in the assessment period compared to the baseline period. As for seawater, it must be noted that monitoring data for Cs-137 in fish from the assessment period contained data based on samples collected close to Ringhals NPP, which was not the case for the baseline period. That there was evidence of a decrease in annual mean concentrations Cs-137 in seaweed based on data that was not derived from samples taken close to Ringhals NPP, would suggest that the observed increases in Cs-137 concentrations in seawater and in fish should be treated with some care.

The sum of the doses from all available data (i.e. including data based on less than values) for the assessment radionuclides (tritium, Cs-137 and Tc-99) in seawater for each year of the period 1995 to 2005 ranged from 0.72 to (<)3.21 µSv/y. Where data was available for tritium, Cs-137 and Tc-99 in seawater, the dose from Cs-137 was the dominant contributor (99.5 to 99.7%). No data was available for environmental concentrations of Pb-210, Po-210, Ra-226 and Ra-228 in seawater for region 12 from a similar time period for comparison purposes.

6.1.13 Region 13. Norwegian Coastal Current

Summary of data

	Baseline Value	LBB	UBB	Range (2002 to 2005)		Student's t-test Probability	Mann-Whitney Probability
				Concentration	Dose (µSv/y)		
Seawater							
Tritium (Bq/l)	-	-	-	-	-	-	-
Cs-137 (mBq/l)	4.4	3.6	5.2	2.1 - 4.5	0.11 - 0.24	0.102	0.267
Tc-99 (mBq/l)	1.1	0.3	1.9	0.8 - 1.0	0.012 - 0.015	0.187	0.190
Pu-239,240 (µBq/l)	-	-	-	-	-	-	-
Biota (Type) : All Bq/kg (w.w.)							
Cs-137 (S)	0.12	0.04	0.20	0.14 - 0.16	-	0.188	0.190
Tc-99 (S)	43.7	1.8	85.6	51.0 - 61.6	-	0.333	0.730
Pu-239,240	-	-	-	-	-	-	-

In this region, the water flows from south to north along the Norwegian coastline. The water in this region is influenced by the Atlantic Current, outflow of low salinity waters from the Baltic Sea and inflow from the North Sea into the coastal current via the Skagerrak. Radionuclides in Atlantic water are mainly due to nuclear weapons fallout. The outflow from the Baltic Sea is contaminated by Chernobyl fallout, while discharges from nuclear reprocessing activities are transported with ocean currents via the North Sea and into the Norwegian Coastal Current. Cs-137 concentrations are generally higher near the coast where the salinity is lower. For seawater in this region, data is available for Cs-137 and Tc-99. Statistical analyses reveal that there is no evidence of any changes in Cs-137 and Tc-99 concentrations in the assessment period compared to the baseline period.

For biota in this region, data is available for Cs-137 and Tc-99 in seaweed. Statistical analyses reveal that there is no evidence of any changes in Cs-137 and Tc-99 concentrations in seaweed in the assessment period compared to the baseline period.

The sum of the doses from all available data for the assessment radionuclides (Cs-137 and Tc-99) in seawater for each year of the period 1995 to 2005 ranged from 0.009 to 0.27 µSv/y. Where data was available for Cs-137 and Tc-99 in seawater, the dose from Cs-137 was the dominant contributor (90.2 to 92.6%). For comparison purposes only and based on the limited data available in the scientific literature, the dose from environmental concentrations of the natural radionuclide Ra-226 in seawater in region 13 (no data available for Pb-210, Po-210 and Ra-228) from a similar time period was 11.2 µSv/y.

6.1.14 Region 14. Barents Sea

Summary of data

	Baseline Value	LBB	UBB	Range (2002 to 2005)		Student's t-test Probability	Mann-Whitney Probability
				Concentration	Dose (µSv/y)		
Seawater							
Tritium (Bq/l)	-	-	-	-	-	-	-
Cs-137 (mBq/l)	3.5	2.7	4.3	-	-	-	-
Tc-99 (mBq/l)	0.7	0*	1.5	0.05 - 0.19	0.001 - 0.003	0.219	0.400
Pu-239,240 (µBq/l)	-	-	-	-	-	-	-
Biota (Type) : All Bq/kg (w.w.)							
Cs-137 (F)	0.28	0.21	0.37	0.17 - 0.28	0.08 - 0.12	0.121	0.114
Tc-99 (S)	-	-	-	31.0 - 47.5	-	-	-
Pu-239,240	-	-	-	-	-	-	-

Water from the Norwegian Coastal Current flows into the Barents Sea and further into the Arctic Ocean. Along the coast of Northern Norway, radionuclide concentrations are influenced by Chernobyl fallout and discharges from Sellafield. In the central Barents Sea, Atlantic water moves towards the east, and meets arctic waters from the north.

For seawater in this region, data is available for Cs-137 and Tc-99. Statistical analyses reveal that there is no evidence of any changes in Tc-99 concentrations in the assessment period compared to the baseline period. No monitoring data for Cs-137 was available for the assessment period.

For biota in this region, data is available for Cs-137 in fish and Tc-99 in seaweed. Statistical analyses reveal that there is no evidence of any changes in Cs-137 concentrations in fish in the assessment period compared to the baseline period. No baseline value for Tc-99 in seaweed has been established, so no assessment can be made.

The sum of the doses from all available data for the assessment radionuclides (Cs-137 and Tc-99) in seawater for each year of the period 1995 to 2005 ranged from 0.001 to 0.20 µSv/y. Where data was available for Cs-137 and Tc-99 in seawater, the dose from Cs-137 was the dominant contributor (94.5%). For comparison purposes only and based on the limited data available in the scientific literature, the dose from environmental concentrations of the natural radionuclide Ra-226 in seawater in region 14 (no data available for Pb-210, Po-210 and Ra-228) from a similar time period was 13.1 µSv/y.

