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Abstract:

The objective of this summary investigation was to identify trends in radionuclide concentrations for wildlife and food products sampled from 1971 through 1988 as part of the Hanford Site Environmental Monitoring Program. No upward trends in radionuclide concentrations were detected for any wildlife or food products. Several sample types demonstrated significantly declining radionuclide concentrations. Three factors appeared to be responsible for the trends. First, the cessation of atmospheric testing by the United States and Soviet Union in 1971 contributed to the decline of radionuclides in some samples. Second, contaminants discharged to the Columbia River were reduced subsequent to the 1971 shutdown of the last Hanford nuclear reactor that used a once-through cooling water design. The reactor closing resulted in declines in activation products in oysters from Willapa Bay and in whitefish from the Hanford Reach of the Columbia River. Third, reductions in radionuclide concentrations in Hanford wildlife suggested a decreasing availability of environmental contaminants to wildlife. Remediation of areas having environmental surface contaminants on the Hanford Site was identified as a probable cause.

Key words: radionuclide trends, wildlife, food products, Hanford Site

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INTRODUCTION

Radiological monitoring at Hanford has been conducted to document the presence of contaminants on and near the Hanford Site and to evaluate radiological impacts from Hanford Site operations. The Hanford Site Environmental Monitoring Program[2] annually samples wildlife near the 100 Area and 200 Area nuclear facilities (Figure 1). Also collected are food products from nearby farms, distant farms, and grocery stores. The monitoring program also collects fish samples from the Columbia River, which bisects the Hanford Site (Figure 1). In the past, oysters were collected from Willipa Bay, downstream from Hanford, near the mouth of the Columbia River. The objective of this summary evaluation is to review the last 18 years (1971 through 1988) of Site monitoring data on wildlife and food products for long-term trends.

Sampling methods, analytical procedures, data, and interpretation of results for wildlife, food products, and other sample media are reported annually for the Hanford Environmental Monitoring Program (see Jaquish and Mitchell, 1989, for the most recent annual report).

METHODS

Six wildlife categories and six food product categories were identified for trend analyses. Wildlife data collected included samples from mule deer (Odocoileus hemionus); rabbits and hares (collectively referred to as rabbits); upland game birds, including ring-necked pheasants (Phasianus colchicus), California quail (Callipepla californica), and grey partridge (Perdix perdix); waterfowl; mice; and mountain whitefish (Prosopium williamsoni). Food product data collected were for leafy vegetables, milk, beef, chickens, eggs, and oysters.

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[2] Environmental monitoring at the Hanford Site is conducted by Pacific Northwest Laboratory.

The radionuclides included in the trend analyses (Table 1) were those known to be of Hanford origin and also of general interest because of their potential for biological transport through food chains. Annual medians were used to evaluate the radionuclide concentration data (pCi/g wet weight) for wildlife and food products. The median was chosen because it is less sensitive than the mean to extreme values (e.g., unusually high or low values) and may be more representative of central tendency for radionuclide data, which are often log-normally distributed.

Simple linear regressions were performed on the annual median values for samples collected between 1971 and 1988. The regressions were conducted to permit an evaluation of trends (increasing or decreasing change through time) in radionuclide concentrations, rather than to define statistical relationships between concentration and time. If a regression fit was significant, then the slope of the regression line was tested (t test) to determine whether the slope was significantly different than zero. In some cases, median values were log-normal transformed before regression analysis to satisfy assumptions necessary for trend tests (Gilbert 1987). These assumptions included normality and independence of errors.

RESULTS AND DISCUSSION

No increasing long-term trends were observed in radionuclide concentrations in wildlife or food products. Some wildlife and food products showed decreasing trends; for others, trends were undetectable (Table 1). Table 1 also shows a third trend category that includes samples that could not be tested for trends because they failed to meet test assumptions.

Median annual concentrations of two activation products, ^{60}Co and ^{65}Zn, demonstrated significant declines in Columbia River mountain whitefish muscle as did ^{65}Zn in oysters (Table 1). A pattern of rapid decline for ^{60}Co in Columbia River mountain whitefish was observed from 1971 through 1976 (Figure 2). Median concentrations of ^{65}Zn in mountain whitefish and oysters decreased from 1.58 and 4.46 pCi/g, respectively, in 1971 to 0.11 and 0.58 pCi/g in 1973. These rapid initial declines from 1971 were attributed to the 1971 closing of the last of the Hanford reactors that discharged primary coolant water to the river. Cushing et al. (1981) documented similar declines in other Columbia River biota following reactor closing.

