# Cesium-137 Contamination in Arctic Sea Ice

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Sea ice and ice-borne sediment samples were collected across the western Arctic basin on the joint U.S./Canada Arctic Ocean Section during August, 1994. Samples were processed on board and returned at the completion of the cruise to Oak Ridge National Laboratory for analysis. Sediment was observed on the surface and in the ice from the southern ice limit in the Chukchi Sea to the North Pole. Preliminary results on the ice-borne sediment samples shows widespread elevated concentrations of $^{137}Cs$ ranging from 4.9 to 73 mBq g dry weight$^{-1}$ (Figure 1). The lowest concentrations measured (4.9 to 5.6 mBq g dry weight$^{-1}$) were found in samples on the Chukchi Sea continental shelf, and correspond to activities reported for Chukchi Sea bottom sediments. The highest value (73 mBq g dry weight$^{-1}$) found north of the Chukchi Sea, is comparable to elevated levels present in the shelf sediments of the Yenesey River estuary. Although these levels are not dangerous, they are in several cases significantly higher than any bottom surface sediments collected in the Bering, Beaufort and Chukchi Seas from 1992-1994 (Figure 2).

In collaboration with Tom Beasley from the Environmental Measurements Laboratory plutonium and neptunium activities were measured. The plutonium isotope ratio ($^{239}Pu$:$^{240}Pu$) of the high $^{137}Cs$ sample discussed above was lower (0.17) than would be expected for integrated world bomb fallout (0.18-0.20), but higher than surface sediments in the Yenesey River estuary (0.13-0.16). Plutonium isotope ratios of surface sediments in the Ob River estuary are similar (0.17-0.18), however, ice formed in these locations in the Kara Sea would not typically be transported into the Beaufort Gyre, where the highest radiocesium concentrations were observed.

Additionally, two other sea ice sediment samples had even lower $^{240}Pu$:$^{239}Pu$ ratios (0.13 and 0.14), indicating an origin which is in part from nuclear re-

processing activities. These ratios were observed in sea ice sediments with modest radiocesium concentrations (7.5 and 12.3 mBq g dry weight $^{-1}$, respectively). All of the other sea ice sediment samples have $^{240}Pu$:$^{239}Pu$ ratios consistent with plutonium of bomb fallout. There are also indications that $^{237}Np$:$^{239}Pu$ levels in the samples with low $^{240}Pu$:$^{239}Pu$ ratios show an excess of neptunium over that in integrated bomb fallout, again suggesting an origin from nuclear re-processing activities.

In comparison to sediment associated with sea ice, $^{137}Cs$ concentrations of the ice itself were less than 1 mBq l$^{-1}$. No other anthropogenic radionuclides were detected during gamma spectroscopy. Concentrations of $^{129}I$ in the sea ice samples, assayed using accelerator mass spectrometry were also consistently low, around 1 x $10^8$ atoms l$^{-1}$, which are comparable to surface Arctic Ocean waters.

These results indicate that sea ice is a primary transport mechanism by which contaminated sediments are redistributed throughout the Arctic Ocean and possibly exported into the Greenland Sea and North Atlantic through Fram Strait. The wide variability in the ice-borne sediment concentrations of $^{137}Cs$ measured along the transect argues that contaminants incorporated on the Siberian shelves can follow much more variable trajectories than is suggested by mean ice drift calculations.

Our findings strongly support future investigations of processes of radionuclide and sediment incorporation into ice. Likewise, modeling of ice transport from the Siberian shelves, as well as probability studies of ice trajectories derived from historical and current buoy drift fields are warranted to determine the fate of ice transported radionuclides. Monitoring on the Beaufort Sea shelf of Alaska is suggested.