6.1.15 Region 15. Norwegian Sea, Greenland Sea and Icelandic Waters

Summary of data

	Baseline Value	LBB	UBB	Range (2002 to 2005)		Student's t-test Probability	Mann-Whitney Probability
				Concentration	Dose (µSv/y)		
Seawater							
Tritium (Bq/l)	-	-	-	-	-	-	-
Cs-137 (mBq/l)	4.6	2.8	6.4	2.4 - 4.0	0.13 - 0.21	-	-
Tc-99 (mBq/l)	-	-	-	0.12 - 0.14	0.002 - 0.002	-	-
Pu-239,240 (µBq/l)	-	-	-	-	-	-	-
Biota (Type) : All Bq/kg (w.w.)							
Cs-137 (S)	0.05	0.01	0.09	0.11 - < *0.20*[a]	-	-	-
Cs-137 (F)	0.03	0.01	0.05	-	-	-	-
Tc-99 (S)	-	-	-	2 - 10[a]	-	-	-

Note, no baseline value or data reported for Pu-239,240 in biota. Baseline value and data for Cs-137 reported for both seaweed and fish. a – Data from only 2002 and 2003.

Seawater from the Arctic flows in from the north, and warmer Atlantic water enters this area via the West-Spitsbergen Current. Cs-137, Tc-99 and Pu-239,240 in the seawater originate mainly from nuclear weapons fallout, but also from Chernobyl fallout and nuclear reprocessing.

For seawater in this region, data is available for Cs-137 and Tc-99. Annual mean concentrations of Cs-137 for the period 2002 to 2005 were below the baseline value, indicating a decline in Cs-137 concentrations. However, no statistical analyses could be performed to validate the significance of this observation. No baseline value has been established for Tc-99 so no assessment can be made. Tc-99 concentrations in the assessment period were practically constant.

For biota in this region, data is available for Cs-137 in seaweed and fish and for Tc-99 in seaweed. Annual mean concentrations of Cs-137 in seaweed were higher than the upper baseline bracket value in 2003, but the general level was low. No statistical analyses could be performed to validate the significance of this observation. No monitoring data for Cs-137 in fish was available for the assessment period. No baseline value has been established for Tc-99 in seaweed so no assessment can be made.

The sum of the doses from all available data for the assessment radionuclides (Cs-137 and Tc-99) in seawater for each year of the period 2002 to 2005 ranged from 0.13 to 0.21 µSv/y. Where data was available for Cs-137 and Tc-99 in seawater, the dose from Cs-137 was the dominant contributor (98.5 to 99.1%). No data was available for environmental concentrations of Pb-210, Po-210, Ra-226 and Ra-228 in seawater for region 15 from a similar time period for comparison purposes.

6.2 Overall conclusions

6.2.1 Tritium

Monitoring data for tritium in seawater in the assessment period was available for 9 of the 15 regions. Of these 9 regions, the highest reported annual mean seawater concentrations during the assessment period were from region 2 (Channel (Cap de la Hague). In terms of changes in annual mean concentrations of tritium in seawater in the assessment period in comparison with the baseline period, there was evidence of an increase in region 9 (German Bight). Statistical analyses revealed no evidence that any change had occurred in tritium concentrations in seawater in region 8 (North Sea South (Belgian and Dutch Coast). Of the other 7 regions, annual mean concentrations for tritium in seawater in regions 2, 3, 6, 7 and 10 were derived from monitoring data either all or partly below detection limits which precluded statistical analyses. In some cases, there were large differences in the magnitude of the detection limits between the data sets submitted by different Contracting Parties. This might be explained by differences in metrology capacity or in the derivation of detection limits. No baseline value has been established for tritium in seawater in regions 1 (Wider Atlantic Iberian Coast Biscay and Channel West) and 12 (Kattegat).

Doses from tritium in seawater were low and typically two orders of magnitude less than the main contributor to dose during the assessment period.

6.2.2 Cs-137

Monitoring data for Cs-137 in seawater in the assessment period was available for 14 of the 15 regions. Of these 14 regions, the highest reported annual mean seawater concentrations during the assessment period were from region 6 (Irish Sea (Sellafield)). In terms of changes in annual mean concentrations of Cs-137 in seawater in the assessment period in comparison with the baseline period, statistical analyses revealed evidence of decreases in regions 4 (Irish Sea (Rep. of Ireland)), 5 (Irish Sea (Northern Ireland)), 6 (Irish Sea (Sellafield)) and 9 (German Bight) and an increase in region 12 (Kattegat). Statistical analyses revealed no evidence that any changes had occurred in Cs-137 concentrations in seawater in regions 10, 11, 13 and 14. Of the other 5 regions, annual mean concentrations for Cs-137 in seawater in regions 1, 2, 3 and 7 were derived from monitoring data either all or partly below detection limits which precluded statistical analyses. In some cases, there were large differences in the magnitude of the detection limits associated with different data sets from different Contracting Parties. This might be explained by differences in metrology capacity or in the derivation of detection limits. In region 15, annual mean concentrations for the assessment period were lower than the baseline value, but comparisons with baseline bracket and statistical analyses could not be performed due to the lack of annual mean concentrations for the baseline period.

Doses from Cs-137 were the major contributor to the total dose from seawater in all 15 regions.

Monitoring data for Cs-137 in biota in the assessment period was available for all 15 regions, with data reported for seaweed in 8 regions, for fish in 7 regions and for molluscs in 1 region (Cs-137 monitoring data was reported for both seaweed and fish for region 1 (Wider Atlantic Iberian Coast Biscay and Channel West) and 12 (Kattegat) during the assessment period). In terms of changes in annual mean concentrations of Cs-137 in biota in the assessment period in comparison with the baseline period, there was evidence of decreases in regions 4 (seaweed), 5 (fish), 6 (molluscs), 7 (seaweed), 9 (fish) and 12 (seaweed) and an increase (in fish) in region 12 (Kattegat). Statistical analyses revealed no evidence that any changes had occurred in Cs-137 concentrations in biota in regions 10 (fish), 13 (seaweed) and 14 (fish). Of the other 6 regions, annual mean concentrations for Cs-137 in regions 1, 2, 3 (all seaweed), 8 (fish) and 15 (seaweed) were derived from monitoring data either all or partly below detection limits which precluded statistical analyses. In some cases, there were large differences in the magnitude of the detection limits associated with different data sets from different Contracting Parties. This might be explained by differences in metrology capacity or in the derivation of detection limits. No baseline value has been established for Cs-137 in biota for region 11 (North Sea (Skagerrak)).

