Has ^{99}Tc from Sellafield entered the English Channel ?

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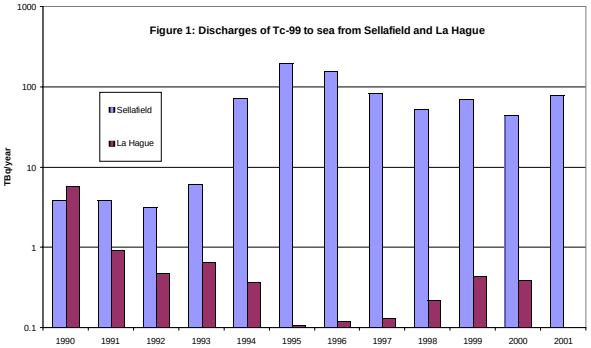
INTRODUCTION

In 1994, operation of the Sellafield Enhanced Actinide Removal Plant (EARP) to treat stored wastes containing actinides and ^{106}Ru also led to increased discharges of ^{99}Tc which could not be treated (Figure 1). The distribution of ^{99}Tc in the Irish Sea and northwards, the direction of predominant flow, has already been subject to a number of investigations. We examine here the potential southerly transfer of ^{99}Tc into St George's Channel, the Celtic Sea and the English Channel over the period 1994 to 2001. The study makes use of the well-known indicator properties of *Fucus* seaweeds for ^{99}Tc.



METHODS

Samples of *Fucus vesiculosus* and *Fucus serratus* have been regularly collected for a number of years from locations on the English, Welsh and Channel Islands coasts for the CEFAS Laboratory, Lowestoft and on the French coast by staff of LERFA, Cherbourg - Octeville. Many of these samples have been analysed for ^{99}Tc as part of regular monitoring or other programmes. These time-series were used to examine temporal changes related to releases from the two main sources, the reprocessing plants at Sellafield and La Hague. The locations of samples used in this study are shown in Figure 2.

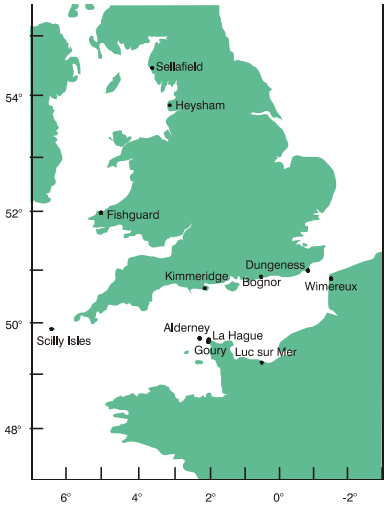


Figure 2.

RESULTS

Results are shown in Figures 3-5.

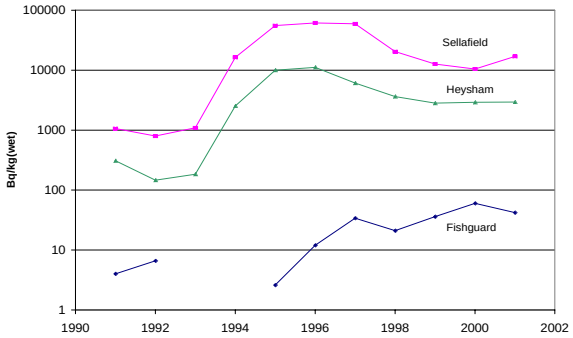


Figure 3. ^{99}Tc in *Fucus vesiculosus* from the Irish Sea, 1991-2001

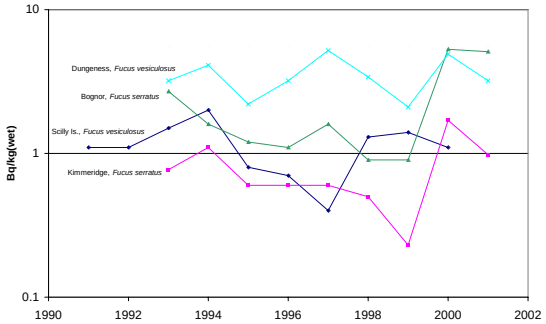


Figure 4. ^{99}Tc in *Fucus* from English coasts, 1991-2001.

