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STRONTIUM-90 IN THE U. S. DIET, 1982

By
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July 1984

U. S. Department of Energy
Environmental Measurements Laboratory
New York, New York

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MASTER

ABSTRACT

Estimates of ^{90}Sr intake via the total diet in New York City and San Francisco have been made since 1960 from quarterly food samplings and average consumption statistics. The dietary intake of ^{90}Sr has decreased from the maximum levels attained during 1963-64, but the decline has become more gradual in recent years due to the continuing small amounts of ^{90}Sr deposition and the little-changing cumulative deposit of ^{90}Sr in soil. The annual intake in 1982 averaged 5.4 pCi/day (0.20 Bq/day) in New York, and 2.6 pCi/day (0.096 Bq/day) in San Francisco, little changed from the previous year. Further gradual reductions in ^{90}Sr intake are anticipated during 1983.

INTRODUCTION

Quarterly samplings of representative food items in New York City and San Francisco have been conducted by the Environmental Measurements Laboratory (EML) since 1960. Estimates of the total dietary intake of ^{90}Sr for residents of these cities have been calculated from the results of the ^{90}Sr analyses and estimates of average consumption (U. S. Department of Agriculture, 1967) of these foods. This information has been used to study the transfer mechanisms of ^{90}Sr fallout through the food chain to man and to relate ^{90}Sr intake to observed variations in ^{90}Sr body burdens (Klusek, 1982).

METHODS

In 1982, food samples were collected in New York City and San Francisco. Analysis of food samples for ^{90}Sr is a continuation of the HASL Tri-City diet studies that were started in March of 1960. Estimates of dietary ^{90}Sr intake were then made from 19 representative food items purchased every three months in New York City, Chicago and San Francisco. Sampling was discontinued in Chicago in 1967 and in San Francisco in 1983. The 19 food items represent five major food categories: dairy products, grain products, vegetables, fruit and the combined category of meat, fish and eggs. A description of the sampling method and further details of the diet study program are given in Rivera and Harley (1964). Previously published reports of the diet studies program are listed in Appendix A. In addition to diet items, milk has been collected monthly in New York City since 1954. These data and a summary of programs where tap water and milk from other U. S. cities were analyzed are presented in Appendix B.

All food and milk samples are analyzed for ^{90}Sr at EML. The method of preparation and analysis are presented in HASL-300 (Volchok and de Planque, 1982). The quality of analysis is checked by means of blanks, blind duplicates and standards. The results of the quality control program are presented in Appendix C.

RESULTS

The quarterly results for this program for 1982 are presented in Appendix D. The variation in quarterly daily intake, pCi/day ($1 \text{ Ci} = 3.7 \times 10^{10} \text{ Bq}$), during 1982 is summarized below for New York and San Francisco. The numbers in parentheses are the results for 1981.

Quarter	New York	San Francisco
1	4.6 (6.4)	2.4 (2.4)
2	5.6 (4.8)	2.8 (2.2)
3	5.5 (6.2)	2.9 (2.4)
4	6.0 (6.7)	2.5 (2.3)
Yearly Avg.	5.4 (6.0)	2.6 (2.3)

The quarterly ^{90}Sr intake results for the entire sampling period, 1960-1982, are illustrated in Figure 1. The average ^{90}Sr concentration in each diet item and estimates of ^{90}Sr and Ca intakes for the entire year 1982 are shown in Table 1. It is noted that the calcium intake is estimated to be 370 g per year. Thus, total diet ^{90}Sr intakes expressed as pCi/day or pCi/g Ca are almost equivalent.

DISCUSSION

^{90}Sr Intake, 1982

In New York City the annual ^{90}Sr intake during 1982 was estimated to be 1978 pCi (73 Bq), an average of 5.4 pCi/day (0.20 Bq/day). This is 10% less than the ^{90}Sr intake in the previous year. Although ^{90}Sr deposition decreased from the previous year, the accumulated ^{90}Sr deposit in soil remains little changed. In New York the annual ^{90}Sr deposition was 0.36 mCi/km² (13 Bq/m²) in 1981 and 0.04 mCi/km² (1.5 Bq/m²) in 1982. The global annual deposition of ^{90}Sr during 1981 showed an increase over the previous year due to the detonation of a nuclear device by the Peoples Republic of China in October of 1980 (Larsen, 1983).