From the data available for the assessment period, doses from Cs-137 concentrations in biota (fish and molluscs) were generally the major contributor to total dose from biota, with doses from fish from region 12 (Kattegat) the highest reported for Cs-137 in biota.

A number of OSPAR regions are still experiencing elevated Cs-137 concentrations due to outflowing Baltic water that has been contaminated with fallout from the Chernobyl Accident. Due to the temporal variability in Cs-137 seawater concentrations in these affected regions, data generated from monitoring Cs-137 concentrations in fish may provide more useful information for trend monitoring of this radionuclide in these regions. In addition, remobilization of Cs-137 from Irish Sea sediments resulting from Sellafield discharges in the past may continue to contribute to elevated seawater concentrations over the long-term, however this requires further study.

6.2.3 Tc-99

Monitoring data for Tc-99 in seawater in the assessment period was available for 8 of the 15 regions. Of these 8 regions, the highest reported annual mean seawater concentrations during the assessment period were from region 6 (Irish Sea (Sellafield)). In terms of changes in annual mean concentrations of Tc-99 in seawater in the assessment period in comparison with the baseline period, there was evidence of a decrease in region 12 (Kattegat). Statistical analyses revealed no evidence that any changes had occurred in Tc-99 concentrations in seawater in regions 4, 6, 11, 13 and 14. No baseline value has been established for Tc-99 in seawater in region 1 (Wider Atlantic Iberian Coast Biscay and Channel West) and 15 (Norwegian Sea, Greenland Sea and Icelandic Waters).

Doses from Tc-99 in seawater in the assessment period varied by up to 3 orders of magnitude but were typically lower than those derived from annual mean concentrations of Cs-137 in seawater.

Monitoring data for Tc-99 in biota (seaweed only) in the assessment period was available for 13 of the 15 regions. Of these 13 regions, the highest reported annual mean seawater concentrations during the assessment period were from region 6 (Irish Sea (Sellafield)). In terms of changes in annual mean concentrations of Tc-99 in seaweed in the assessment period in comparison with the baseline period, there was evidence of decreases in regions 2 (Channel (Cap de la Hague)), 3 (Channel east), 5 (Irish Sea (Northern Ireland)), 6 (Irish Sea (Sellafield)) and 7 (Scottish Waters (Dounreay)). Statistical analyses revealed no evidence that any changes had occurred in Tc-99 concentrations in seaweed in regions 4, 10, 12 and 13. No baseline value has been established for regions 1, 11, 14 and 15.

Although discharges of Tc-99 to the OSPAR marine environment have decreased in recent years it is worth noting that no apparent decrease in environmental concentrations has occurred during the assessment period. In the long-term, remobilization of Tc-99 from Irish Sea sediments resulting from Sellafield discharges in the past may continue to contribute to elevated seawater concentrations, however this requires further study.

6.2.4 Pu-239,240

Monitoring data for Pu-239,240 in seawater in the assessment period was available for regions 8 (North Sea South (Belgian and Dutch Coast)) and 9 (German Bight). Statistical analyses revealed no evidence that any change had occurred in Pu-239,240 seawater concentrations in region 9. Statistical analyses could not be performed on data from region 8, as monitoring data was only reported for one year of the assessment period.

Doses from Pu-239,240 in seawater from region 9 were only slightly lower than those from Cs-137 in seawater where annual mean concentrations were available for both radionuclides in the same region.

Monitoring data for Pu-239,240 in biota in the assessment period was available for 8 of the 15 regions, with data reported for molluscs in 7 regions and for fish in 2 regions (Pu-239,240 monitoring data was reported for both molluscs and fish for region 8 (North Sea South (Belgian and Dutch Coast)) during the assessment period). In terms of changes in annual mean concentrations of Pu-239,240 in biota in the assessment period in comparison with the baseline period, there was evidence of decreases in molluscs in regions 2 (Channel (Cap de la Hague)), 4 (Irish Sea (Rep. of Ireland)) and 6 (Irish Sea (Sellafield)) and an increase in molluscs in region 10 (North Sea (Northwest, Southeast and Central)). Statistical analyses revealed no evidence that any changes had occurred in Pu-239,240 concentrations in molluscs in regions 5 and 7. Annual mean concentrations for Pu-239,240 in fish in regions 8 and 9 were derived from monitoring data either all or partly below detection limits which precluded statistical analyses.

Doses from Pu-239,240 in molluscs were greater than those for Pu-239,240 in fish and were similar or higher than doses from Cs-137 in fish or molluscs where annual mean concentrations were available for both radionuclides in the same region. For region 6 (Irish Sea (Sellafield)), doses from Pu-239,240 in molluscs were up to 50 fold higher than those from Cs-137 in molluscs for the same year of the assessment period.

It is important to consider that where there are differences between baseline values and annual mean concentrations in assessment period, these differences may be due to environmental scatter from remobilisation of Pu-239,240 from sediments resulting from discharges in the past.

6.2.5 General conclusions

6.2.5.1 Background on application of the baseline

1. The overall objective of the OSPAR Radioactive Substances Strategy includes consideration of: legitimate uses of the sea, technical feasibility, and radiological impacts on man and biota

2. However, OSPAR has ***not*** collectively agreed that the aim of reduction of discharges, emissions and losses of radionuclides applies without qualification to all radionuclides: the three factors that are to be taken into account allow some qualification, particularly for those radionuclides that are not radiologically significant and the production of which varies according to the levels of activity of installations;

3. The 2003 Progress Report on the More Detailed Implementation of the OSPAR Strategy with regard to Radioactive Substances sets out the principles on which the baseline for the evaluation of concentrations of radioactive substances has been derived.