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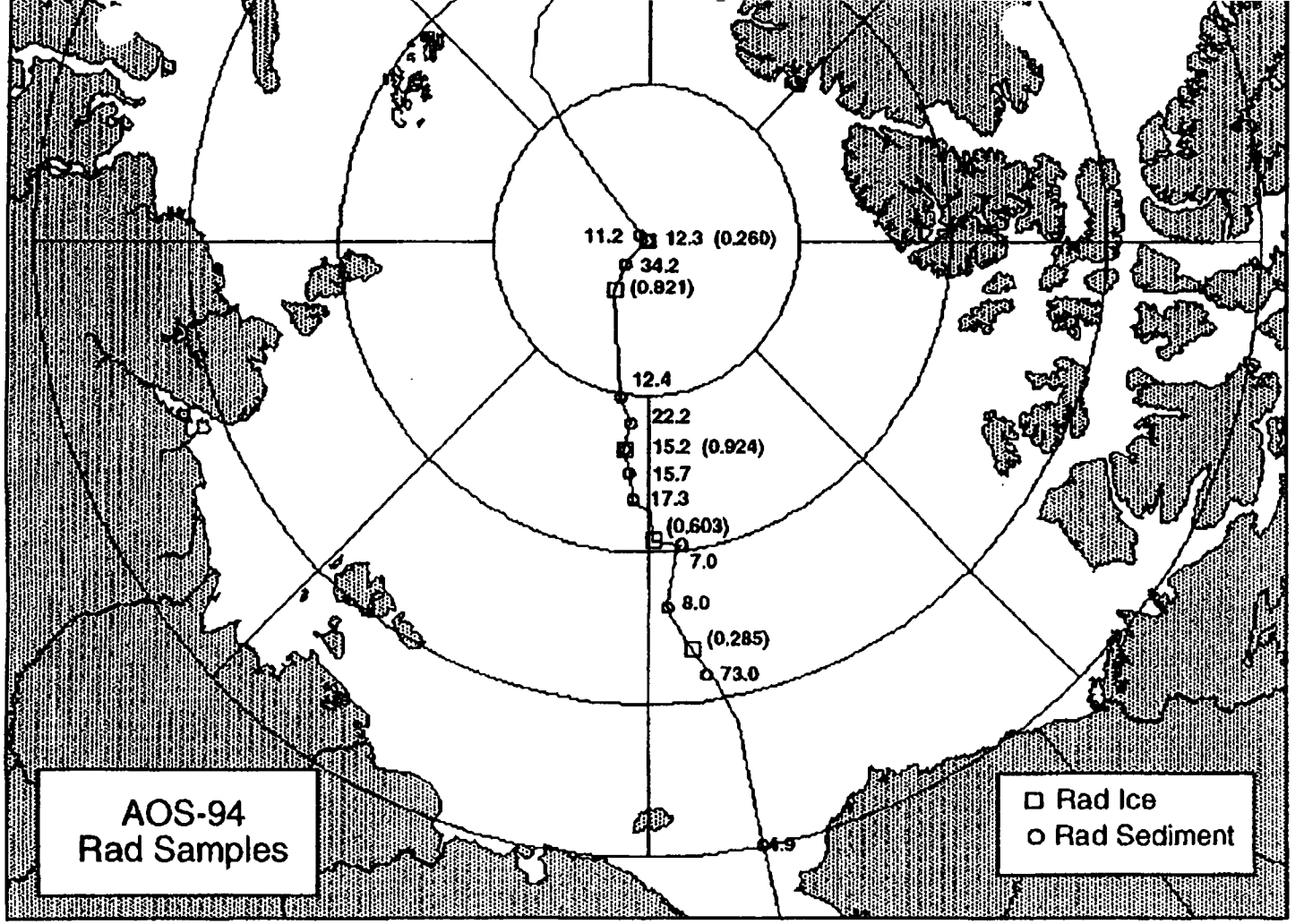


Figure 1. AOS-94 cruise track. Numbers indicated by squares are $^{137}Cs$ activities for sea ice samples, those indicated by circles are $^{137}Cs$ activities for ice associated sediment.