Variations in ^{90}Sr intake were noted for several food items, including increases in concentration in dried beans and canned fruit and decreases in fresh fruit and shell fish. In terms of food categories, ^{90}Sr intake in New York in 1982 via fresh vegetables and meat remained unchanged (within 10%) from the previous year, while intake from grain products increased 19%. Intake from milk and fruit decreased 16% and 25%, respectively. Vegetables contributed 36% of the total ^{90}Sr intake in New York during 1982, while milk and other dairy products accounted for 32%. Grain products accounted for 18%, fruits 11%, and the combined category of meat, fish and eggs, 3%.

In San Francisco the ^{90}Sr intake during 1982 was estimated to be 967 pCi (36 Bq), an average of 2.6 pCi/day (0.096 Bq/day), compared to 868 pCi (32 Bq) during 1981. The contributions from the food categories remained

unchanged with the exception of vegetables which increased. The relative contributions to the total ^{90}Sr intake in San Francisco during 1982 were vegetables 36%, grain products 25%, dairy products 21%, fruit 13%, and meat, fish and eggs 5%.

^{90}Sr Intake, 1960-1982

The estimates of annual intake since 1960 of ^{90}Sr in the total diet and the major food categories in New York and San Francisco are illustrated in Figures 2 and 3. The total diet ^{90}Sr levels in San Francisco have been consistently lower than in New York because of less fallout deposition in the San Francisco food-producing region. The declines in ^{90}Sr intake in 1960-61 followed the nuclear testing moratorium in 1959-60. Maximum levels of ^{90}Sr in the diet were recorded in 1963-64, following the period of most active nuclear testing from September 1961 until late 1962, following which the Test Ban Treaty was signed.

The rapid decline in ^{90}Sr intake, following the peak values in 1963-64, became more gradual after 1966-67 as uptake from the little-changing cumulative deposit of ^{90}Sr in soil became the dominant factor contributing to ^{90}Sr levels in food. The resumption of atmospheric testing by the French and Chinese in 1966, resulting in a relatively constant low fallout rate of ^{90}Sr , has also been a factor in maintaining the dietary intake of ^{90}Sr at little changing levels since 1968. The values reported here for New York ^{90}Sr intake are similar to survey data for the U. S. (Simpson et al., 1981) and other Northern Hemisphere countries (UNSCEAR, 1982).

The relative importance of the major food categories to the total daily ^{90}Sr intake can be seen in Figures 2 and 3. Milk, including dairy products, has been the most important contributor to ^{90}Sr intake. Grain products are the second greatest contributors during periods of heavy deposition, but vegetables and to a lesser extent fruit become important in later years. Meat, fish and eggs are minor contributors.

The variation in the relative contributions of the major food categories to the total daily ^{90}Sr intake are listed in Table 2. The contribution from dairy products to the total intake in New York has declined to between 30 and 40%, it previously being above 40% during periods of heavier deposition. The contribution from grain products varies from 30% in periods of heavy deposition to 15% or less in later years.

For vegetables the range is similar to grain products, but the greatest relative contribution has been occurring in more recent years, due in part to the more rapid declines in the contribution of other food categories. In San Francisco, the milk contribution has varied from 20 to 31% of the total yearly ^{90}Sr intake since 1966, the greater contribution having occurred during periods of heavier deposition. Grain products have usually accounted for 20 to 30% with a maximum contribution of 39% in 1964, one year after the peak milk contribution. The contribution from vegetables has increased from 10% in

1964 to 25 to 36% during the last decade. The contribution from fruit in both New York and San Francisco has shown a trend similar to vegetables, but with a somewhat lower relative contribution. Meat, fish and eggs have accounted for 5% or less of the total intake in New York and slightly higher relative amounts in San Francisco.