From 1981 through 1988, median concentrations of ^{60}Co in the muscle of mountain whitefish collected upstream from the Hanford Site were similar to those found in mountain whitefish from the Hanford Reach (Figure 2). Upstream samples were not taken before 1981.

Median annual concentrations of ^{65}Zn and ^{131}I in milk from local and distant dairies exhibited statistically significant declines as did ^{137}Cs and ^{90}Sr for local milk (Table 1). Autocorrelations in the data prevented a trend analysis for ^{137}Cs and ^{90}Sr on milk from distant dairies; however, nearly identical patterns were observed for declining concentrations of ^{137}Cs in milk from both local and distant dairies (Figure 3). The decline occurred most rapidly from 1971 through 1976. This pattern was representative of ^{65}Zn and ^{131}I concentrations in milk as well.

The decreases in radionuclide concentrations in milk are consistent with declining atmospheric fallout concentrations subsequent to the 1971 treaty limiting atmospheric testing of nuclear weapons by the United States and the Soviet Union. Gross beta analyses of atmospheric particulate samples from eastern Washington for 1971 through 1975 also show a trend of decreasing beta radioactivity in air (Speer, Fix, and Blumer 1976).

Local beef and Willipa Bay oysters showed significant declines in median annual ^{137}Cs concentrations (Table 1). The declines in ^{137}Cs concentrations in these two foods, similar to those discussed for milk, may also have resulted from decreased fallout subsequent to the 1971 limitations on atmospheric testing of nuclear weapons. However, because of a lack of data, no comparisons could be made with distant or control samples. But the maximum ^{137}Cs concentrations for these two foods were low compared with ^{137}Cs concentrations in many Hanford wildlife (Table 2), suggesting that the source term was fallout.

Rabbits, mule deer, and upland game birds sampled on the Hanford Site each showed significant declines of ^{137}Cs in their muscle tissue (Table 1). Most of these animals were obtained in the vicinity of the 100 and 200 Areas (Figure 1), which contain nuclear facilities. Maximum values (Table 2) for these species were several orders of magnitude above median values, indicating that some specimens sampled had obtained contamination from local sources. However, no control samples for wildlife were obtained, and thus, it is unclear what fraction of the total ^{137}Cs in these samples resulted from fallout and what may have been of Hanford origin. The trend of declining concentrations of ^{137}Cs in mule deer, rabbits, and upland game birds may have been the result of a combination of decreased atmospheric fallout since the 1971 test ban treaty and clean up of surface contamination near Hanford facilities. Since 1980, contaminated ponds and ditches have been drained, and terrestrial sites have been covered with clean soil and stabilized with vegetation (A. R. Johnson, Westinghouse Hanford Company, personal communication).

Cesium-137 concentrations in waterfowl, ^{90}Sr and $^{239-240}$Pu concentrations in mule deer, and ^{90}Sr concentrations in rabbits from the Hanford Site showed no detectable long-term trends (Table 1). Eberhardt et al. (1989) summarized the median and maximum radionuclide concentrations for these samples and noted that the samples probably included radioactivity of Hanford origin. Annual median ^{137}Cs concentrations in Hanford Site waterfowl peaked during the late 1970s and early 1980s and then declined thereafter (Figure 4). The data provided by Eberhardt et al. (1989) also suggest that concentrations of ^{90}Sr in mule deer bone and $^{239-240}$Pu in deer liver declined after peak concentration that occurred during the late 1970s and early 1980s. Despite the lack of long-term trends, a pattern of decreasing radionuclide concentrations is apparent in some Hanford wildlife from about 1978 through 1988. This pattern is consistent with the earlier observation that remediation of environmental surface contaminants may have contributed to a decreased availability of radionuclides to some Hanford wildlife.

