^{137}Cs accumulation in coastal sediments in Sweden

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Abstract: Seabed sediment samples were collected in 1998, 2000 and 2001 at 20 sites located in the Baltic Sea and 4 sites in the Skagerrak. The objectives of the sampling campaigns were (i) to establish the coastal sediment distribution of ^{137}Cs, (ii) to evaluate the vertical core distribution of ^{137}Cs, (iii) to study the sediment accumulation rates, and (iv) to assess the sediment inventories of ^{137}Cs. The results show a very high variation in ^{137}Cs concentrations and an almost 100-fold difference in inventories, showing predominance of Chernobyl derived ^{137}Cs in the Baltic Proper compared to the western Baltic and the Skagerrak areas. Sediment accumulation rates were highly dependent on sediment types and ranged from 0.05 to 1.8 cm y^{-1}.

Introduction

Seabed sediment samples were collected during three cruise expeditions along the Swedish coast in June 1998 (GAUSS #320), July/August 2000 (GAUSS #352) and in June/July 2001 (GAUSS #369), (Fig. 1), organized by the German Federal Maritime and Hydrographic Agency. Six sites located in the Baltic Proper and 2 sites close to the Danish Straits were investigated in the 1st cruise. Five sites located in the Bothnian Sea of the Baltic Sea and 3 sites in the Baltic Proper were investigated in the 2nd cruise. In the 3rd cruise 8 sites were investigated, 1 site located on the southern part of the Baltic Proper, 3 sites located on the western coast in the Kattegat, and 4 sites situated in the Skagerrak.

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Material and methods

The sediment samples were collected by means of gravity corers and box-core samplers (sub sampling with cylindrical tubes) for sediment depths down to about 50 cm. The sediment cores were sliced on-board at 1 cm intervals and collected and sealed in plastic bottles. After freeze-drying in the home laboratory and determination of sample wet- and dry weights, the samples were homogenized and transferred to standard geometry plastic tubs (60ml, 90 ml volume) for analysis by gamma spectrometry in a low-level underground laboratory. The sediment concentrations of ^{137}Cs and ^{226}Ra were assessed by using ^{137}Cs and ^{226}Ra standard solutions (traceable to NIST) thoroughly mixed in inactive sediment materials.

The gamma spectrometry analysis were followed by radiochemical analysis of ^{210}Po. About 0.5-2 g dry sample material was used together with ^{208}Po standard solution for

yield determination. The samples were wet ashed by microwave treatment using a standard protocol at approx 200°C/12 bar. After dissolution and conversion into chloride form, Po was deposited spontaneously onto Ag discs using a standard protocol. The ^{208}Po and ^{210}Po content was assessed by alpha spectrometry using a Ortec Octete^{TM} system with PIPS detectors. The sediment accumulation of ^{210}Pb was then obtained by assessing the non-(^{226}Ra)-supported ^{210}Pb concentrations using the ^{210}Po and ^{226}Ra data. The calculations were made from the assumption of constant rate of supply (CRS) of ^{210}Pb.

