MARINE RADIOACTIVITY IN THE CHANNEL ISLANDS, 1990 - 2009

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1 INTRODUCTION

Since the mid-1960s, samples of marine environmental materials collected from Alderney, Guernsey and Jersey have been analysed to determine the concentrations of artificial radionuclides in the vicinity of these Channel Islands. The three surveillance programmes now primarily monitor the effects of radioactive discharges from the French reprocessing plant at La Hague and the power station at Flamanville; they also serve to monitor any effects of historical disposals of radioactive waste in the Hurd Deep, a natural trough in the western English Channel. Fish and shellfish are monitored in order to determine exposure from the internal irradiation pathway; sediment is analysed with relevance to external exposures. Seawater and seaweeds are sampled as environmental indicator materials and, in the latter case, because of their use as fertilisers. Milk and crop samples from the Channel Islands have also been analysed and reported in recent years, but these will not be discussed here.

Regular reporting of environmental surveillance data, providing radionuclide concentrations in surface and coastal waters of the British Isles began in 1967[1], reports generally being published annually. Channel Islands data were also included in this report series, but were limited to a few samples (mostly seaweed) for the analyses of gross beta, caesium-137 and ruthenium-106. By the 1970s the transport and behaviour of transuranic elements plutonium and americium in the Irish Sea from Sellafield (then Windscale) had been extensively studied and reported - a few examples are cited.[2-5] At this time, information on the environmental fate of La Hague discharges was more sparse in comparison to Sellafield discharges, however it was shown that plutonium and americium could be detected in the waters of the English Channel (and southern North Sea).[6,7] The Channel Islands surveillance programmes also contained a few measurements showing low level uptake of these radionuclides in shellfish, reported in the then ongoing MAFF annual monitoring report series.[5] In 1981, a study to determine the occurrence of transuranic elements in the marine environment of the Channel Islands concluded that plutonium and americium was present at concentrations much higher than those apportioned to fallout from atmospheric weapons testing.[8]

A thorough review of the adequacy of arrangements for the monitoring for the Channel Islands was carried out in 1989, which provided information of possible changes in radiological exposure pathways which may affect dose to people, interpretation of the 1989 monitoring data, assessment of doses to people who consumed large amounts of seafood and were exposed to external radiation for long periods, and time trend analysis of gross beta and ruthenium-106 in seaweed (*Porphra*).[9] The report concluded that the environmental concentrations of radionuclides, from wastes disposed to sea, from the mid-1960s to 1989, showed there had been no major trends in concentrations.

The Channel Islands surveillance programmes have continued throughout the intervening years to the present time and although the monitoring requirements are reviewed annually, any changes to the programme mostly reflect observations from the previous one or two years and/or future requirements based on likely seafood consumption. The Channel Island monitoring data are presently reported annually in the joint UK regulators' annual Radioactivity in Food and the Environment (RIFE) series of reports. The most recent report is RIFE 15, which provides information for all the monitoring carried out in 2009.[10]

The objective of this paper is to provide concentrations of certain radionuclides in selected indicators (seafood, seaweed, and sediment) over a long time period to assess the impact upon the surrounding environment of the Channel Islands. The concentration data have been compiled to assess the time trends from 1990 (after the last published review of 1989 data) until the present time. These data give a clearer and broader picture of radionuclide trends in the environment which are not obvious from the annually published technical reports.

2 SOURCES OF ARTIFICIAL RADIONUCLIDES

There are three main sources of artificial radionuclides that could impact the marine environment of the Channel Islands.

i) Authorised discharges from the French reprocessing plant at la Hague;
   This site is a nuclear fuel reprocessing plant of AREVA on the Cotentin Peninsula. It has been in operation since 1976 and produces plutonium which is then recycled into MOX fuel at the Marcoule site.

i) Authorised discharges from the French nuclear power station at Flamanville;
   This power station site is also located on the Cotentin Peninsula. It is powered by two pressurised water reactors (PWRs) and began commercial operation in 1986. Construction began on a new reactor (Flamanville 3) in 2007.

ii) Releases from historical disposals of radioactive waste in the Hurd Deep.
   The disposal of packaged radioactive wastes at the eastern end of the Hurd Deep occurred on fourteen occasions between 1950 and 1963. The disposals were authorised by the UK Government. The waste consisted of small amounts of radioactivity[11] originating from various laboratory processes.