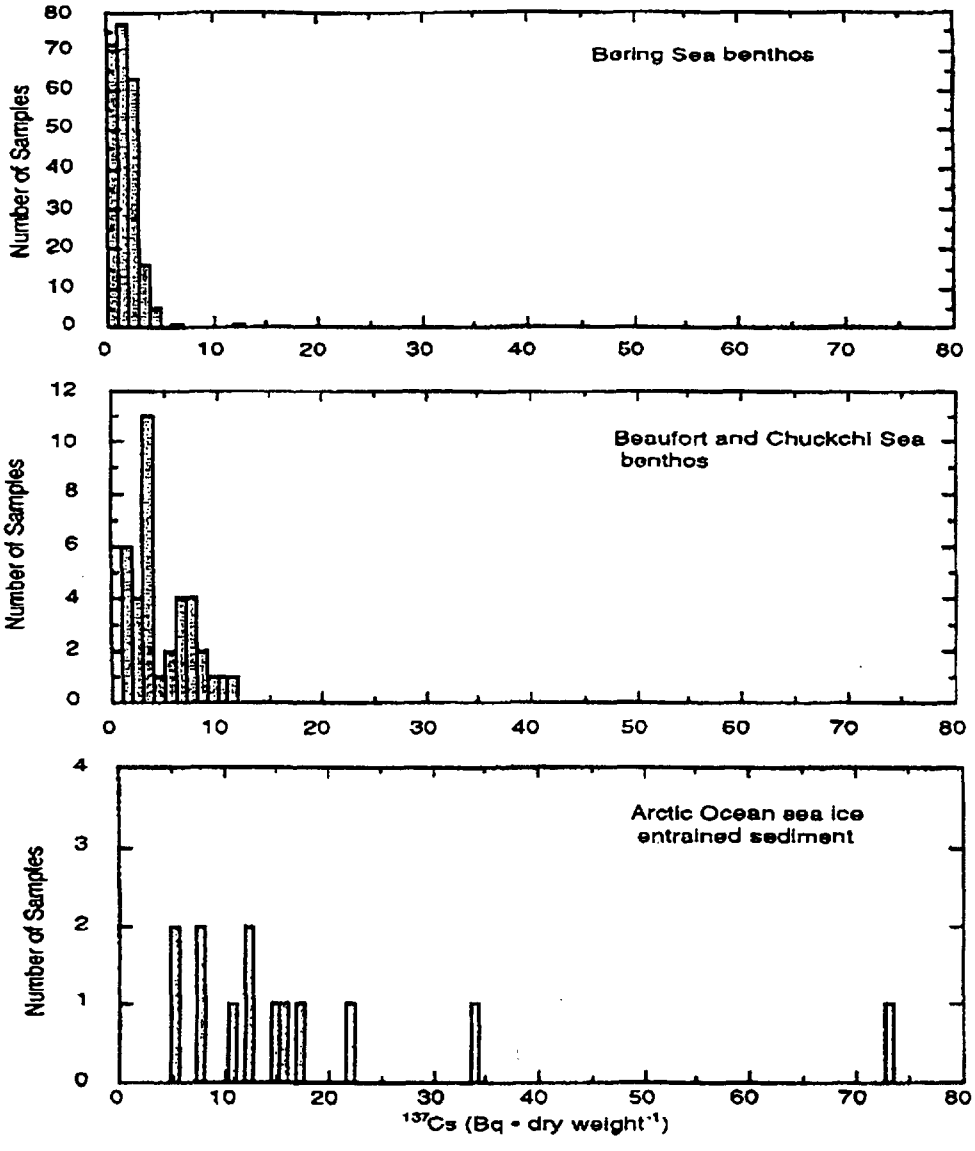


Figure 2. Distributions of sediment activities of $^{137}Cs$ (Bq • kg dry weight-1) detected in surface (0-4 cm) sediments collected in the Bering Sea (top panel), Beaufort and Chukchi Seas (middle panel) and in sediments entrained in Arctic Ocean sea ice (bottom panel). Radioactivity ranges reported correspond to the date of collection. Bering Sea samples were collected in 1990, 1992, 1993, and 1994. Samples north of Bering Strait were collected in 1991, 1992, and 1993. Sediments entrained in sea ice were all collected in August, 1994 except for one sample collected in August, 1993.