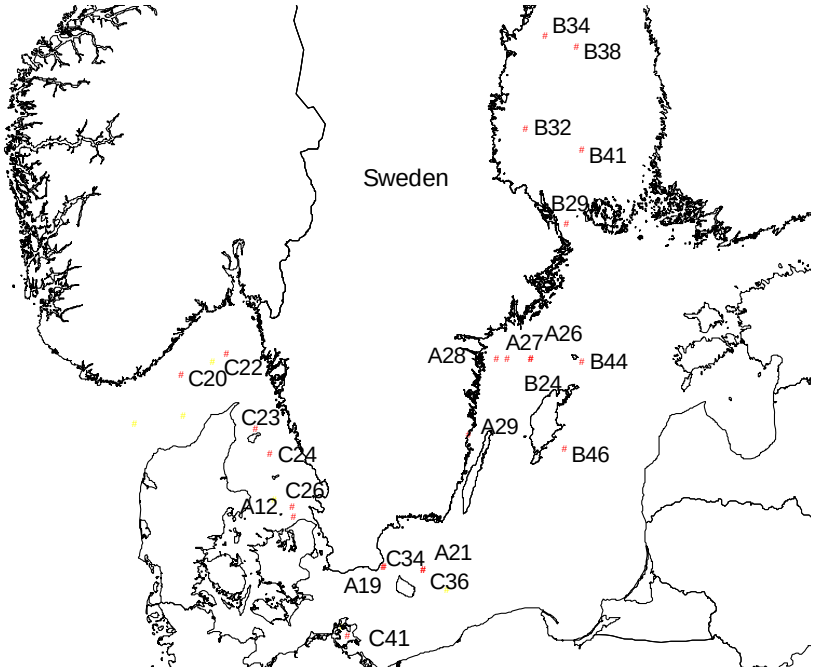

FIG. 1. Sampling sites

Results and discussion

The set of graphs in Fig. 2 show the depth distributions of ^{137}Cs and ^{210}Pb for 6 of the 24 sampling sites (site symbols A denote the 1998 cruise, B the 2000 cruise and C the 2001 cruise). The sediment depth distributions show in general a typical distinct peak concentration, ranging from parts of cm up to about 30 cm, followed by a monotone decline with depth. The depth of the mixing zone is much dependent on the sedimentation rate and organic content. In general, the maximum ^{137}Cs concentrations are at least one magnitude higher in the Baltic Sea compared to the Skagerrak and Kattegat areas, showing the predominance of deposition from the Chernobyl accident release. The total input to the Baltic Sea from the Chernobyl accident amounts to about 4700 TBq, compared to the estimated deposition of 900 TBq from atmospheric weapons tests and about 250 TBq from European nuclear reprocessing releases (EC 1998).

The sediment accumulation rates (Fig. 2) show on large variation, ranging from 0.05 to 1.8 cm y^{-1}. The sediments are of different types; sands, sandy mud, muddy sand, varved clays, pelitic muds, fine aleurite muds and moraine deposits. In addition, the organic content in the upper part of the sediments showed on large variation. No clear correlation between accumulation rates and sediment type was observed. Neither is there an indica-