Of minor significance to the Channel Islands are the discharges from the UK nuclear site at Winfrith; the main source of discharge was the Steam Generating Heavy Water

Reactor (SGHWR) which was shut down in 1995 and is currently undergoing decommissioning, and from sites with operational nuclear reactors at Dungeness (in the UK), Paluel, Penly and Gravelines (in France). The locations of these sources are shown in Figure 1. Contributions from Chernobyl and weapon test fallout are also negligible.

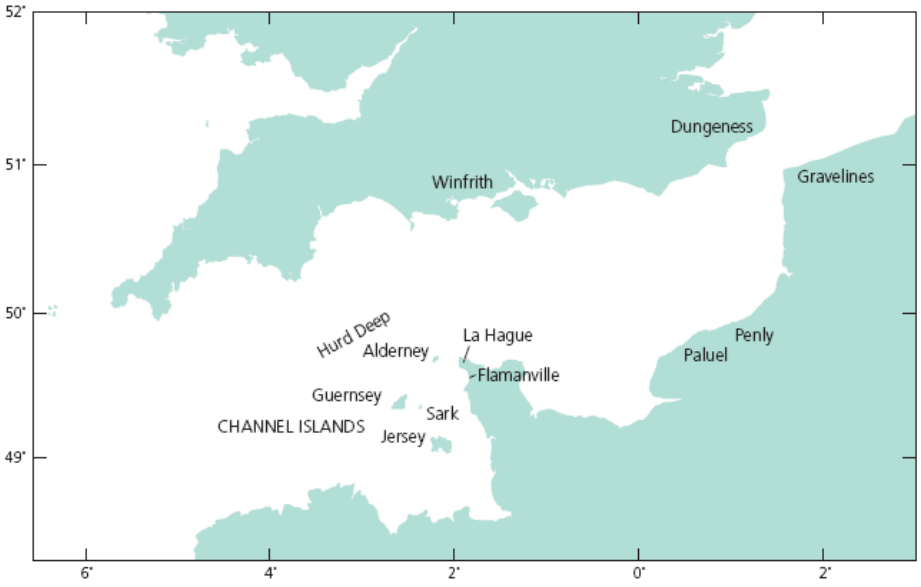

Figure1 *Sources of artificial radionuclides near the Channel Islands*

3 RADIONUCLIDE MONITORING DATA

The data in this paper have all been published in the annual Radioactivity in Food and the Environment Report (RIFE) reports and the earlier MAFF annual monitoring report series. Most recent data, for the Channel Islands surveillance programme in 2009, is located in Table 8.3 in RIFE 15,[10] with supporting text in Section 8.2. In the RIFE data tables, if more than one sample is collected and analysed, the value of the radionuclide concentration is reported as the mean of the individual concentrations for that sample. These mean values have also been used in the compilation of the datasets reported here.

From the concentration data available, three indicators types (seafood, seaweed, and sediment) were chosen to investigate radionuclide trends around Alderney, Guernsey and Jersey. Many measurements of radionuclide concentrations were at or below the analytical limits of detection. Therefore, comment on the data collated here has focused on the using positively detected values. Further description of the 3 indicators types are given in Table 1, together with a list of the determinand radionuclides for which data have been analysed and annually reported over the last two decades.

Table1 *Sample details and available determinands*

LOCATION	SAMPLE TYPE	DETERMINANDS
ALDERNEY (Little Crabbe Harbour)	Sand	Cs-137. Ru-106
JERSEY (St Helier)	Mud	Cs-137, Ru-106, Pu-239+240, Am-241
GUERNSEY (St Sampson's Harbour)	Mud	Cs-137, Ru-106, Pu-239+240, Am-241
ALDERNEY (Quenard Point)	*Fucus* seaweed	Cs-137, Ru-106, Tc-99, Pu-239+240, Am-241
JERSEY (La Rozel)	*Fucus* seaweed	Cs-137, Ru-106, Tc-99, Pu-239+240, Am-241
GUERNSEY (Fermain Bay)	*Fucus* seaweed	Cs-137, Ru-106, Tc-99, Pu-239+240, Am-241
ALDERNEY	Toothed Winkles	Cs-137, Ru-106, Pu-239+240, Am-241
JERSEY (La Rozel)	Limpets	Cs-137, Ru-106, Pu-239+240, Am-241
GUERNSEY	Limpets	Cs-137, Ru-106