Concentrations of ^{137}Cs in local eggs; ^{90}Sr in local and distant leafy vegetables, beef, local and distant chickens, and local eggs; and ^{65}Zn in distant and local chickens all had undetectable trends (Table 1). Annual median radionuclide concentrations for these food products appeared to vary randomly from year to year (Eberhardt et al. 1989).

Unknown trends are largely the result of peculiarities or features of the data that preclude long-term trend analyses. For example, mouse samples could not effectively be analyzed for long-term trends because sampling was conducted for only a few years as part of the Environmental Monitoring Program, samples were from different locations, and sample sizes were generally small. Other samples having unknown trends include ^{137}Cs concentrations in leafy vegetables and in distant milk. For leafy vegetables, many of the median values were negative and thus the analysis for trend was not conducted. The test for autocorrelation was significant for ^{137}Cs in distant milk samples, resulting in an unknown trend.

CONCLUSIONS

Radiological concentration data for selected wildlife and food products collected on and near the Hanford Site from 1971 through 1988 were summarized, and the annual median values were analyzed for long-term trends.

A number of wildlife species showed significantly decreasing radionuclide concentrations from 1971 through 1988 (Table 1). Among food products analyzed, milk, beef, and oysters also showed significant declines for several radionuclides. Although declines in radioactive material concentration in the tissues of individual plants or animals can result from a combination of radioactive decay and biological elimination, long-term declines in equilibrium concentrations indicate a decreasing availability of radionuclides in the environment. The three factors identified as probable contributors to the observed long-term declines were: 1) a reduced contribution of radionuclides to the Columbia River subsequent to the 1971 shutdown of the last Hanford reactors, which was responsible for decline in fish and oysters; 2) reduced fallout following limitations on atmospheric testing of nuclear weapons, which was responsible for decreased radionuclide concentrations in some food products, and 3) waste management area reduction activities on the Hanford Site that have apparently resulted in declining concentrations of radioactive materials in samples of Hanford Site wildlife since the late 1970s.

Trend analyses could not always be completed for all sample types and radionuclides. Sampling was not conducted solely for the purpose of making long-term trend analyses and, for some sample types, sampling periods were brief, sample locations were sometimes variable, and sample sizes were small. Radiological concentration data did not meet test criteria for some samples, and trends were therefore determined to be unknown.

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LIST OF TABLES

TABLE 1. Trends in Median Radionuclide Concentrations in Wildlife and Food Products Collected From 1971 Through 1988

	Trends		
Radionuclide	Decrease[a]	Undetectable[b]	Unknown[c]
^{137}Cs	Rabbits	Waterfowl	Mice
	Mule deer	Local eggs	Distant milk
	Upland game birds		Distant eggs
	Local milk		Distant leafy vegetables
	Beef		Local leafy vegetables
	Oysters		
^{90}Sr	Local milk	Rabbits	Distant milk
		Mule deer	Distant eggs
		Local leafy vegetables	
		Distant leafy vegetables	
		Beef	
		Local chickens	
		Distant chickens	
		Local eggs	
^{65}Zn	Mountain whitefish	Distant chickens	Local leafy vegetables
	Local milk	Local chickens	Distant leafy vegetables
	Distant milk		Local eggs
	Oysters		Distant eggs
^{54}Mn			Mice

^{131}I	Local milk		
	Distant milk		
^{60}Co	Mountain whitefish		Mice
$^{239-240}Pu$		Mule deer	

(a) Significant ($P = 0.05$) regression analyses and significant ($P < 0.05$) t-test for slope.

