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Cefas Environment Report RL 11/08

A report on the investigation of the Cefas monitoring database for incidences of high activities in mollusc samples

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A report on the investigation of the Cefas monitoring database for incidences of high activities in mollusc samples

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Contents

1. Summary

The Food Standards Agency (FSA) is investigating the possible transfer of radioactive particles from the marine environment to the foodchain. In order to facilitate this investigation, the Centre for Environment, Fisheries and Aquaculture Science (Cefas) has interrogated relevant sections of their monitoring database. This database contains extensive details of the radiological monitoring programme and analytical results undertaken by Cefas on behalf of the FSA and others, culminating in the annually published Radioactivity in Food and the Environment (RIFE) report.

The practice of reporting annual mean concentrations, by species and collection location, in RIFE is not sufficient to distinguish the contribution of one high-level concentration from a series of slightly raised concentrations. By comparing individual analyses to a nuclide-dependent screening level, it is intended to identify any high-level concentrations that may indicate the contamination of the mollusc by a radioactive 'hot' particle.

The motivating factor behind the current interest in radioactive particles entering the foodchain is the collection of 'hot' particles found in the vicinity of the Sellafield nuclear site in Cumbria over the past 18 months. Similar cases of radioactive particles being found on beaches and in the marine environment around nuclear sites have been recorded in the past, including at Sellafield, and so, whilst this report focuses on recent events at Sellafield, the method and analysis could be potentially applied at other locations around the United Kingdom.

2. Background

Beach monitoring trials in November 2006 and January 2007, carried out on Sellafield and Braystones beaches, detected a number of radioactive 'particles' at depths of up to 120 mm. The precise source of the particles is unknown, but appears to be a combination of historic and recent releases (Environment Agency, 2007), although it should be noted that Sellafield is not authorised to discharge particulate material from the site. Subsequent monitoring of the beaches on a stretch of coastline from St Bees Head, 13km north of the Sellafield site, to Ravenglass, 8km south of the site, is ongoing, and has detected further contaminated particles. The physical nature of these particles varies, from contaminated grains of sand of ~200 micron minimum diameter to stones of a few cm diameter, and a piece of wire of ~3000 microns length by <400 microns diameter.

In order for the FSA to assess the risk posed to the public by these particles, via the consumption of fish and shellfish that had in turn consumed a radioactive particle, Cefas was asked to produce a report on the size of particles typically consumed by molluscs and crustacea (Beecham, 2008). This report reviewed the literature on the subject and concluded that particles of up to 1 mm (1000 microns) minimum diameter could be consumed, albeit those particles above ~200 microns were likely to have been inadvertently ingested. The paucity of peer-review data concerning

particle size ingestion led the FSA to request further investigation from Cefas in order to supplement this initial report and provide a broader basis for subsequent risk assessments.

It is reasonable to assume that the collection of contaminated objects found to date is not exhaustive, and that due to the nature of the beach monitoring equipment, particles with higher specific activities are more likely to be found. However, there may be radioactivity associated with particles in the marine environment formed from environmental processes, with specific activities considerably lower than those of the hot particles. Depending upon the magnitude of the specific activities, the particulate discharges may be practically indistinguishable from environmentally derived radioactive particles.

3. Cefas' monitoring database

Cefas conduct an annual radioanalysis programme involving the testing of a number of marine samples from locations associated with nuclear sites. Samples include fish, crustacea, molluscs, seaweed, sediments and seawater, and these are analysed by radiometric and radiochemical methods to determine the activity concentrations of a range of radionuclides.

Individual analytical results are recorded and maintained on a LIMS database along with collection date and location, and each sample is assigned a unique identification number. The results of this monitoring and analysis programme are then used to derive an annual mean activity concentration for each sample type at each monitoring location, and this data is collated to form an important part of the RIFE series of reports (for example, Environment Agency *et al.*, 2007).

To assist the FSA in their study of particle ingestion by molluscs and crustacea, Cefas were requested to investigate this monitoring database for any anomalously high activity concentrations in seafood sourced from the Sellafield area, which may indicate the presence of a contaminated particle in the gut contents of the sample.

4. Data Analysis

In order to enable the differentiation of high activity concentrations due to particle ingestion from those due to temporal and spatial variation, this investigation has focused on seven radionuclides. These include five nuclides for which the activities of particles found on the Sellafield beaches has been analysed and recorded. These are: cobalt-60, ruthenium-106, caesium-137, plutonium-239+240 and americium-241. Radioanalysis results for strontium-90 and curium-243+244 were also extracted from the database, as a mollusc sample containing a high activity concentration of these nuclides was known to have been recently analysed.

Data from the past ten years' mollusc sampling and analysis programme were obtained. This was then filtered according to the seven radionuclides mentioned above and the proximity of the sample location to Sellafield; for the purpose of this

initial investigation, the proximity was restricted to locations in Cumbria and the Solway estuary.

The filtered dataset was then split by nuclide and arranged in chronological order of sample collection date. Annual mean and maximum activity concentrations across all locations were found (Figures 1 – 7), and these can be compared in order to identify potential instances of a sample contaminated by a radioactive particle. In the first instance, a screening level was set that triggers further investigation of individual samples. This initial screening level was set to three times the highest annual mean concentration recorded over the selected time period, such that if the highest annual mean concentration recorded over the ten-year period were, say, 20 Bq/kg then the screening level would be 3 x 20 = 60 Bq/kg, and all annual maxima above this level would be considered possible indicators of particle contamination.