4 RESULTS AND DISCUSSION

Figures 2, 3 and 4 provide the trends of radionuclide concentrations in sediments, seaweed and seafood over the period, 1990-2009. Overall, low concentrations of radionuclides were detected in the marine environment around all the Channel Islands. There was evidence of routine releases from the nuclear industry in some samples for ruthenium-106 in all substrates (in the early 1990's), and for technetium-99 in seaweed for the last decade. These were most likely due to discharges from the nuclear fuel reprocessing plant at La Hague in France. With the available data, apportionment of the other radionuclides to the possible different sources, including weapon test fallout, is difficult in view of the low concentrations detected. There was no detectable effect in Channel Islands waters of any releases of radioactivity from the Hurd Deep site.

Figure 2 provides Channel Islands data for caesium-137, ruthenium-106, plutonium-239+240 and americium-241 in sediments. All trend data, with the exception of ruthenium-106, were above the analytical level of detection (i.e. values positively detected). Ruthenium-106 concentrations were all below the level of detection at all sites from 1997 onwards. Overall, radionuclide concentrations were slightly higher at Jersey (in comparison to Guernsey and Alderney), and this was most likely due to the differences in the type and mineralogy of the sediments sampled. Between 1990 and 1996, ruthenium-106 concentrations declined with time. Although there were some data scatter observed within years for caesium-137 concentrations, the trend in sediments generally decreased over the whole study period generally reflecting the changes in liquid discharges from La Hague, especially with the decreases in these discharges in the early 1990s.[12] At Guernsey, one higher caesium-137 result was observed in 1998. This is also consistent with a small caesium-137 peaks (in the same year) in the *fucus* seaweed result, but not observed in the limpet result (Figures 3 and 4). Trends in plutonium-239+240 and americium-241 also show some scatter in concentrations between individual years, but the trends for the same radionuclides are remarkably similar for both Guernsey and Jersey, with a suggestion that both transuranic concentrations have decreased over time at Jersey.

Figure 3 provides Channel Islands data for caesium-137, ruthenium-106, technetium-99, plutonium-239+240 and americium-241 in *fucus* seaweed (*fucus vesiculosus or fucus serratus*). Technetium-99 data are only available from 1998 onwards. All trend data were positively detected values except for caesium-137 and ruthenium-106 concentrations which were below the level of detection from 1997 onwards for Alderney and Guernsey, and from 2000 onwards for Jersey. With the exception of ruthenium-106 data, radionuclide concentrations were also slightly higher at Jersey (in comparison to Guernsey and Alderney) in the earlier of the two decades. However in the more recent decade, with the exception of technetium-99, there is no noticeable difference in the concentrations observed between the Channel Islands. The reasons for these observations are not clear but the differences could be related to water dispersion mechanisms following discharge from La Hague, which become more apparent during relatively higher discharges (during the1990s) or for the most conservative radionuclides such as technetium-99. Indeed, it has been reported that a small percentage (5%) of the La Hague discharge is swept southwest towards the Channel Islands.[13] The results from the monitoring data presented here tend to support the schematic transport map reporting that the water transport flows southwards along the west Cotentin Peninsula coastline, before being swept southwest.[12]

Between 1990 and 2009, caesium-137, ruthenium-106, plutonium-239+240 and americium-241 concentrations in *fucus* seaweed declined with time. The trends in technetium-99 show some scatter in concentrations between individual years, probably due to a variety of environmental reasons (e.g. differences in uptake due to seasonality) and differences in sampling procedures (e.g. different *fucus* species). Overall concentrations are shown to be relatively constant with time, particularly at Alderney and Guernsey.