4. In 2003 Ministers ***agreed*** that consideration of a small range of issues should be referred for future consensus agreement. These issues included:

   a. an appropriate method for applying the baseline to the radionuclides iodine-129, carbon-14 and tritium (the “three isotopes”);

   b. taking account of variability in the level of operation of installations.

5. To date, OSPAR has ***not*** reached a consensus on the way in which the baseline is to be applied to the three isotopes; there is therefore no consensus on how progress in implementing the Strategy should be evaluated in respect of them.

6. Since the start of reporting on discharges of radioactive substances, there has been consensus that tritium is sufficiently significant, in terms of becquerels discharged to merit annual reporting of tritium discharges from nuclear installations.

7. The baseline element for discharges of radioactive substances currently includes total α, total β and tritium However, because of the lack of consensus referred to above, the First Periodic Evaluation of Progress towards the Objective of the OSPAR Radioactive Substances Strategy did not include any evaluation of tritium against this baseline element.

6.2.5.2 Considerations with regard to tritium

8. The assessment of tritium concentrations has been considered carefully by RSC. On the one hand:

- tritium is one of the radionuclides included in the OSPAR monitoring agreement on concentrations of radioactive substances;
- RSC has been tasked with agreeing an appropriate method for applying the baseline to tritium (as well as iodine-129 and carbon-14); and
- For reasons of transparency, there is a good argument for including tritium data in the Second Periodic Evaluation and for RSC continuing to work towards consensus on a basis for evaluating tritium concentrations.

9. On the other hand, it can be argued that:

- in the opinion of France and some other Contracting Parties there is no clear need to deal with the evaluation of tritium concentrations in the context of the Second Periodic Evaluation;
- the impact of tritium is low and the sum of the doses from all available data shows that the relative contribution of tritium to dose is minor (although Contracting Parties accepted that the situation

should be reappraised if there is scientific evidence that the dose coefficient and concentration factors used should be re-assessed);

- in the opinion of France and some other Contracting Parties, tritium discharges are linked to productivity of nuclear installations and there is no feasible method of removing tritium from tritiated water on an industrial scale; Ireland took a different view – the positions of Ireland and France are recorded at Annex 5;
- the concentrations of tritium in a particular region (and the consequent doses) cannot be directly related to discharges of tritium into that region.

10. RSC agreed to continue to build on the constructive level of consensus so far achieved on the evaluation of tritium, with the aim of reaching agreement by 2010. This consideration might take account of further available data, in particular on discharges from the non-nuclear sectors and the associated concentrations and doses, to allow a risk-based approach to be developed.

6.2.5.3 General conclusion of the Second Periodic Evaluation

11. With regard to the Second Periodic Evaluation, the general conclusion is that:

a. There is sufficient data available for the development of baseline elements for certain aspects of concentrations of radioactive substances, both in seawater and in biota (fish, shellfish, and seaweed), although baseline values could not be derived for all regions, radionuclides and compartments.

b. In total, 32 seawater and 36 biota baseline values have been established for the assessment of concentrations of radionuclides. Statistical analyses could only be performed to compare annual mean concentrations from the assessment period with those from the baseline period in 17 cases for seawater and in 25 cases for biota. For seawater, there was evidence in 5 cases of decreases in concentrations, 2 cases of increases in concentrations and 10 cases where no change in concentration could be determined. For biota, there was evidence in 14 cases of decreases in concentrations, 2 cases of increases in concentrations and 9 cases where no change in concentration could be determined. It was not possible to make any firm conclusions on the remaining 15 cases for seawater and 11 cases for biota due to either a lack of data or as a result of baseline and/or assessment values being derived from data below detection limits. In addition, data was reported for the assessment period in 3 cases for seawater and 7 cases for biota, where no reciprocal baseline value had been established.

c. From the data available for the assessment period, maximum doses occurring from concentrations of Cs-137, Tc-99 and Pu-239,240 in seawater were of the order of 1 µSv/yr, while the maximum dose occurring from tritium in seawater was of the order of 0.01 µSv/yr. In comparison and from the limited data available in the scientific literature, doses occurring from Ra-226, Ra-228 and Pb-210 in seawater in the OSPAR region are typically of the order 10 µSv/y with doses from Po-210 of the order of 1000 µSv/yr. Doses occurring directly from biota were only available for Cs-137 and Pu-239,240 for the assessment period, with maximum doses of the order of 1 µSv/yr and 10 µSv/yr respectively.

d. Some OSPAR regions are still experiencing elevated concentrations due to outflowing Baltic water that has been contaminated with fallout from the Chernobyl Accident or due to remobilisation of radionuclides from Irish Sea sediments as a result of past discharges.

e. On the basis of this evaluation, it is not clear whether the aims of the OSPAR Radioactive Substances Strategy are being delivered.

ANNEX 1 - Regions identified for the establishment of baselines on concentrations of radioactive substances

Table A1:

Region	Related MARINA II area
1. Wider Atlantic, Iberian Coast and Biscay and Channel West	8-10: (Atlantic North SE) 38-44: (Celtic Sea, Bristol Channel, Bay of Biscay, French Continental shelf, Cantabrian Sea, Portuguese Continental shelf, Gulf of Cadiz) 46: English Channel West; part of 47:, Channel Islands
2. Channel (Cap de la Hague)	48: Cap de la Hague; 49: Lyme Bay
3. Channel East	50-54: Baie de la Seine, Sam's Beach, Central Channel SE, Central Channel N.E., Isle of Wight, part of 47
4. Irish Sea (Rep. of Ireland)	33: Irish Sea West; 36 Irish Sea South
5. Irish Sea (Northern Ireland)	30: Irish Sea NW
6. Irish Sea (Sellafield)	31, 32, 33, 35, 37: Irish Sea N, Irish Sea NE, Irish Sea SE, Cumbrian Waters, Liverpool and Morecambe Bays
7. Scottish waters (Dounreay)	28-29: Scottish Waters West and East
8. North Sea South (Belgian and Dutch Coast)	56: North Sea SE
9. German Bight	58: North Sea East
10. North Sea (Northwest, Southeast and Central)	55, 57, 59: North Sea SW, North Sea Central, North Sea North
11. North Sea (Skagerrak)	60: Skagerrak
12. Kattegat	61/62: Kattegat
13. Norwegian Coastal Current	27: Norwegian Waters
14. Barents Sea	23-26: Barents Sea
15. Norwegian, Greenland Seas and Icelandic Waters	2-4: Atlantic North NE 16-19: Arctic Ocean and Spitsbergen