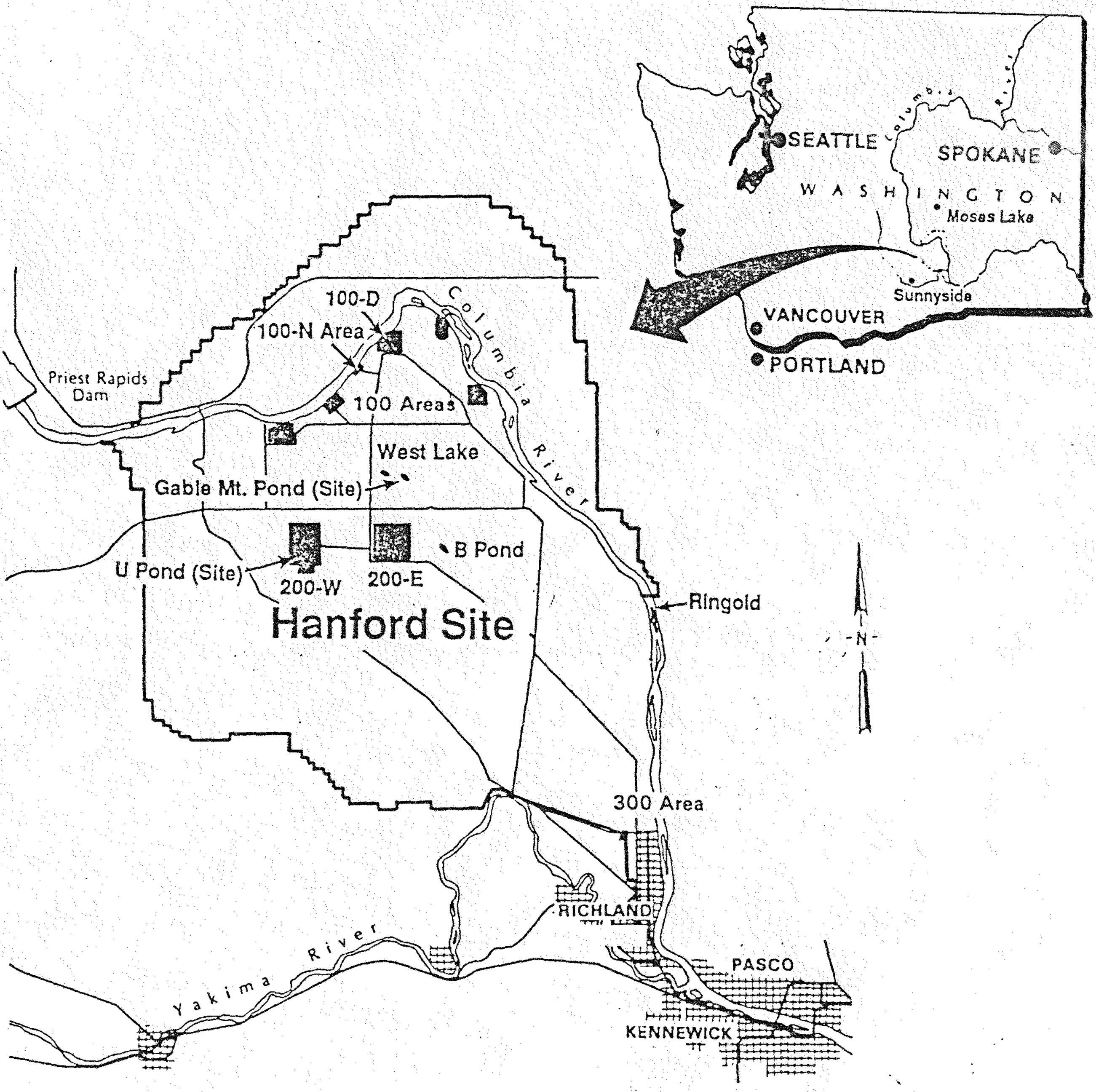
(b) Nonsignificant regression analyses.