Figure 4 provides Channel Islands data for caesium-137, ruthenium-106, plutonium-239+240 and americium-241 in seafood (mollusc). Trend data for caesium-137 and ruthenium-106 were at or below the analytical level of detection from 1997 onwards, together with all radionuclide data obtained in 1998. Radionuclide concentrations in mollusc samples were significantly lower than their corresponding determinands in sediments. From the available data, caesium-137 and ruthenium-106 concentrations declined in the early 1990s, reflecting decreasing La Hague discharges,[12] thereafter concentrations were at or below the analytical level of detection. Trends in plutonium-239+240 and americium-241 show some scatter in concentrations between individual years, particularly for the winkle samples collected from Alderney. This scatter in winkle concentrations is to be expected since it has been previously reported that variation (including seasonal changes) is due to varying amounts of sediment being ingested, and that 90-95% of the activity within the winkle is present in the sediment in the alimentary tract.[14]

Assessments of the dose to people who consume high-rates of fish and shellfish are undertaken annually and published in the RIFE report series. In 2009, they were estimated to receive less than 0.005 mSv, which is less than 0.5 per cent of the dose limit for members of the public.[10] The assessment included a contribution from external exposure. In 1989, the survey on the Channel Islands confirmed that doses due to discharges from the French reprocessing plant at La Hague and other local sources were less than 1 per cent of the limit.[9] The concentrations of artificial radionuclides in the marine environment of the Channel Islands and the effects of discharges from local sources, therefore, continued to be of negligible radiological significance.