Correlation of ^{90}Sr Deposition with Levels in Milk

A useful model for correlating ^{90}Sr deposition with ^{90}Sr levels in milk and a procedure for using milk concentrations to predict total diet ^{90}Sr intake were discussed by Bennett (1972). The deposition-milk model is given by the formula:

$$M_n = p_1 F_n + p_2 F_{n-1} + p_3 \sum_{m=1}^{\infty} F_{n-m} e^{-m\mu}$$

where M_n (pCi/g Ca) is the average $^{90}\text{Sr}/\text{Ca}$ ratio in milk in the year n , and F_n (mCi/km²) is the ^{90}Sr fallout deposition during the year n . The proportionality constant p_1 includes the rate and deposition effects of the current year's deposition; p_2 is the lag factor for the previous year's deposition; and $p_3 e^{-m\mu}$ is the deposit factor with exponential removal due to reduced uptake availability of the deposition from each of the preceding years. A similar deposition-milk model has been used previously by Bartlett et al. (1972). Their results for the U. K. are in general agreement with the results reported here.

The results of the least squares fit of the average ^{90}Sr to Ca ratio for milk in New York City through 1982 to the formula are shown in Figure 4. Inclusion of the 1982 fallout and milk data results in no change in the proportionality factors from 1981, which are $p_1 = .68$, $p_2 = .26$, $p_3 = .16$, $\mu = .11$. The mean residence time of ^{90}Sr in soil, i.e., the time ^{90}Sr is available for uptake by plants, inferred from the exponential removal term, is 9.1 years after the initial deposition year. This corresponds to 8% per year removal of ^{90}Sr in addition to the 2.4% radioactive decay. The results of least squares fits to the average yearly ^{90}Sr concentrations in milk in New York through 1970, and subsequent years have been reported previously (see Appendix C). No changes in the model have been required by the additional years of data. The relative stability of the parameter values with fits to additional data reflects the appropriateness of the model formulation.

Table 3 shows the measured annual ^{90}Sr deposition and the $^{90}\text{Sr}/\text{Ca}$ ratio in milk in New York and the milk $^{90}\text{Sr}/\text{Ca}$ ratio calculated by the above model using the given proportionality factors. Estimates from the model are usually within 10% of the average observed value. Also shown in Table 3 is the percentage of the $^{90}\text{Sr}/\text{Ca}$ ratio attributable to uptake of ^{90}Sr from soil. Since 1965, contamination of milk has been primarily due to uptake of ^{90}Sr from the cumulative deposit in soil. In 1982, this source accounted for 95% of the ^{90}Sr contamination of milk.

Estimating ^{90}Sr Intake from Milk Concentration

The procedure for estimating total diet ^{90}Sr intake from milk is given by the following formula (Bennett, 1972):

$$D_i = M_i + fM_{i-1}$$

where D_i is the quarterly ^{90}Sr intake in total diet (pCi), M_i is the measured ^{90}Sr intake in milk during the quarter i and fM_{i-1} is the estimated intake of ^{90}Sr in foods other than milk based on the milk levels during the preceding quarter. Milk may be used as an empirical indicator of ^{90}Sr in total diet, but it is inappropriate to assume a constant relationship through the entire fallout period. During periods of low fallout deposition the proportionality factor, f , is 1.4. The formula gives 4.3 pCi per day in total diet in New York during 1982, somewhat lower than the measured intake of 5.4 pCi per day (Table 1).

The application of this formula to estimate total diet ^{90}Sr intake from milk data, and comparison with the measured total diet intake are shown in Figure 5. Using a constant proportionality factor, $f = 1.4$, for the entire period 1960-82 yields annual estimates of total diet intake within 25% of measured values. To maintain the correlations within 10%, the proportionality factor must be reduced somewhat during the quarters when ^{90}Sr deposition is greater than 3 mCi/km² per quarter (Bennett, 1972). This correction is indicated by the dotted line during 1962-64 in Figure 5.

The more rapid decline of ^{90}Sr contamination of milk compared to other foods in recent years necessitates a further correction in the proportionality factor. Since 1971, a value of $f = 1.8$ is appropriate. This modification is indicated by the dashed line in Figure 5. For 1982, this formula then gives an estimate of 5.0 pCi per day in total diet.

Correlation of ^{90}Sr Deposition with Sr-Ca Ratios in Diet

A more detailed investigation of the transfer of ^{90}Sr deposition to diet is possible by applying the deposition-milk model presented above to other food categories and to the Sr-Ca ratios in total diet. Since there is a

wide area of supply of the various food items, except for milk, the ^{90}Sr deposition has been taken to be the average for the 30-50°N latitude band (Appendix A). The results of the correlations with New York diet data are listed in Table 4 and illustrated in Figure 6.