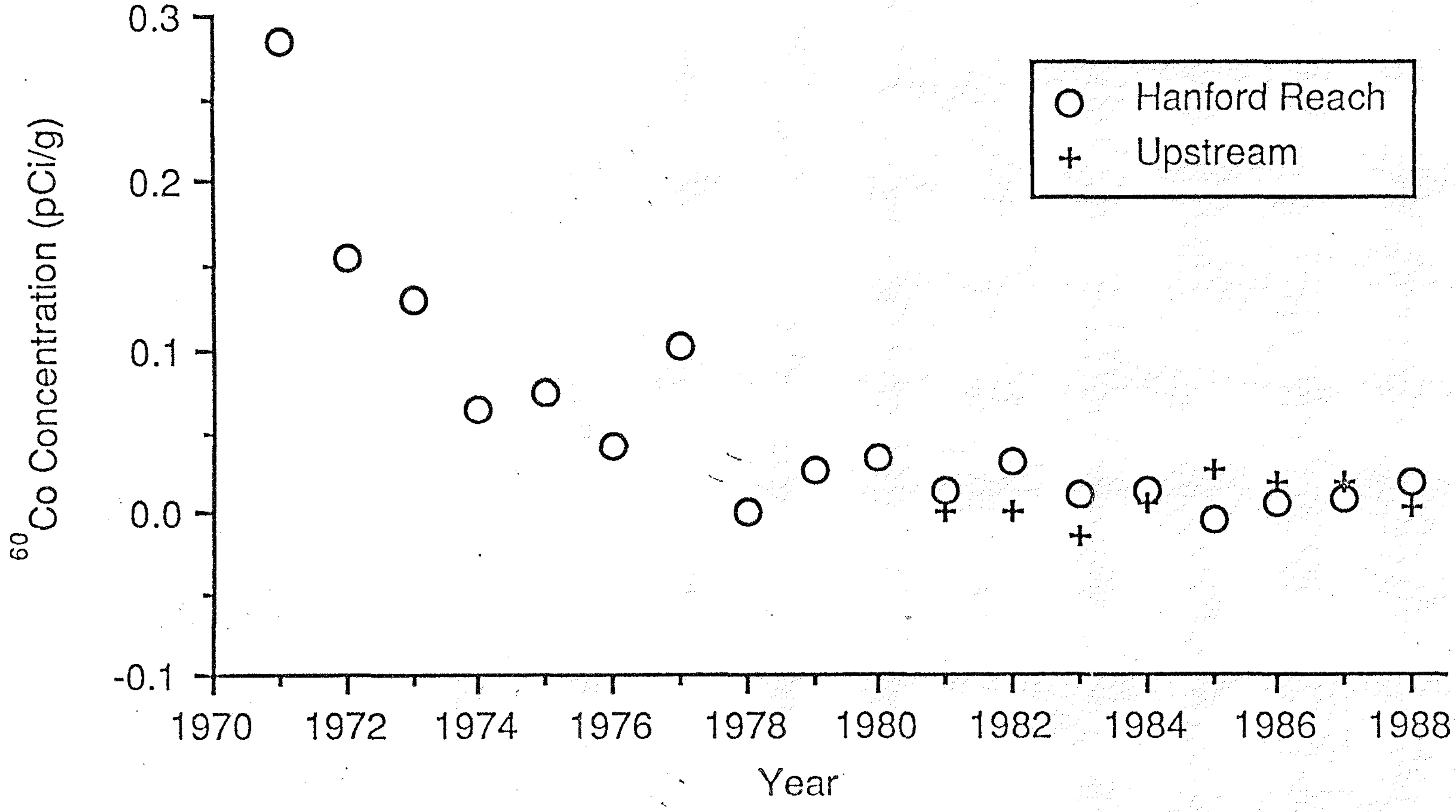
(c) Trend direction is unknown because of autocorrelation, small sample sizes, and/or a large number of samples below detection limits.

TABLE 2. Maximum Radionuclide Concentrations (pCi/g wet weight) in Selected Wildlife and Food Products Collected From 1971 Through 1988