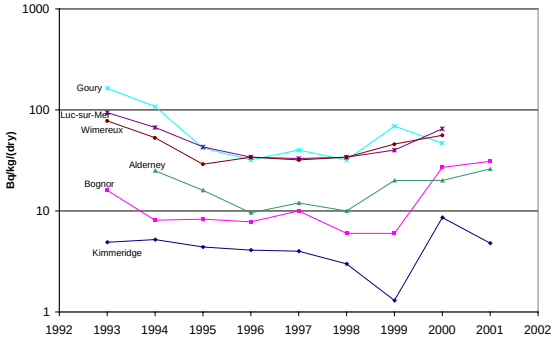


Figure 5. ^{99}Tc in *Fucus serratus* (Bq/kg(dry)) from both sides of the Channel, 1993-2001

DISCUSSION

Data from Sellafield and Heysham (Figure 3) show a clear increase in the level of ^{99}Tc in *Fucus* in 1994, with a generally reducing level from 1996-7, following the pattern of discharges (Figure 1). At Fishguard, the increase is not noted until the sample for 1996, followed by a generally smoother and possibly continuing plateau. However, the peak concentration, 60 Bq kg^{-1} (wet) measured in 2000, is some 3 orders of magnitude lower than the average peak value near Sellafield in 1996 (62000 Bq kg^{-1} (wet)).

For the data on the English coastline (Figure 4), there is much less clear evidence of a front following that observed at Fishguard for 1996. The Scilly Isles samples show no significant differences; a t-test comparing the data for 1998-2000 with 1991-1997 gives P ~ 0.2. Similarly, at Kimmeridge, if one selects data for 2000-01 and compares with 1993-99, the increase is not significant (P ~ 0.15). For these two sites, the ambient levels are low and of the order of 1 Bq kg^{-1} (wet), which may be considered to be close to the background levels of the Atlantic due to weapons-test fallout. The data are in reasonable agreement as experience has indicated that *Fucus vesiculosus* gives about twice the concentration of *Fucus serratus*. Similar low levels are observed in Fucus harvested on the French coast, in the vicinity of Brest. For samples from Bognor, there are greater ambient levels than at Scilly and Kimmeridge, possibly due to earlier higher levels of discharges from La Hague. At Bognor there is an increase for samples in 2000 and 2001 which is significant compared with 1993-1999 on the basis of a t-test (P < 0.001). It is unclear whether this could be due to the Sellafield front, in the absence of one at Scilly or Kimmeridge. At Dungeness, also, no significant increase is noted for data for 2000/1 (P ~ 0.3).

Fucus from Goury, Luc sur Mer and Wimereux (Figure 5) demonstrate higher ambient levels of ^{99}Tc than on the English coast, by about an order of magnitude. At Alderney, levels are only about a factor of two higher than on the English coast; in addition, eastwards from La Hague along the French coast, levels do not diminish significantly with distance from La Hague. Both these observations reflect the flow pattern close to the French coastline. There is an indication of increased concentrations in *Fucus* from 1998 at French locations, Alderney and Bognor in 2000-1 as already noted; this could reflect the trend in La Hague discharges.

Figure 6. Collection of *Fucus* seaweed

CONCLUSIONS

In this study, the effects of ^{99}Tc from Sellafield, particularly the increased discharges from 1994, have not been clearly observed in the English Channel. It is instructive to derive a "detection limit" for this study. We can first make some quantitative estimates of the effect due to postulated inputs. If, say, 1% of the mean discharge from 1994-1997 (1.25 TBq y^{-1}) entered the Channel, with a mean eastward residual flow rate (including wind forcing) of 114000 m^3 s^{-1}, the mean sustained increase in concentration of ^{99}Tc in sea water of the Channel would be ~0.35 Bq m^{-3}. This would correspond to an increase in concentration in brown seaweed (CF ~3 10^4) of about 10 Bq kg^{-1}(wet). In this study, following the increased Sellafield discharges, it is likely that a systematic increase of say 2 Bq kg^{-1}(wet) in the ^{99}Tc concentration would have been observed. This is equivalent to about 0.2% of the Sellafield discharges of ^{99}Tc.