ANNEX 2 - Summary contributions from each Contracting Party for the assessment period (2002 to 2005)

Key to all tables:

- n - number of observations; SD - standard deviation.
- Type: S - Seaweed (Fucus spp.); F - Fish; M - Molluscs.
- Greyed box: Sampling not specified under the Agreement on a Monitoring Programme for Concentrations of Radioactive Substances in the Marine Environment.
- Empty box: no data available.
- Value in italic denotes that all measurements on which the value has been based were below the detection limit.
- Value in bold italic denotes that some/most measurements on which the value has been based were below the detection limit.
- Dash: Standard deviation not calculated because either n=1 or value has been based on all or some/most measurements below the detection limit.

Belgium

Region 8. North Sea South (Belgian and Dutch Coast)

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (µBq/l)		
Year	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
2002				20	*< 102*	-						
2003				15	*< 107*	-						
2004				20	*< 104*	-						
2005				15	*< 117*	-				15	***< 373***	-

	Biota											
	Cs-137 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	Type	n	Mean	SD	Type	n	Mean	SD	Type	n	Mean	SD
2002	F	25	***< 0.15***	-	M	6	***< 0.191***	-				
2003	F	25	***< 0.15***	-	M	4	*< 0.250*	-				
2004	F	25	***< 0.13***	-	M	3	*< 0.217*	-				
2005	F	24	***< 0.22***	-	M	4	*< 0.125*	-	F	24	***< 0.027***	-

Denmark

Region 12. Kattegat

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (µBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
2002				10	41.7	5.4	4	0.5	0.3			
2003				10	38.2	5.1	4	0.6	0.2			
2004				10	26.3	4.7	4	0.5	0.1			
2005				10	31.1	4.9	3	0.5	0.2			

	Biota											
	Cs-137 (Bq/kg w.w.)				Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)			
Year	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**
2002	S	4	1.3	0.8	F	3	3.3	4.6	S	4	23.1	7.1
2003	S	4	1.3	0.3	F	3	2.4	3.4	S	4	24.7	9.6
2004	S	4	1.2	0.3	F	3	2.2	2.8	S	4	23.4	7.2
2005	S	4	1.2	0.4	F	3	2.8	2.3	S			

Region 15. Norwegian Sea, Greenland Sea and Icelandic Waters

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (µBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
2002				3	4.0	1.6	1	0.03	-			
2003				3	3.5	1.4						
2004				3	3.4	1.4						
2005				3	2.4	1.2						

France

Region 1. Wider Atlantic, Iberian Coast and Biscay and Channel West

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (µBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
2002	10	***< 9.7***	-	10	*< 30.7*	-						
2003	10	*< 9.4*	-	10	*< 26.1*	-						
2004	10	*< 9.0*	-	10	*< 25.5*	-						
2005	10	*< 9.1*	-	10	*< 28.3*	-						

	Biota											
	Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**
2002	S	12	***< 0.06***	-								
2003	S	12	0.06	0.02								
2004	S	7	0.06	0.02								
2005	S	8	***< 0.06***	-								

Region 2. Channel (Cap de la Hague)

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (µBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
2002	29	***< 14.6***	-	29	*< 30.4*	-						
2003	29	***< 11.8***	-	29	*< 25.5*	-						
2004	27	***< 14.6***	-	27	*< 24.8*	-						
2005	28	***< 11.5***	-	28	*< 25.4*	-						

	Biota											
	Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**
2002	S	32	***< 0.15***	-	S	4	6.8	1.6	M	16	0.010	0.003
2003	S	29	***< 0.14***	-	S	2	10.2	0.2	M	14	0.011	0.007
2004	S	28	***< 0.12***	-	S	2	6.5	3.9	M	16	0.013	0.009
2005	S	28	***< 0.12***	-	S	1	5.2	-	M	16	0.013	0.007

Region 3. Channel east

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (µBq/l)		
Year	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
2002	4	*< 10.2*	-	4	*< 31.3*	-						
2003	4	*< 9.8*	-	4	*< 24.0*	-						
2004	4	*< 9.0*	-	4	*< 26.3*	-						
2005	4	*< 9.1*	-	4	*< 25.5*	-						

	Biota											
	Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	Type	n	Mean	SD	Type	n	Mean	SD	Type	n	Mean	SD
2002	S	8	0.06	0.01	S	5	5.3	0.7				
2003	S	8	0.07	0.02	S	2	5.7	0.7				
2004	S	8	0.08	0.03	S	4	5.3	0.6				
2005	S	8	0.08	0.02	S	2	4.9	1.0				

Germany

Region 9. German Bight

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (μBq/l)		
Year	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
2002				19	3.2	0.7				8	6.0	2.6
2003				24	3.2	0.7				7	7.5	1.5
2004				22	2.9	0.6				10	12.6	3.7
2005				24	2.6	0.4						

	Biota											
	Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	Type	n	Mean	SD	Type	n	Mean	SD	Type	n	Mean	SD
2002	F	2	0.29	0.01					F	1	*< 0.000046*	-
2003	F	2	0.33	0.17								
2004	F	1	0.12	-					F	1	*< 0.000032*	-
2005	F	4	0.18	0.09								

Region 10. North Sea (Northwest, Southeast and Central)

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (μBq/l)		
Year	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
2002				1	5.7	-						
2003				1	4.2	-						
2004				7	4.3	1.0				6	11.8	3.8
2005				6	4.2	0.9						

	Biota											
	Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	Type	n	Mean	SD	Type	n	Mean	SD	Type	n	Mean	SD
2002	F	4	0.37	0.09					F	2	0.000042	0.000020
2003	F	10	0.31	0.13					F	2	0.000041	0.000001
2004	F	10	0.30	0.21					F	2	***< 0.000052***	-
2005	F	5	0.21	0.10								

Data for Pu-239,240 in fish is not used in Chapter 4 as baseline value for Pu-239,240 in biota for region 10 has been derived from molluscs.