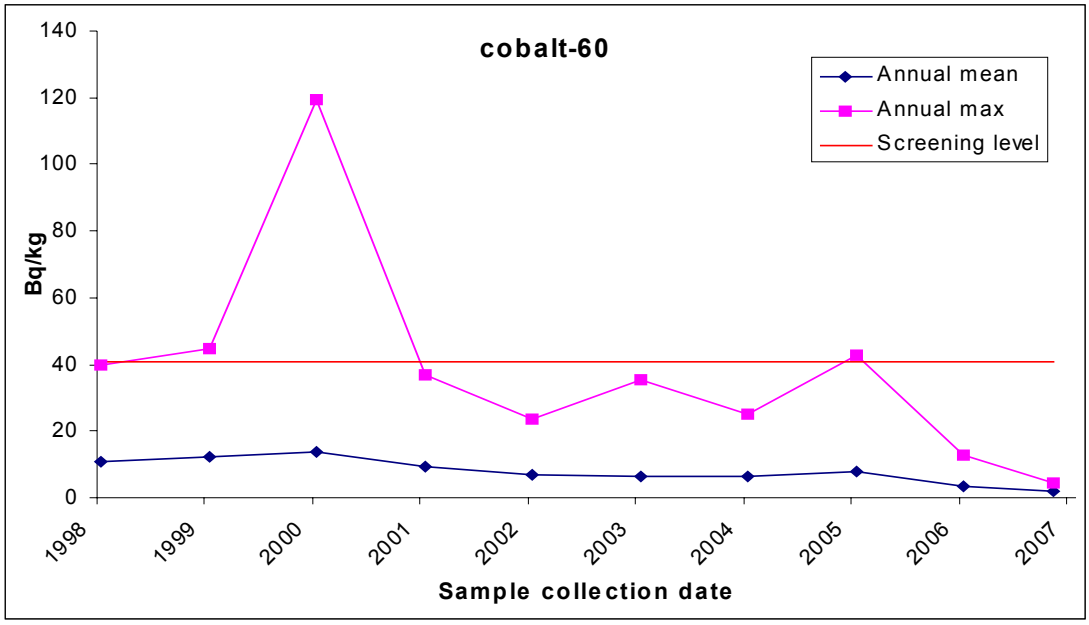
Where samples with activities greater than the screening level were identified, further filtering of the dataset was undertaken in order to compare the high-level sample with samples collected in the same year from the same location (as a check on spatial variability between different sampling sites) and from the same species (as a check on concentration factor variability). If the high-level sample had a concentration greater than three times the mean concentration of both of these subsets (which exclude the high-level sample), the associated sample was further considered as being possibly contaminated. It should be noted that there is still a possibility that environmental mechanisms (other than hot particles) may be responsible for a sample exceeding both screening methods (such as the influence of historic discharges), and the current methodology cannot differentiate a low-activity 'hot' particle from sediment contaminated by historical (relatively high) authorised liquid discharges.

In the following sections of this report, when a reference is made to a sample being contaminated by a radioactive particle, the implication is that this particle is 'hot' (i.e., a particle discharge from source.) The feeding mechanism of mollusc species involves the intake of sediment particles, which will account for a portion of the sample activity within the whole species. It is therefore likely that many of the samples analysed contain sediment particles taken up during feeding, and many of these particles will have some radioactivity associated with them due to authorised liquid discharges.

Cobalt-60

The results of 788 cobalt-60 analyses for mollusc samples were extracted from the Cefas monitoring database. Activity concentrations ranged from the limit of detection (LoD) to 119 Bq/kg, with an overall mean of 8.1 Bq/kg. Figure 1 shows that the maximum concentrations recorded in 1999, 2000 and 2005 exceed the screening level of 40.7 Bq/kg, and thus indicate possible contamination with a radioactive particle.

Figure 1 – *Comparison of annual mean cobalt-60 concentrations with annual maxima*



The maximum recorded concentration in 1999 was 44.5 Bq/kg, obtained from an edible winkle at Nethertown. The mean concentration of all other mollusc samples from Nethertown in 1999 is 21.1 Bq/kg, and the mean of all other edible winkle samples in 1999 is 17.9 Bq/kg. This gives a secondary screening level of 63.3 Bq/kg (3 x 21.1), which is above the maximum concentration recorded and thus indicates that this high-level sample is more likely to be a result of spatial variability than particle contamination.