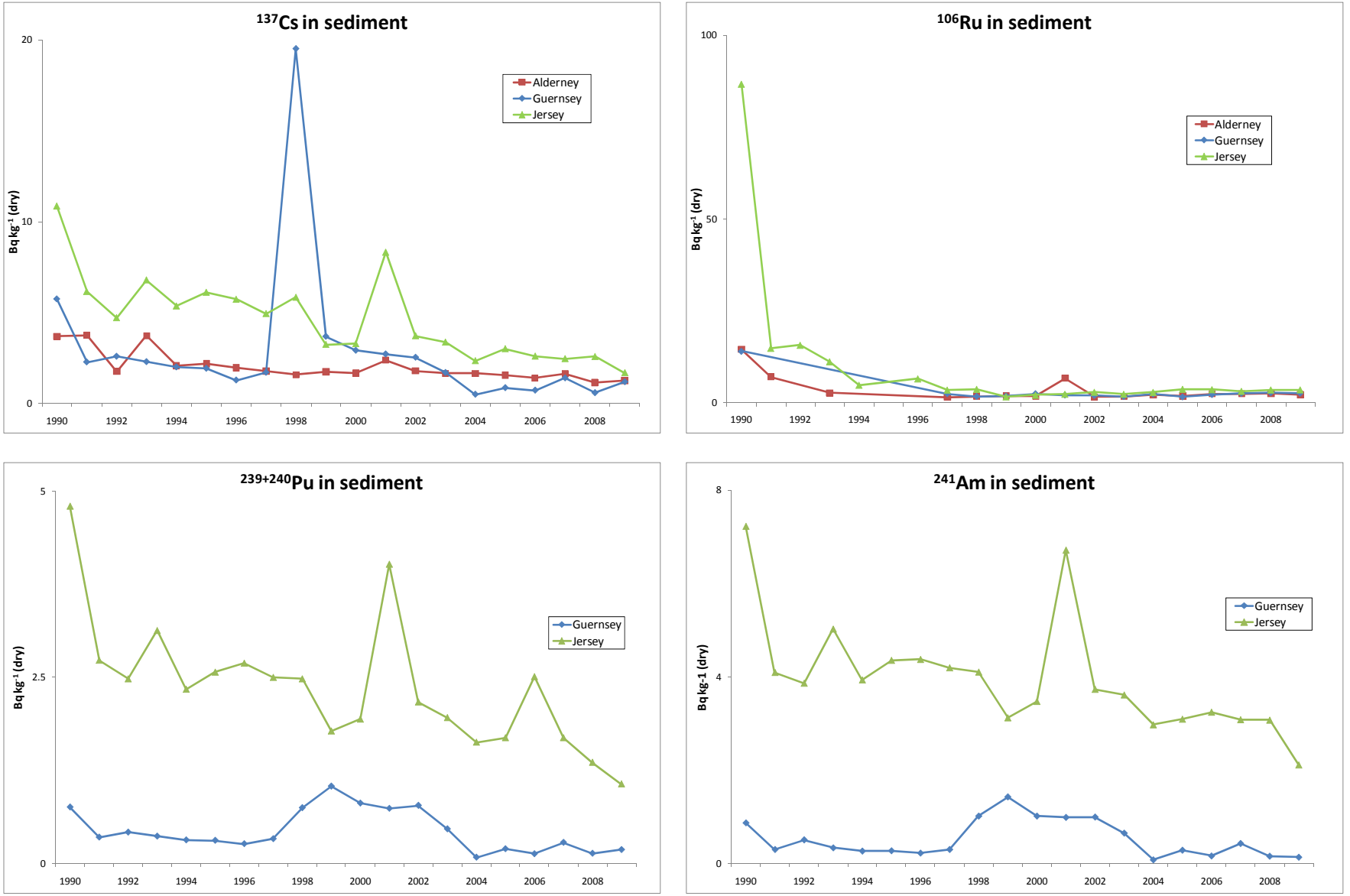

Figure 2 Trends of radionuclide concentrations in Channel Islands sediments (data below the level of detection are indicated in the text)