Ireland

Region 1. Wider Atlantic Iberian Coast Biscay and Channel West

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (μBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
2002				3	2.7	0.6	2	*< 0.1*	-			
2003				3	***< 0.9***	-	2	*< 0.1*	-			
2004				3	3.0	1.0						
2005												

	Biota											
	Cs-137 (Bq/kg w.w.)				Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)			
Year	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**
2002	F	3	0.23	0.06	S	3	***< 0.056***	-	S	2	2.16	0.76
2003	F	3	0.33	0.12	S	3	***< 0.068***	-	S	3	1.56	0.27
2004	F	3	0.27	0.06	S	3	0.065	0.021				
2005												

Region 4. Irish Sea (Rep. of Ireland)

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (μBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
2002				29	16.0	5.6	18	20.5	7.6			
2003				24	11.6	4.2	16	18.3	10.0			
2004				28	16.3	4.5	7	17.3	7.4			
2005				24	19.4	10.0	7	12.1	4.9			

	Biota											
	Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**
2002	S	18	0.64	0.31	S	11	373	227	M	3	0.050	0.013
2003	S	19	0.64	0.28	S	10	605	436	M	1	0.028	-
2004	S	19	0.65	0.29	S	4	376	187	M	1	0.034	-
2005	S	18	0.67	0.26	S	4	379	156	M	1	0.033	-

Netherlands

Region 8. North Sea South

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (µBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
2002	36	4.2	2.2									
2003	36	4.2	1.0									
2004	36	5.4	1.3									
2005	36	5.5	1.5									

Region 9. German Bight

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (µBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
2002	4	2.8	1.1									
2003	4	4.1	0.8									
2004	4	5.1	1.1									
2005	4	4.3	1.1									

Region 10. North Sea (Northwest, Southeast and Central)

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (µBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
2002	3	***< 0.9***	-									
2003	4	***< 0.4***	-									
2004	4	***< 0.3***	-									
2005	4	***< 0.6***	-									

Norway

Region 11. North Sea (Skagerrak)

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (μBq/l)		
Year	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
2002							2	1.7	0.6			
2003				1	6.6	-	2	1.5	0.4			
2004				2	10.0	2.0	2	2.3	1.8			
2005				2	8.6	0.6	2	1.2	0.4			

	Biota											
	Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	Type	n	Mean	SD	Type	n	Mean	SD	Type	n	Mean	SD
2002	S	1	6.00	-	S	1	89	-				
2003	S	1	2.76	-	S	1	126	-				
2004	S	1	3.75	-	S	1	119	-				
2005	S	1	3.74	-	S	1	132	-				

Region 13. Norwegian Coastal Current

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (μBq/l)		
Year	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
2002				2	4.5	1.8	12	1.0	0.2			
2003				4	3.1	0.6	12	0.8	0.1			
2004				3	2.1	0.7	12	0.8	0.1			
2005				2	3.0	0.2	12	0.9	0.1			

	Biota											
	Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	Type	n	Mean	SD	Type	n	Mean	SD	Type	n	Mean	SD
2002	S	16	0.16	0.09	S	16	61.6	20.6				
2003	S	15	0.15	0.14	S	15	51.8	14.2				
2004	S	14	0.14	0.14	S	16	51.0	13.9				
2005	S	15	0.15	0.15	S	16	52.5	14.0				

Region 14. Barents Sea

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (μBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
2002							1	0.18	-			
2003							1	0.05	-			
2004							1	0.19	-			
2005							1	0.19	-			

	Biota											
	Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**
2002	F	8	0.17	0.08	S	2	47.5	17.7				
2003	F	21	0.23	0.08	S	2	34.0	7.1				
2004	F	16	0.28	0.05	S	2	31.0	9.9				
2005	F	7	0.27	0.04	S	2	34.5	9.2				

Region 15. Norwegian Sea, Greenland Sea and Icelandic Waters

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (μBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
2002							3	0.16	0.06			
2003							3	0.14	0.06			
2004							3	0.14	0.05			
2005							3	0.12	0.06			

	Biota											
	Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**
2002	S	1	*< 0.20*	-	S	1	2	-				
2003	S	1	0.11	-	S	1	10	-				
2004												
2005												

Spain

Region 1. Wider Atlantic Iberian Coast Biscay and Channel West

	Seawater											
	Tritium (Bq/l)			**Cs-137 (mBq/l)**			**Tc-99 (mBq/l)**			**Pu-239,240 (µBq/l)**		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
2002	27	0.16	0.03	4	2.3	0.1						
				27	< ***69.9***	-						
2003	28	0.14	0.03	4	2.0	0.2						
				28	< ***91.6***	-						
2004	27	0.15	0.05	4	2.1	0.2						
				28	< ***101***	-						
2005	25	0.15	0.06	4	2.5	1.0						
				28	< ***128***	-						

Due to the difference in magnitude between data reported above and below detection limits for Cs-137 in seawater for 2002 to 2005, two sets of annual means are reported for this radionuclide for these years, one set based only on data above detection limits and one set based on all available data (i.e. data above and below detection limits).

Sweden

Region 12. Kattegat

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (µBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
2002	4	*< 3.07*	-	4	***< 106.0***	-						
2003	4	***< 2.33***	-	4	92.5	7.0						
2004	4	***< 2.85***	-	4	91.8	5.7						
2005	4	*< 2.25*	-	4	90.5	8.7						

It should be noted that the reported values for Cs-137 in seawater are derived from a sampling point only 200 metres from the actual release point at the Ringhals NPP.