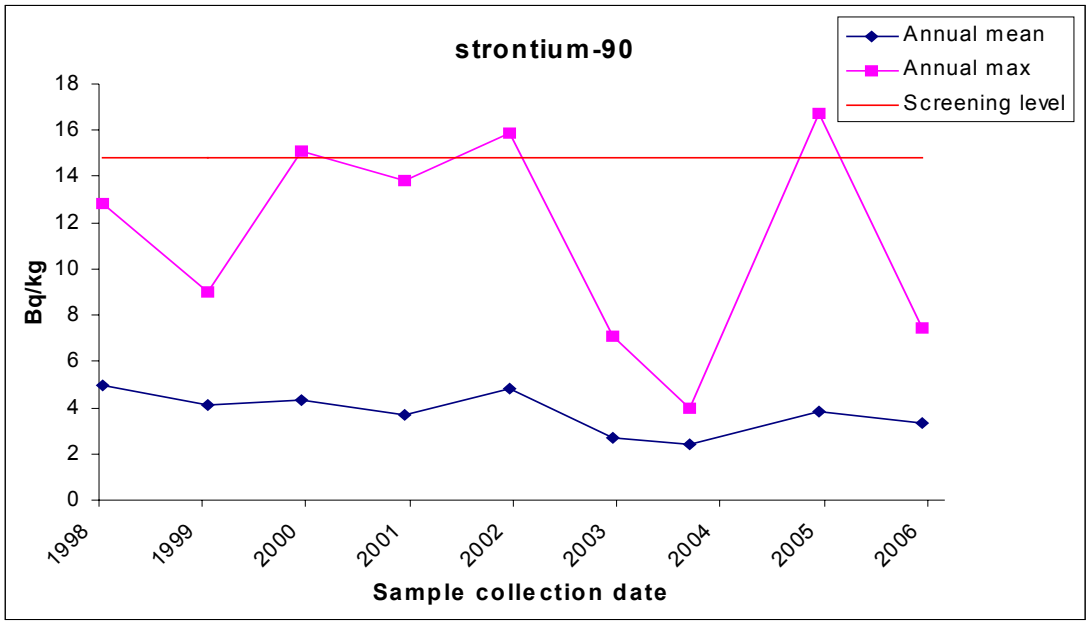
Over the ten-year period currently considered, the maximum cobalt-60 concentration recorded was from a sample collected in May 2000, specifically an edible winkle sample collected from Nethertown. Analysis of this sample returned an activity concentration of 119.2 Bq/kg. The mean of all other Nethertown mollusc samples collected that year is 25.9 Bq/kg, and the mean of all edible winkle samples is 16.7 Bq/kg, giving a secondary screening level of 77.8 Bq/kg. We thus retain the high-level sample as a possible instance of particle contamination. It may be useful to note that the next highest activity concentration in molluscs in 2000 was also found in an edible winkle sample from Nethertown (collected in April), and was also above the secondary screening level with a cobalt-60 concentration level of 116.6 Bq/kg.

The most recent instance of an annual maximum exceeding the initial screening level occurred in 2005, when an edible winkle sample from the Sellafield pipeline vicinity recorded a concentration of 42.7 Bq/kg. The mean of all other mollusc samples from this location in 2005 is 16.8 Bq/kg, and the mean of all other edible winkle samples is 10.8 Bq/kg. The high-level sample is thus below the secondary screening level of 50.4 Bq/kg, and we conclude that the relatively high concentration recorded during this year is the result of spatial variability.

Strontium-90

A total of 97 strontium-90 analyses for mollusc samples around Sellafield and the Solway were recorded on the Cefas monitoring database for the period of interest. Recorded activities ranged from LoD to 16.7 Bq/kg, with an overall mean concentration of 3.8 Bq/kg. Figure 2 compares the annual mean and maximum concentrations, and shows that the screening level of 14.8 Bq/kg was exceeded during the years 2000, 2002 and 2005.

Figure 2 – *Comparison of annual mean strontium-90 concentrations with annual maxima*



The maximum recorded concentration in 2000 was 15.1 Bq/kg, obtained from an edible winkle from Nethertown. The mean of all other Nethertown mollusc samples that year is 5.1 Bq/kg, and the mean of all other edible winkles sampled in 2000 is 5.5 Bq/kg. In this case the high-level concentration does not exceed the secondary screening level (16.5 Bq/kg), and is thus likely to be due to spatial and species variability.

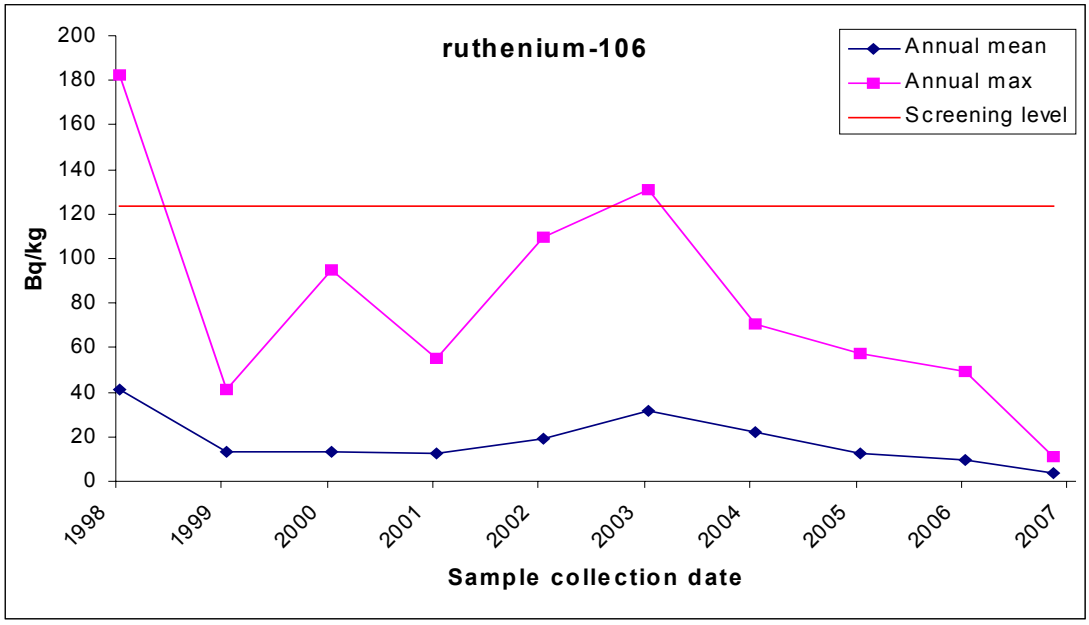
An edible winkle sample from Nethertown provided the maximum concentration again in 2002, with an activity of 15.9 Bq/kg. During this year, the mean of all other Nethertown mollusc samples was 5.2 Bq/kg and the mean of all other edible winkle samples was 5.9 Bq/kg, so that this high-level concentration is also screened out by the secondary screening level of 17.7 Bq/kg.