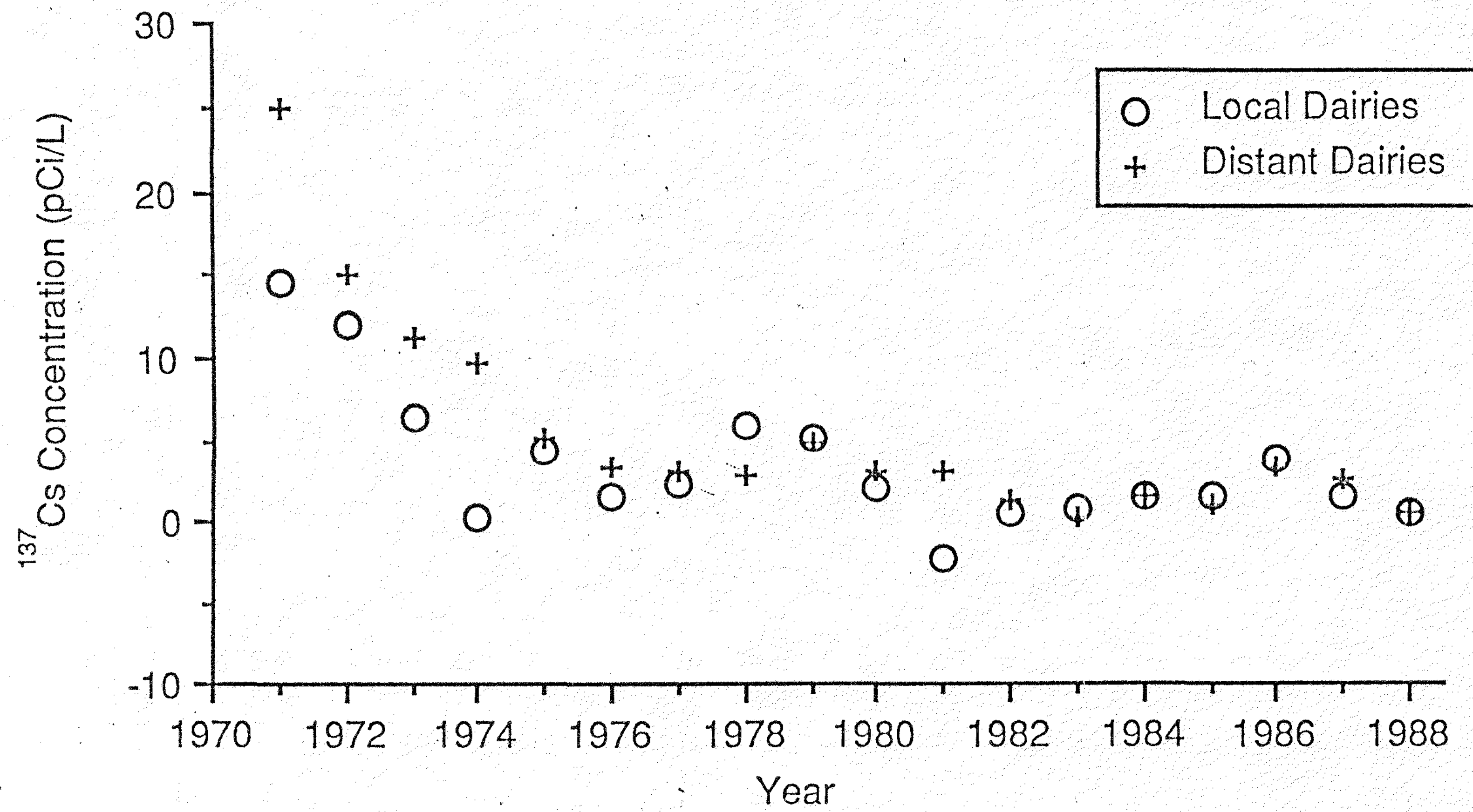
Sample Type	Radionuclide	N	Maximum
Wildlife			
Mule deer	^{137}Cs	91	1.08
Rabbits	^{137}Cs	141	1.94
Upland game birds	^{137}Cs	238	0.09
Mountain whitefish (Hanford)	^{65}Zn	225	1.59
Mountain whitefish (Hanford)	^{60}Co	203	0.28
Waterfowl (Hanford)	^{137}Cs	358	52.3
Food products			
Local milk[(a)]	^{90}Sr	344	2.35
Local milk[(a)]	^{65}Zn	1866	19.1
Local milk[(a)]	^{131}I	1929	0.93
Local milk[(a)]	^{137}Cs	1868	14.45
Distant milk[(a)]	^{65}Zn	460	18.1
Distant milk[(a)]	^{131}I	478	0.81
Local beef	^{137}Cs	107	0.04
Oysters	^{65}Zn	42	4.47
Oysters	^{137}Cs	40	0.04