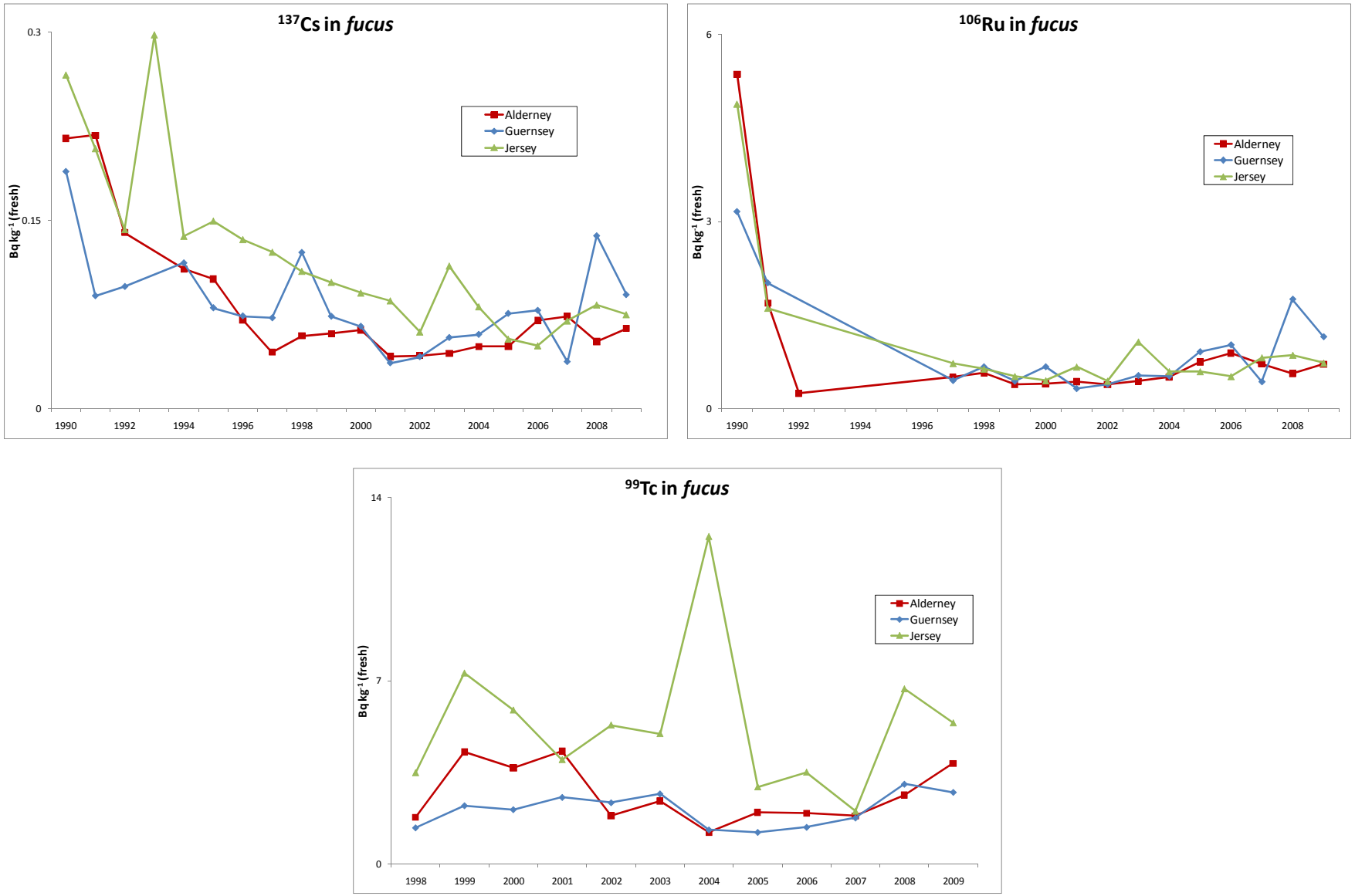

Figure 3 Trends of radionuclide concentrations in Channel Islands seaweeds (data below the level of detection are indicated in the text)

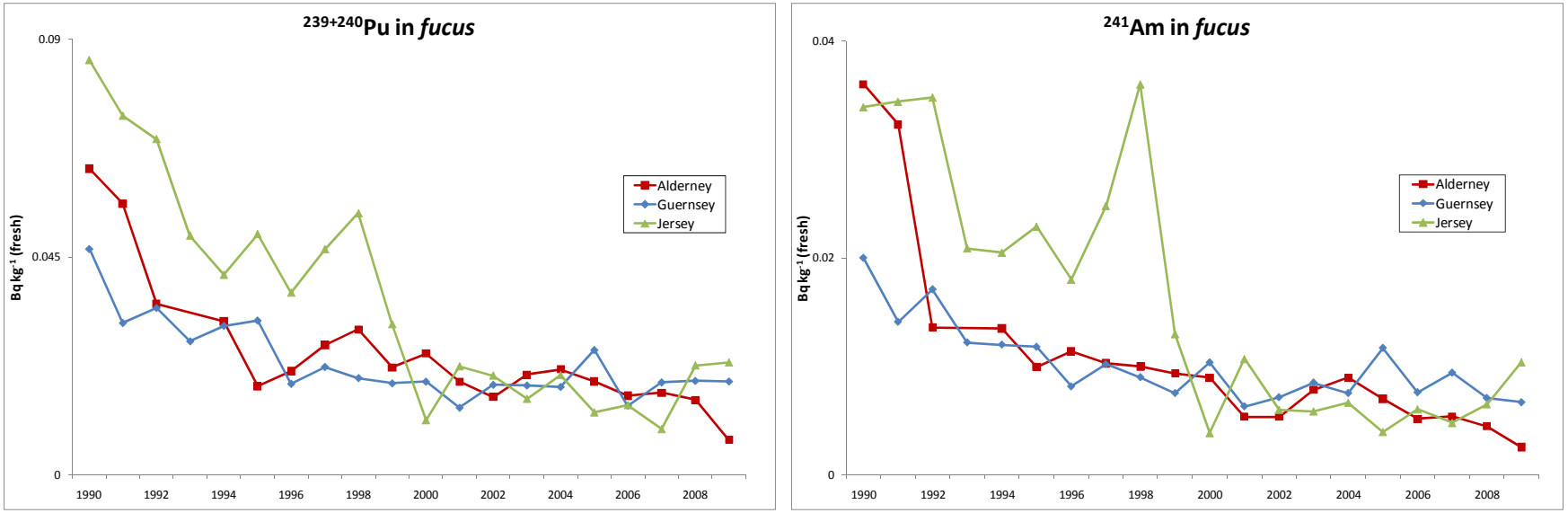

Figure 3 (continued) Trends of radionuclide concentrations in Channel Islands seaweeds (data below the level of detection are indicated in the text)