In 2005, the maximum recorded concentration of strontium-90 in mollusc samples from Cumbria and Solway was 16.7 Bq/kg. This was again obtained from a Nethertown edible winkle sample, but, although not significantly higher than the maxima recorded in 2000 and 2002, in this case the activity concentration is above the secondary screening level of 13.8 Bq/kg provided by the Nethertown mean of 4.6 Bq/kg (the mean of all other edible winkles that year being 3.4 Bq/kg).

Ruthenium-106

There are 788 ruthenium-106 results for mollusc samples from the Sellafield and Solway area. The range of activity concentrations is from LoD to 182.1 Bq/kg, with an overall mean of 18.1 Bq/kg. The initial screening level is 123.3 Bq/kg. Figure 3 indicates that secondary screening of samples from 1998 and 2003 is necessary.

Figure 3 – *Comparison of annual mean ruthenium-106 concentrations with annual maxima*



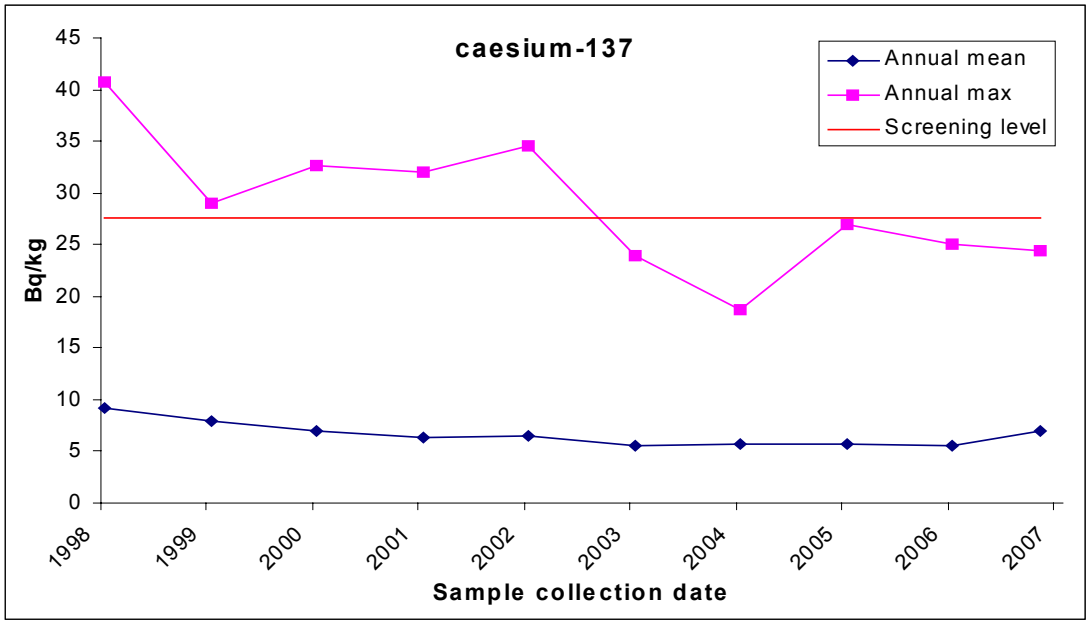
The maximum activity recorded in 1998 is 182.1 Bq/kg, in an edible winkle sample from Nethertown. The mean of all other Nethertown mollusc samples in this year is 62.0 Bq/kg and the mean of all other edible winkles in this year is 49.9 Bq/kg. The secondary screening level is therefore 186.0 Bq/kg, which is slightly greater than the concentration of ruthenium-106 in the high level sample. It is likely that this high level is due to the normal spatial variability rather than contamination of the winkle by radioactive particle.

In 2003, a maximum activity concentration of 130.7 Bq/kg was recorded in a sample of edible winkle from Nethertown. This is below the secondary screening level of 180.6 Bq/kg, obtained from the mean of all other mollusc samples sourced from Nethertown in 2003 (60.2 Bq/kg, compared with a mean of 36.5 Bq/kg for all other edible winkle samples). It is again suggested that this high level is due to spatial variability.

Caesium-137

Seven hundred and eighty-eight caesium-137 results of mollusc samples, taken over the past ten years from the specified locations, were extracted from the Cefas database. The maximum recorded activity concentration during this period is 40.7 Bq/kg in 1998 (see Figure 4), and the mean value of all samples is 6.6 Bq/kg. The initial screening level for caesium-137 is 27.6 Bq/kg, a level which has been exceeded by the maximum sample concentration in the five consecutive years from 1998 to 2002.

Figure 4 – *Comparison of annual mean caesium-137 concentrations with annual maxima*



The maximum recorded concentration of caesium-137 in 1998 is also the maximum of the ten-year period under consideration. The value of 40.7 Bq/kg was obtained from an edible winkle sample from St Bees Seamill. The mean of all other mollusc samples from this location in 1998 is 9.4 Bq/kg, and the mean of all other edible winkle samples is 12.1 Bq/kg. This high-level sample thus exceeds the secondary screening level of 36.2 Bq/kg and is retained as a possible indicator of particle contamination.