(a) pCi/L

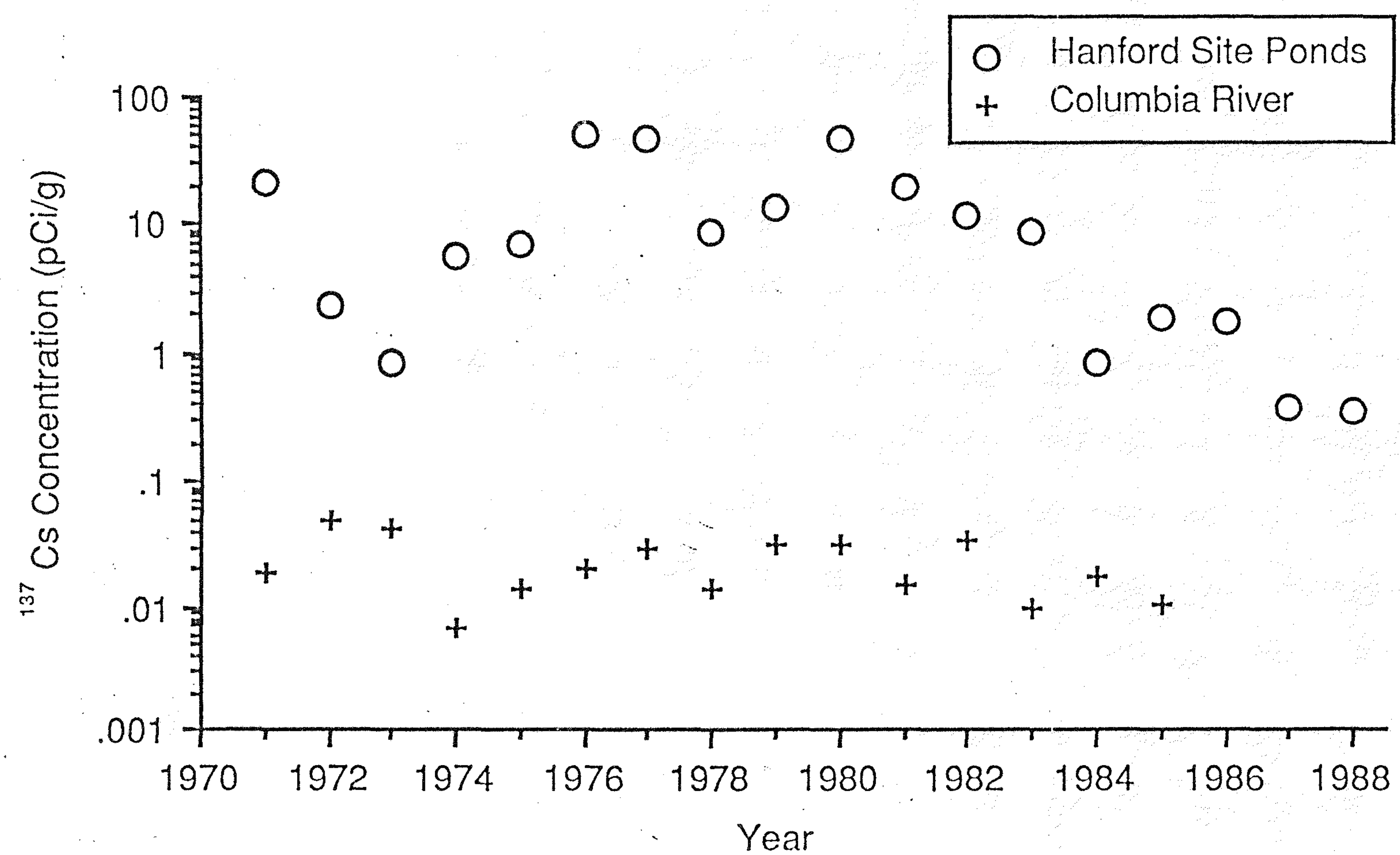

SEATTLE
SPOKANE
WASHINGTON
Moses Lake
Sunnyside
VANCOUVER
PORTLAND
Columbia River
100-D
100-N Area
Priest Rapids Dam
100 Areas
West Lake
Gable Mt. Pond (Site)
B Pond
U Pond (Site)
200-W
200-E
Hanford Site
Ringold
N
300 Area
RICHLAND
Yakima River
PASCO
KENNEWICK



0.3
0.2
0.1
0.0
-0.1
60Co Concentration (pCi/g)
Hanford Reach
Upstream
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
Year



^{137}Cs Concentration (pCi/L)
30
20
10
0
-10
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
Year
Local Dairies
Distant Dairies



Hanford Site Ponds
Columbia River
100
10
1
.1
.01
.001
137 Cs Concentration (pCi/g)
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
Year