	Biota											
	Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**
2002	F	6	9.05	1.63								
2003	F	6	8.01	0.28								
2004	F	6	7.39	1.01								
2005	F	6	6.73	2.05								

United Kingdom

Region 2. Channel (Cap de la Hague)

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (μBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
2002	2	*< 1.45*	-	2	2.1	0.2						
2003	2	*< 1.45*	-	2	1.8	0.5						
2004	2	*< 1.45*	-	2	1.6	1.2						
2005	2	*< 1.45*	-	2	2.1	0.6						

	Biota											
	Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**
2002	S	4	*< 0.065*	-	S	2	1.2	0.5	M	1	0.0043	-
2003	S	4	***< 0.068***	-	S	2	1.0	0	M	1	0.0024	-
2004	S	4	*< 0.063*	-	S	2	1.1	0.5	M	1	0.0022	-
2005	S	4	*< 0.064*	-	S	2	0.5	0.2	M	1	0.0026	-

Region 3. Channel East

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (μBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
2002	2	***< 1.51***	-									
2003	2	3.09	1.07									
2004	2	2.93	1.81									
2005	2	46.6	56.4									

	Biota											
	Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**
2002	S	1	*< 0.55*	-	S	1	7.6	-				
2003	S	1	*< 0.95*	-	S	1	5.2	-				
2004	S	1	*< 1.45*	-	S	1	8.5	-				
2005	S	1	*< 1.07*	-	S	1	*2.5*	-				

Region 4. Irish Sea (Rep. of Ireland)

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (μBq/l)		
Year	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
2002												
2003				10	10.9	6.9						
2004												
2005				8	13.3	6.6						

Region 5. Irish Sea (Northern Ireland)

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (μBq/l)		
Year	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
2002				12	18.8	6.1						
2003				14	17.4	2.7						
2004				12	16.8	5.3						
2005				14	17.4	6.1						

	Biota											
	Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	Type	n	Mean	SD	Type	n	Mean	SD	Type	n	Mean	SD
2002	F	5	2.39	0.67	S	4	269	289	M	2	0.131	0.035
2003	F	6	1.44	0.39	S	4	255	268	M	2	0.383	0.357
2004	F	6	1.70	0.38	S	4	304	322	M	2	0.192	0
2005	F	6	1.51	0.74	S	4	173	172	M	2	0.131	0.049

Region 6. Irish Sea (Sellafield)

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (μBq/l)		
Year	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
2002	18	***< 21.7***	-	6	97.2	69.8	4	256	174			
2003	41	***< 12.9***	-	29	73.4	49.7	4	230	136			
2004	16	***< 18.1***	-	6	147.2	73.1	4	104.0	53.8			
2005	40	***< 11.7***	-	28	77.5	47.9	2	73.2	29.6			

	Biota											
	Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	Type	n	Mean	SD	Type	n	Mean	SD	Type	n	Mean	SD
2002	M	20	4.30	5.49	S	10	6525	4997	M	8	9.7	11.8
2003	M	20	3.73	4.02	S	10	6386	4664	M	8	9.4	11.5
2004	M	20	3.80	3.57	S	9	2339	1518	M	8	7.2	6.5
2005	M	20	3.79	4.34	S	10	2279	1948	M	8	10.4	12.9

Region 7. Scottish Waters (Dounreay)

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (µBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
2002	6	*< 1.16*	-	2	4.6	0.4						
				6	***< 68.2***	-						
2003	4	***< 1.08***	-	4	*< 100*	-						
2004	6	*< 1.15*	-	2	3.5	1.3						
				6	***< 67.8***	-						
2005	4	*< 1.00*	-	4	*< 100*	-						

Due to the difference in magnitude between data reported above and below detection limits for Cs-137 in seawater for 2002 and 2004, two sets of annual means are reported for this radionuclide for these years, one set based only on data above detection limits and one set based on all available data (i.e. data above and below detection limits).

	Biota											
	Cs-137 (Bq/kg w.w.)				Tc-99 (Bq/kg w.w.)				Pu-239,240 (Bq/kg w.w.)			
Year	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**
2002	S	14	0.20	0.08	S	6	158	72	M	3	0.068	0.028
2003	S	16	0.21	0.10	S	6	238	124	M	3	0.118	0.039
2004	S	16	0.21	0.15	S	6	170	113	M	3	0.089	0.030
2005	S	14	0.17	0.10	S	6	194	101	M	3	0.105	0.073

Region 8. North Sea South (Belgian and Dutch Coast)

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (µBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
2002	3	3.93	1.50	3	3.0	0.5						
2003												
2004	2	5.26	0.74	2	2.4	0.7						
2005												

Region 9. German Bight

	Seawater											
	Tritium (Bq/l)			Cs-137 (mBq/l)			Tc-99 (mBq/l)			Pu-239,240 (µBq/l)		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
2002	3	***< 2.75***	-	3	4.7	1.8						
2003												
2004	2	2.80	0.49	2	3.3	0.8						
2005												

Region 10. North Sea (Northwest, Southeast and Central)

	Seawater											
	Tritium (Bq/l)			**Cs-137 (mBq/l)**			**Tc-99 (mBq/l)**			**Pu-239,240 (μBq/l)**		
Year	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**
2002	34	**< *1.94***	-	29	4.5	1.7						
2003	5	**< *3.04***	-									
2004	32	**< *1.62***	-	27	4.5	1.4						
2005	5	**< *1.60***	-									

	Biota											
	Cs-137 (Bq/kg w.w.)				**Tc-99 (Bq/kg w.w.)**				**Pu-239,240 (Bq/kg w.w.)**			
Year	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**	**Type**	**n**	**Mean**	**SD**
2002	F	7	0.54	0.26	S	3	43.4	56.0	M	1	0.083	-
2003	F	7	0.43	0.21	S	3	25.2	19.5	M	1	0.079	-
2004	F	6	0.43	0.19	S	3	23.8	35.3	M	1	0.079	-
2005	F	8	0.44	0.30	S	3	73.6	78.3	M	1	0.058	-

ANNEX 3 - Dose assessment method for measured concentrations in seawater

1. The method uses a simplified version of the MARINA II dose assessment model.

2. Doses to individuals due to consumption of seafoods (fish, crustaceans, molluscs) are assessed by multiplying the concentration of radioactivity in the seafoods by the amounts of seafood consumed and by dosimetric factors which convert intake of radioactivity into dose. Activity concentrations in seafoods are calculated from seawater activity concentrations using element specific concentration factors.