In 1999, a maximum activity level of 29.0 Bq/kg was recorded in a sample of edible winkle from Nethertown. The mean of all other Nethertown mollusc samples is 11.6 Bq/kg and the mean of other winkle samples is 10.7 Bq/kg, giving a secondary screening level of 34.9 Bq/kg and suggesting that this elevated activity concentration is an incidence of spatial variability.

A concentration of 32.6 Bq/kg was the maximum recorded in 2000, again from a Nethertown edible winkle sample. This value is slightly greater than the secondary screening level of 31.5 Bq/kg obtained from the mean of all Nethertown mollusc samples from 2000, which is 10.5 Bq/kg. The mean of all other edible winkle

samples in this year is 10.0 Bq/kg. The high-level sample is retained as a possible indicator of particle contamination.

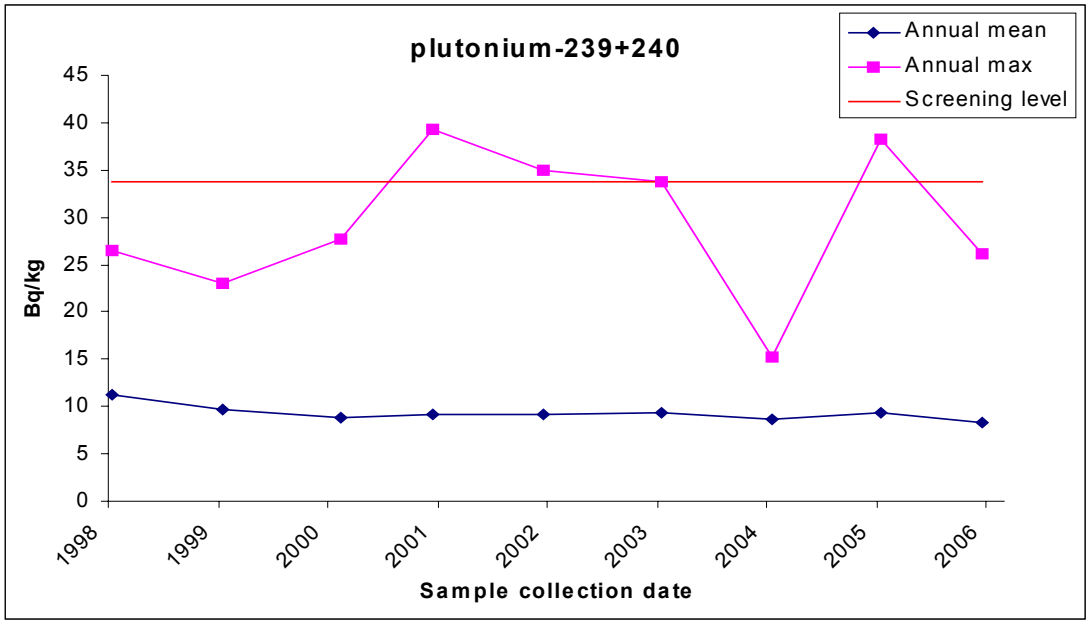
An edible winkle sample from Nethertown was again the source of the maximum recorded concentration in 2001, with an activity of 32.0 Bq/kg. This sample is also retained as a possible indicator of particle contamination, as it exceeds the secondary screening level of 29.8 Bq/kg. The mean of all other Nethertown mollusc samples is 9.9 Bq/kg, and the mean of all other edible winkle samples is 8.9 Bq/kg.

The maximum caesium-137 concentration recorded in 2002 is 34.5 Bq/kg, in an edible winkle sample from St Bees Seamill. The mean of all other mollusc samples from this location is 9.8 Bq/kg, and the mean of all other edible winkle samples collected in 2002 is 8.7 Bq/kg. As the maximum is greater than the derived secondary screening level of 29.3 Bq/kg, this high-level sample is retained as a possible indicator of particle contamination.

Plutonium-239+240

A total of 226 results were extracted from the Cefas database in order to examine the incidence of high levels of plutonium-239+240 for mollusc samples originating from the Sellafield area. Activity concentrations ranged from 0.0029 Bq/kg to 39.3 Bq/kg, with an overall mean of 9.3 Bq/kg. Annual maxima and mean activity concentrations are shown in Figure 5, along with the initial screening level, which is set at 33.7 Bq/kg. Four of these maxima (those recorded in 2001, 2002, 2003 and 2005) exceed the screening level, and are thus subjected to further investigation.

Figure 5 – *Comparison of annual mean plutonium-239+240 concentrations with annual maxima*



The maximum concentration of plutonium-239+240 recorded in 2001 is 39.3 Bq/kg. This came from an edible winkle sample from Nethertown. The mean of all other

Nethertown mollusc samples in 2001 is 11.6 Bq/kg, and the mean of all other edible winkle samples is 10.8 Bq/kg. The high-level sample has a greater concentration than the secondary screening level of 34.7 Bq/kg, and the sample is thus retained as a possible indicator of particle contamination.

An edible winkle sample from Nethertown provided the maximum activity concentration of 34.9 Bq/kg in 2002. This is slightly greater than the secondary screening level of 34.0 Bq/kg derived from the mean of all other Nethertown mollusc samples (11.3 Bq/kg). The mean of all other edible winkle samples is 10.6 Bq/kg. This high-level sample is also retained as an indicator of particle contamination.