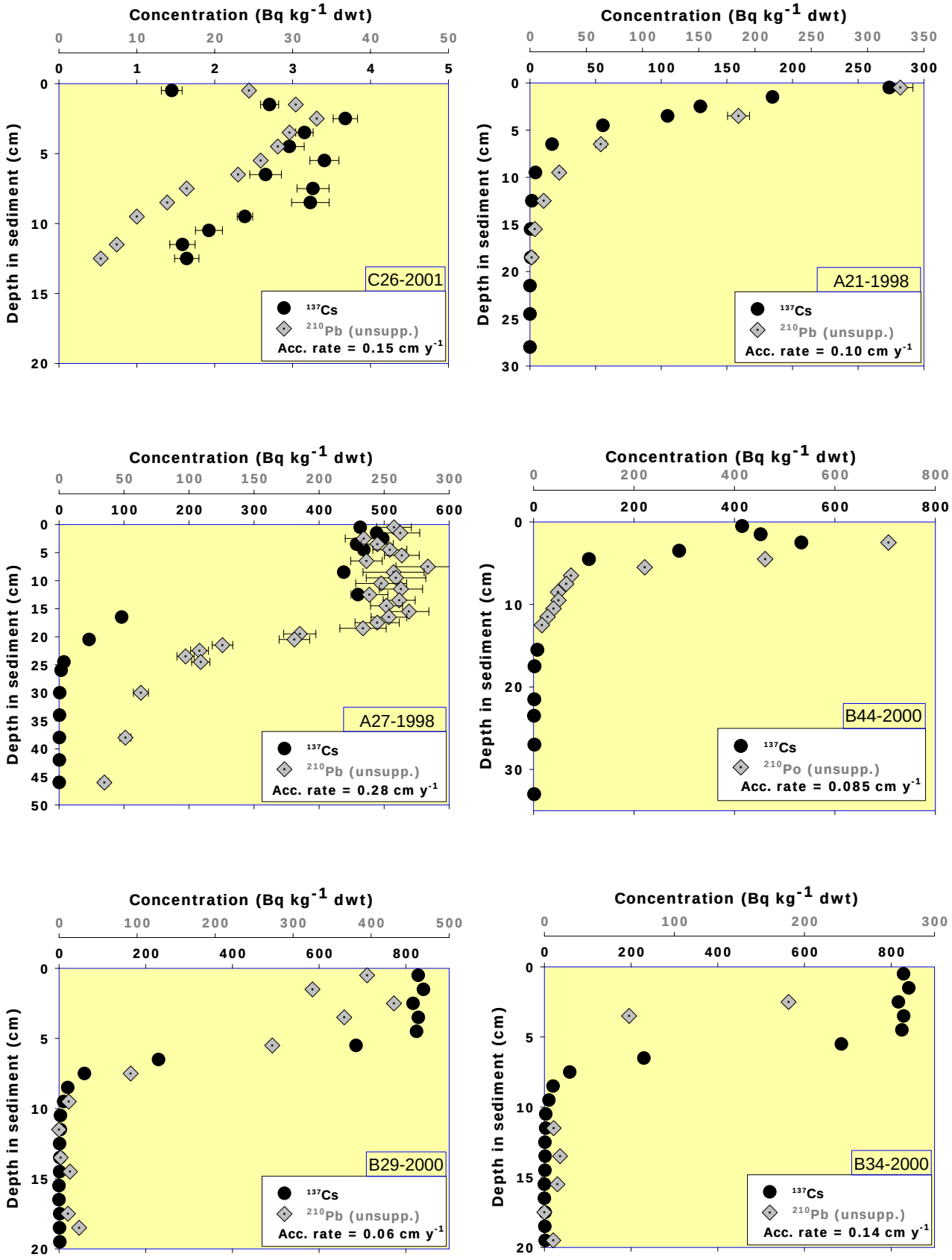

FIG. 2. Concentrations of ^{137}Cs and ^{210}Pb and sediment accumulations rates in Baltic Sea sediments

tion of expectedly higher deposition rates in deep basin areas or with water depth in general. However, the deposition rates show good agreement with literature data for the Baltic Sea (Jonsson et al. 1990, Jonsson 1992) and for the Gulf of Finland (Vallius et al. 1998).

The sediment inventories of ^{137}Cs are displayed in the figure 3, showing an almost 100-fold difference in inventories. In general, as expected, the western coast display very moderate inventories, comparable to the cumulative deposition from global atmospheric fallout, whereas the inventories in the Baltic Sea show a predominance from the Chernobyl accident release (for some sites comparable to the terrestrial deposition of the areas).

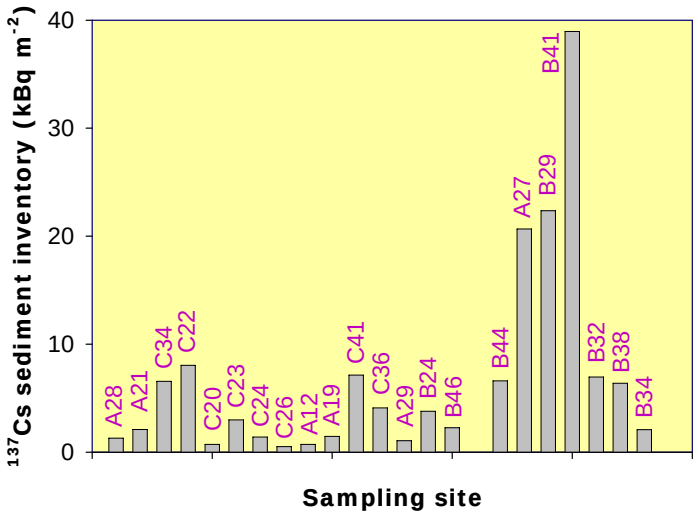

FIG. 3. ^{137}Cs sediment column inventories in the Baltic Sea

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