3. This is represented by the following basic equation:

$$D_{indS} = \Sigma (C_R \times CF_{SR} \times I_S \times DPUI_R)$$

where:

D_{indS} is the individual dose due to seafood consumption (Sv y^{-1});

C_R is the concentration of radionuclide R in seawater (Bq L^{-1}),

CF_{SR} is the concentration factor of radionuclide R in seafood type S (e.g. fish) (L kg^{-1}),

I_S is the consumption rate for seafood type S (kg y^{-1});

$DPUI_R$ is the dose per unit intake of radionuclide R (Sv Bq^{-1}).

4. Concentration factors for fish, crustaceans and molluscs are those assumed in Table 2 of the MARINA II Report of Working Group D (J.R. Simmonds *et al.*) and are presented in Table A3.1.

Table A3.1: Concentration factors (Bq/kg / Bq/l)

	H	Tc	Cs	Pb	Po	Ra	Pu
Fish	1	30	100	200	20000	500	100
Crustaceans	1	1000	30	1000	50000	100	200
Molluscs	1	1000	30	1000	10000	1000	3000

5. Mean ingestion rates of fish, crustaceans and molluscs are those assumed in section 6 of the MARINA II Report of Working Group B (S.P. Nielsen and M. Keith-Roach) and are presented in Table A3.2.

Table A3.2: Ingestion rates

Ingestion rates	Fish	Crustaceans	Molluscs
kg/y	34	12	11

6. Dose coefficients (committed effective dose per unit intake via ingestion) used are those published in the EURATOM directive 96/29 and are presented in Table A3.3.

Table A3.3: Dose coefficients (Sv/Bq)

	Tritium	Tc-99	Cs-137	Pb-210	Po-210	Ra-226	Ra-228	Pu-239,240
D.C.	1.8×10^{-11}	6.4×10^{-10}	1.3×10^{-8}	6.9×10^{-7}	1.2×10^{-6}	2.8×10^{-7}	6.9×10^{-7}	2.5×10^{-7}

ANNEX 4 - Dose assessment method for measured concentrations in biota

1. Doses to individuals due to consumption of seafoods are assessed by multiplying the concentration of radioactivity in the seafoods by the amounts of seafood consumed and by dosimetric factors which convert intake of radioactivity into dose. This is represented by the following basic equation:

$$D_{indS} = \Sigma (C_{SR} \times I_S \times DPUI_R)$$

where:

D_{indS} is the individual dose due to seafood consumption (Sv y^{-1});

C_{SR} is the activity concentration of radionuclide R in seafood type S (e.g. fish) (Bq kg^{-1}),

I_S is the consumption rate for seafood type S (kg y^{-1});

$DPUI_R$ is the dose per unit intake of radionuclide R (Sv Bq^{-1}).

2. Mean ingestion rates of fish and molluscs are those assumed in section 6 of the MARINA II Report of Working Group B (S.P. Nielsen and M. Keith-Roach). The ingestion rates are presented in Table A4.1.

Table A4.1: Ingestion rates

Ingestion rates	Fish	Molluscs
kg/y	34	11

3. Dose coefficients (committed effective dose per unit intake via ingestion) used are those published in the EURATOM directive 96/29 and are presented in Table A4.2.

Table A4.2: Dose coefficients (Sv/Bq)

	Tritium	Tc-99	Cs-137	Pu-239,240
D.C.	1.8×10^{-11}	6.4×10^{-10}	1.3×10^{-8}	2.5×10^{-7}

ANNEX 5 - Elaborating issues associated with tritium

Following discussions at the meeting of the Radioactive Substances Committee (RSC) in Berne (19-22 February 2007), RSC agreed that the following points concerning tritium should be added to the Second Periodic Evaluation towards the Objective of the OSPAR Radioactive Substances Strategy as a separate Annex to Report:

a. tritium is a natural product produced by cosmic rays, accounting for approximately 20 - 30% of the radionuclide measured in the North Sea;

b. tritium has a very low dose coefficient and therefore exhibits a very low radiotoxicity to humans and inherently low radiotoxicity to biota;

c. nevertheless, there is a need to look into the effects of discharges on marine biota.

During the discussion, the following points were made by Ireland and Norway:

a. the production of tritium is directly linked with the amount of electricity production from nuclear power stations and associated reprocessing;

b. however, any associated increase in discharges is at variance with the agreed OSPAR Radioactive Substances Strategy, which makes no distinction between different radionuclides and states that the Strategy is to be achieved by progressive and substantial reductions of discharges;

c. abatement technology for reducing tritium discharges exists and should be implemented.

These points were countered by the views of France, UK, Belgium and Spain that:

a. on the other hand, the Strategy objective required that the following should be taken into account:

   (i) legitimate uses of the sea;

   (ii) technical feasibility;

   (iii) radiological impacts on man and biota;

b. the work carried out under the framework of the preparation of the Second Periodic Evaluation shows that doses to human populations due to concentrations of tritium in the marine environment are extremely low. This radionuclide is therefore not a priority compared to other more radiotoxic radionuclides;

c. the reports of Contracting Parties presented in the framework of PARCOM Recommendation 91/4 on the application of BAT to light water reactor (LWR) power stations and to reprocessing plants did not state any use of abatement technology of tritium in liquid discharges of these installations. Moreover, following a comprehensive study (RSC 07/3/5), France noted that no abatement technology of tritium was presently feasible for liquid discharges of LWR power stations and for reprocessing plants, and that furthermore there was no safe storage of highly tritiated waste. The lack of such techniques did not allow the reduction of tritium in liquid discharges of these installations in the short term;

d. France indicated that they would examine the opportunity to drop their reservation (RSC 07/2/3) on both statistics and tritium (cf. §2.6) .

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ISBN 978-1-905859-77-1
Publication Number: 338/2007