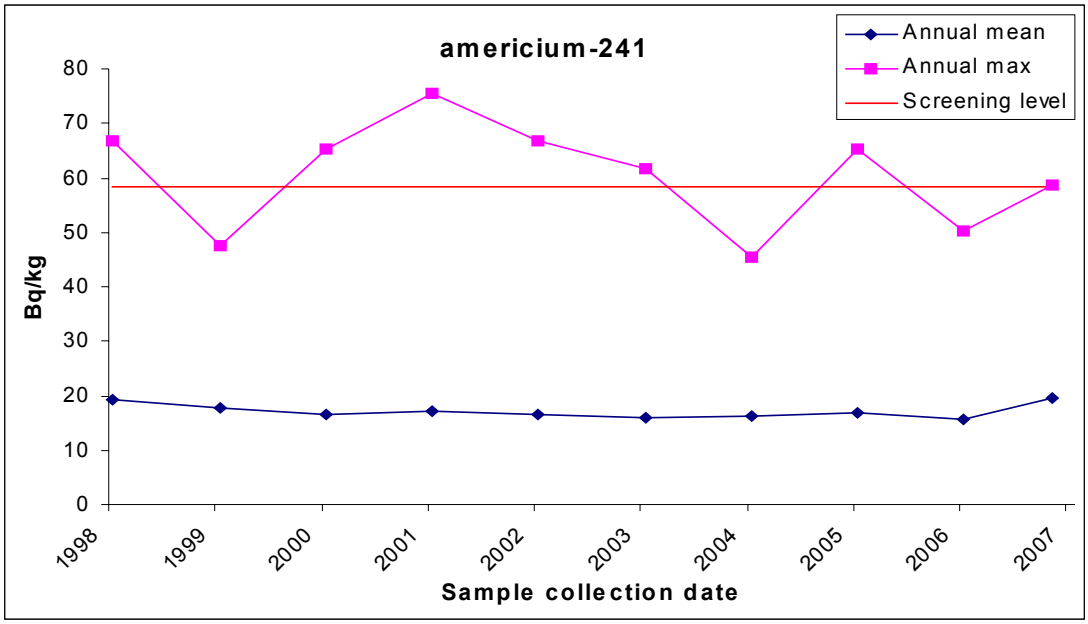
The 2003 maximum recorded concentration of 33.8 Bq/kg is barely above the initial screening level. This high-level sample was again from a Nethertown edible winkle. The mean of all other Nethertown mollusc samples is 12.2 Bq/kg and the mean of all other edible winkles is 9.0 Bq/kg, giving a secondary screening level of 36.5 Bq/kg and leading us to conclude that this sample is an example of spatial variability rather than particle contamination.

An activity concentration of 38.2 Bq/kg, found in an edible winkle sample from Nethertown, provided the maximum recorded in 2005. The mean of all other Nethertown molluscs collected in 2005 is 10.1 Bq/kg, and the mean of all other edible winkles is 10.1 Bq/kg. The secondary screening level of 30.2 Bq/kg is below the high-level concentration (and indeed, below the initial screening level), and this sample is thus retained as a possible indicator of particle contamination.

Americium-241

The Cefas monitoring database contains 1014 americium-241 results for mollusc samples obtained from 1998 to 2007 around Sellafield and the Solway estuary. Concentrations in these samples range from 0.0029 Bq/kg to 75.6 Bq/kg with an overall mean of 17.0 Bq/kg. The initial screening level for americium-241 is 58.3 Bq/kg, and Figure 6 indicates that this was exceeded by the annual maxima in seven of the ten years for which data were extracted. The high-level samples recorded in 1998, 2000 to 2003 inclusive, 2005 and 2007 are further investigated.

Figure 6 – *Comparison of annual mean americium-241 concentrations with annual maxima*



The maximum recorded concentration in 1998 was 66.7 Bq/kg, in an edible winkle sample from St Bees Seamill. This compares to a mean of 22.7 Bq/kg for all other St Bees Seamill mollusc samples and a mean of 24.0 Bq/kg for all other edible winkle samples, from which a secondary screening level of 71.9 Bq/kg is derived. This high-level sample falls below the screening level.

In 2000, the maximum activity concentration was found in an edible winkle sample from Nethertown, which was found to contain 65.4 Bq/kg. The mean of all other Nethertown mollusc samples collected in 2000 is 26.4 Bq/kg, giving a secondary screening level of 79.1 Bq/kg, and the mean of all other edible winkle samples is 21.3 Bq/kg. It is suggested that this high-level sample is the result of spatial variability.

The 2001 maximum of 75.6 Bq/kg is also the highest americium-241 concentration recorded in mollusc samples over the ten-year period. However, as the mean of all other Nethertown mollusc samples is 27.5 Bq/kg this high-level sample concentration falls below the secondary screening level of 82.4 Bq/kg and is thus considered an example of spatial variability rather than particle contamination. The mean of all other edible winkle samples is 21.2 Bq/kg.

A maximum concentration of 66.7 Bq/kg was recorded in an edible winkle sample from St Bees Seamill in 2002. The mean concentration of all other mollusc samples collected from St Bees Seamill during this year is 23.9 Bq/kg, and the mean concentration in all edible winkle samples is 20.0 Bq/kg. This gives a secondary screening level of 71.8 Bq/kg, which is greater than the activity found in this high-level sample.

The maximum recorded concentration in 2003 was 61.7 Bq/kg, found in an edible winkle sample from Nethertown. The mean of all other mollusc samples from Nethertown is 25.1 Bq/kg and the mean of all other edible winkle samples is 18.2

Bq/kg, deriving a secondary screening level to be 75.2 Bq/kg. The 2003 maximum falls below this level, and is thus considered to be an example of spatial variability.