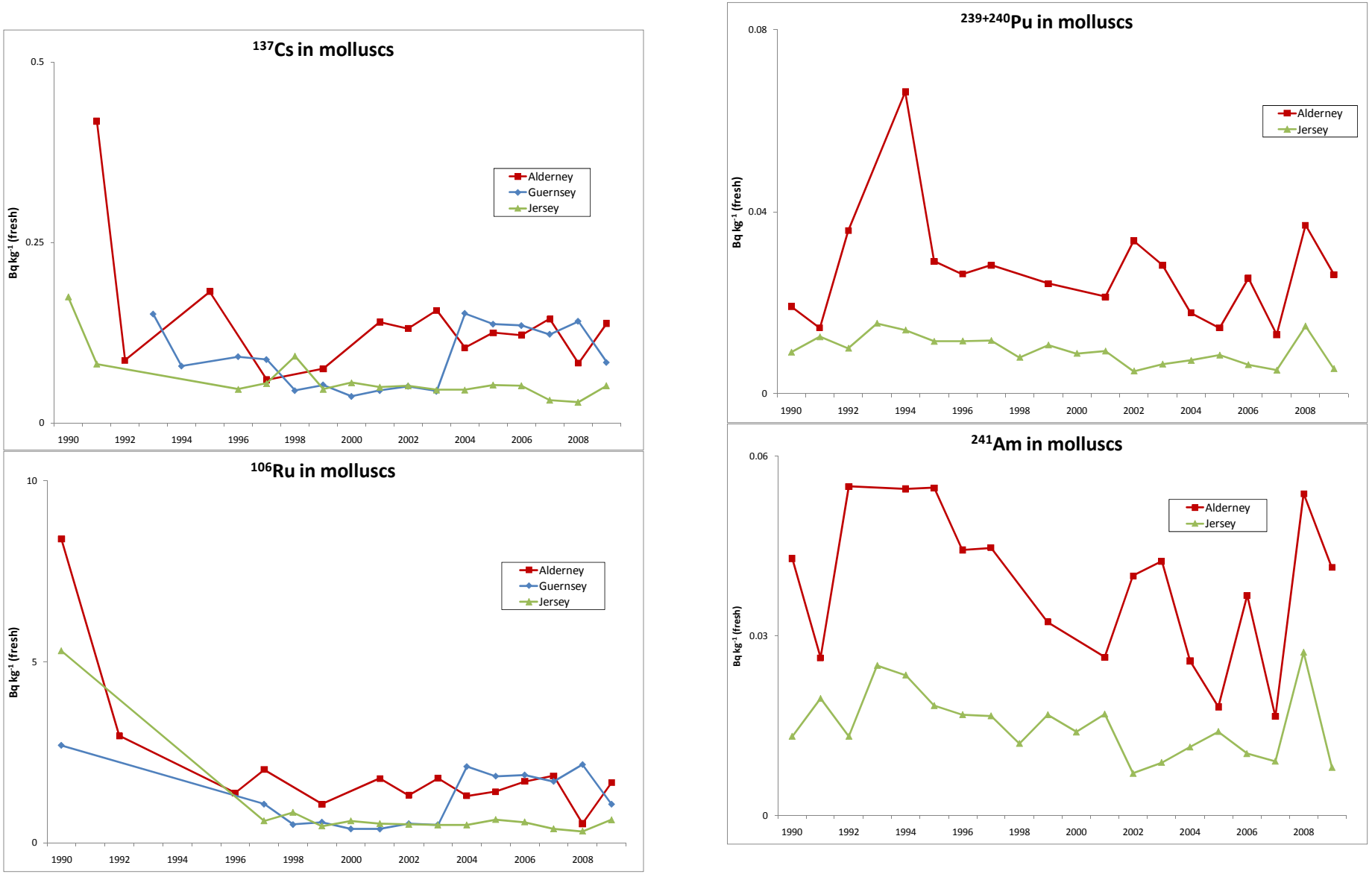

Figure 4 Trends of radionuclide concentrations in Channel Islands molluscs (data below the level of detection are indicated in the text)

5 CONCLUSIONS

The conclusions are summarised as follows

- Relatively low concentrations of radionuclides were detected in the marine environment around all the Channel Islands.

- Most non-transuranic radionuclide concentrations reported here (caesium-137 and ruthenium-106) have declined since the last review in 1998.

- Transuranic radionuclide concentrations reported here (plutonium-239+240 and americium-241) and have either declined since the last review in 1998, or there has been no significant change in concentrations (albeit with some environmental scatter between individual years).

- The effects of discharges from local sources have continued to be of negligible radiological significance.

- There was no detectable effect in Channel Islands waters of any releases of radioactivity from the Hurd Deep site.

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