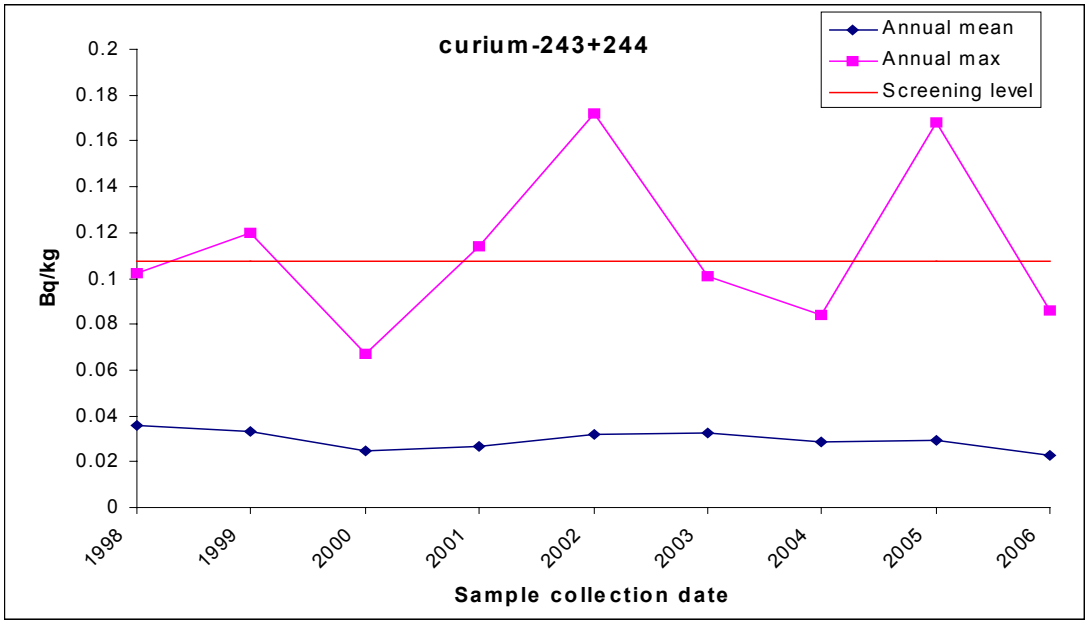
An edible winkle sample from Nethertown, with an activity concentration of 65.2 Bq/kg, again provided the maximum recorded concentration in 2005. The mean of all other Nethertown mollusc samples is 23.4 Bq/kg and the mean of all other edible winkle samples collected that year is 19.6 Bq/kg, so that the high-level sample again falls below the secondary screening level of 70.3 Bq/kg.

In 2007, the maximum recorded concentration of 58.6 Bq/kg was from an edible winkle sample from St Bees Seamill. This compares to a mean of 18.5 Bq/kg for all mollusc samples collected from St Bees Seamill and a mean of 25.2 Bq/kg for all other edible winkles. The secondary screening level of 75.6 Bq/kg is greater than the concentration in the high-level sample, and it is concluded that this is another example of spatial variability.

Curium-243+244

The overall mean of the 320 curium-243+244 analyses extracted from the database is 0.030 Bq/kg, ranging from LoD to 0.17 Bq/kg. The initial screening level is 0.11 Bq/kg, and it can be seen from Figure 7 that the annual maximum exceeded this level four times – in 1999, 2001, 2002 and 2005.

Figure 7 – *Comparison of annual mean curium-243+244 concentrations with annual maxima*



The maximum recorded curium-243+244 concentration in mollusc samples in 1999 is 0.12 Bq/kg, from a blue mussel collected at St Bees Seamill. The mean of all other molluscs collected at this location during this year is 0.038 Bq/kg, and the mean of all other blue mussel samples is 0.033 Bq/kg. Thus a secondary screening

level of 0.11 Bq/kg is derived, and as the annual maximum is in excess of this level the sample is retained as a possible indicator of contamination.

In 2001 a concentration of 0.11 Bq/kg in an edible winkle from Nethertown provided the maximum activity in mollusc samples. However, the mean of all other Nethertown samples is 0.046 Bq/kg giving a secondary screening level of 0.14 Bq/kg, and so this high-level sample is considered a product of spatial variation and discounted as a potentially contaminated sample. The mean of all other edible winkle samples collected in 2001 is 0.032 Bq/kg.

The maximum concentration recorded in 2002 was 0.17 Bq/kg. This was again from a sample of edible winkle collected at Nethertown. The mean of all other Nethertown mollusc samples is 0.042 Bq/kg and the mean of all other edible winkle samples is 0.037 Bq/kg, giving a secondary screening level of 0.13 Bq/kg. The activity in the high-level sample exceeds this, and so this sample is retained.

Finally, the highest concentration in mollusc samples analysed in 2005 was 0.17 Bq/kg in an edible winkle from Nethertown. This is greater than the secondary screening level of 0.12 Bq/kg, which is derived from the mean of all other Nethertown mollusc samples, 0.042 Bq/kg.

5. Discussion

The previous section identified eleven mollusc samples as potentially contaminated by a radioactive particle, due to exceeding a secondary location- and species-specific screening level. In ten of these cases the sample in question was an edible winkle, as indeed were all but one of the annual maxima that exceeded the initial screening level. The final high-level sample was from a blue mussel. The majority of the individual samples that exceeded the screening levels were collected from Nethertown, with the remainder from St Bees Seamill.

The prevalence of Nethertown winkles would appear to indicate one, or a combination, of two scenarios. Firstly, it may be that the distribution of contaminated particles is concentrated around Nethertown, and winkles are particularly prone to ingestion of these (and presumably other inorganic) particles; secondly, it may be that winkles have a higher concentration factor than other molluscs for the elements considered above (IAEA (1985) provide a reference concentration factor value of 10 l kg^{-1} for molluscs), and that the Nethertown area is subject to higher radionuclide concentrations in seawater than other local areas.

Comparison of the high-level mollusc concentrations with the specific activities recorded in particles found on the Sellafield beaches implicates the latter scenario as most prevalent. Results from analyses conducted by the National Physical Laboratory (NPL) indicate that the specific activities of the Sellafield particles are far in excess of even the highest mollusc concentrations. Activities from a few hundred becquerels (americium-241) through to thousands and tens of thousands of becquerels (cobalt-60, caesium-137, plutonium-239) and even higher (~10^5 Bq in some caesium and americium analyses, and >10^6 Bq americium in one particle)

have been recorded, clearly some orders of magnitude greater than the levels recorded in mollusc samples the Cefas monitoring database.

It was mentioned at the beginning of section 4 that strontium-90 and curium-243+244 were included in this investigation due to a known incidence of high concentrations being recorded. A strontium-90 activity concentration of 26.1 Bq/kg was initially detected in a limpet sample collected from the Sellafield coastal area in 2004. This is significantly higher than the initial screening level set for this nuclide, and 60% greater than the maximum concentration recorded on the Cefas database. Analysis of a separate aliquot returned a concentration of 4.0 Bq/kg, which is the value reported in RIFE.

The same sample returned a curium-243+244 activity concentration of 1.1 Bq/kg, some 6.5 times the highest concentration noted in the previous section. Significantly, a separate portion of this sample was found to contain just 0.041 Bq/kg, a level in keeping with the overall mean concentration of curium-243+244 in molluscs.

Re-analysis of this limpet sample was undertaken because the high concentrations obtained from the first analysis were considered to be either an erroneous count or the result of a 'hot' particle residing in one portion of the sample. Contamination with such a particle, and its effect on any subsequent dose assessment, was assumed to be unrepresentative of the likely concentration in seafood, and thus, after notifying the FSA of the need for reanalysis, the initial results were removed from the monitoring database. The incidence referred to above is the only one for which the original analysis data is still available. Comparison of the strontium-90 and curium-243+244 concentrations with specific activities in recent particle finds is not currently possible as, to our knowledge, no analysis of these nuclides has yet been conducted. However, levels of plutonium and americium in the original limpet sample are in line with their respective mean levels across all mollusc species, and these concentrations were similar in the aliquot used for reanalysis.

The procedure of re-analysing samples when an erroneous count is suspected is standard quality control practice. The monitoring and analysis programme is designed to provide a reflection of the prevailing environmental levels of radionuclides that have been released under authorisation from licensed nuclear sites, rather than identify potential contamination by unauthorised, highly active particles. The current climate regarding particle contamination, and the search for hot particles in general, is likely to ensure that any future marine samples displaying activity concentrations above the 'normal' range (those that would typically lead to reanalysis) are treated as potentially contaminated by a particle of the type that are being found on the beaches around Sellafield.

In conclusion, under the current search criteria, Cefas' monitoring and analysis database was not found to contain any samples that would conclusively indicate the ingestion of a hot particle. Although a number of sample concentrations did exceed our arbitrary secondary screening level, they do not approach the activity levels recorded in recent beach particle analyses. It was mentioned previously that the current methodology can not differentiate between raised activities due to a 'hot' particle from those due to sediments subjected to historical higher discharge levels.

One possible method of distinguishing the two is to investigate the activity ratio of plutonium-239+240 to plutonium-238. This ratio has been steadily falling since the 1960s, and is considered a reliable indicator of discharge chronology. Such analysis is beyond the scope of this report.

The most likely candidate for contamination is a limpet sample containing elevated levels of strontium-90 and curium-243+244; reanalysis of a separate aliquot of this limpet returned normal levels of both nuclides. The Cefas database contains these second, lower results, as will be the case for any previous samples deemed to require reanalysis.

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About us

Cefas is a multi-disciplinary scientific research and consultancy centre providing a comprehensive range of services in fisheries management, environmental monitoring and assessment, and aquaculture to a large number of clients worldwide.

We have more than 500 staff based in 3 laboratories, our own ocean-going research vessel, and over 100 years of fisheries experience.

We have a long and successful track record in delivering high-quality services to clients in a confidential and impartial manner.
(www.cefas.co.uk)

Cefas Technology Limited (CTL) is a wholly owned subsidiary of Cefas specialising in the application of Cefas technology to specific customer needs in a cost-effective and focussed manner.

CTL systems and services are developed by teams that are experienced in fisheries, environmental management and aquaculture, and in working closely with clients to ensure that their needs are fully met.
(www.cefastechnology.co.uk)

Customer focus

With our unique facilities and our breadth of expertise in environmental and fisheries management, we can rapidly put together a multi-disciplinary team of experienced specialists, fully supported by our comprehensive in-house resources.

Our existing customers are drawn from a broad spectrum with wide ranging interests. Clients include:

- international and UK government departments
- the European Commission
- the World Bank
- Food and Agriculture Organisation of the United Nations (FAO)
- oil, water, chemical, pharmaceutical, agro-chemical, aggregate and marine industries
- non-governmental and environmental organisations
- regulators and enforcement agencies
- local authorities and other public bodies

We also work successfully in partnership with other organisations, operate in international consortia and have several joint ventures commercialising our intellectual property.

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