As seen in Figure 6, the Sr-Ca ratios in fruit and vegetables have been higher than in milk. Fruits and vegetables peaked at just above 50 pCi/g Ca in 1964-65, while the milk reached 25 pCi/g Ca in 1963. However since milk provides 7 and 15 times more calcium to total diet than vegetables and fruits, respectively, the contribution to total daily ^{90}Sr intake from milk has, until recently, been much more important (see Figure 2).

The Sr-Ca ratios in milk and grain products declined relatively rapidly since 1964, corresponding to a sharp decline in the fallout deposition rate. The Sr-Ca ratios in fruits and vegetables have declined less markedly, reflecting a stronger dependence on root uptake from the relatively constant cumulative deposit of ^{90}Sr in soil. The parameters from the model fits (Table 4) illustrate these dependencies. The rate dependence ($p_1 + p_2$) is highest for grain products, which is three times higher than for milk. The deposit dependence (p_3) is about six times greater for vegetables and fruits than for milk, and the mean time for uptake availability (μ^{-1}) is inferred to be 9, 14, and 20 years for milk, vegetables, and fruit, respectively.

For individuals or populations who maintain more nearly vegetarian diets, the Sr-Ca levels in diet, and thus the ^{90}Sr concentration in bone would be expected to have declined less markedly than for individuals consuming diets consisting of greater quantities of meat and dairy products.

The total transfer to diet per unit deposition is given by the transfer coefficient P_{23} (UNSCEAR, 1972). The subscripts refer to the transfer chain:

Atmosphere (1) $\rightarrow$ Earth's Surface (2) $\rightarrow$ Diet (3) $\rightarrow$ Tissue (4)

The transfer coefficient is defined as the ratio of the infinite integral of concentration in diet to the integrated deposition rate. As applied to the correlation model, assuming unit deposition in the year $n = 1$, the transfer coefficient is

$$P_{23} = \frac{\sum_{n=1}^{\infty} D_n}{\sum_{n=1}^{\infty} \delta_{n,1} F_n} = p_1 + p_2 + p_3 \sum_{m=1}^{\infty} e^{-m\mu} = p_1 + p_2 + p_3 \frac{e^{-\mu}}{1 - e^{-\mu}}$$

The units are pCi yr/g Ca per mCi/km². The overall transfer to food categories, as measured by P_{23} , is highest for fruits (21.6) and vegetables (15.4), due to longer-term availability and greater uptake of ⁹⁰Sr from soil. The value for grain products is 5.3, for milk 2.4, and for meat, fish and eggs is 1.3. When weighted for contribution to total Ca intake in diet, the contributions to total diet P_{23} are 1.4 from milk and vegetables, 1.0 from grain products, 0.8 from fruit, and 0.2 from meat, fish and eggs. The total, 4.7 pCi yr/g Ca per mCi/km², from the separate fits to the food groups, agrees with the results from fitting the total diet Sr-Ca ratios. The fits to total diet data is shown in Figure 7. The model provides good correlation between deposition and diet levels, the correlation coefficients ranging from 0.67 for fruits, in which considerable scatter in the data is evident due to the diverse supply regions, to greater than 0.99 for total diet.

Anticipated ⁹⁰Sr Intake in 1983

Atmospheric nuclear tests have occurred sporadically from 1963 through 1980. During 1976, three atmospheric tests were conducted by the Chinese, including a large 4 MT test in November. Atmospheric tests of low yields were conducted by the Chinese in September of 1977, and in March and December of 1978 (Carter, 1979). There were no announced atmospheric tests during 1979. An atmospheric test of intermediate yield was conducted by the Chinese in October of 1980. There were no announced atmospheric tests during 1981-1982.

Dietary intake of ⁹⁰Sr remained little changed in 1982. The large contribution to diet attributed to uptake from the relatively constant cumulative deposit of ⁹⁰Sr in soil precludes large changes in ⁹⁰Sr intake from one year to the next. Based on the formula presented above, relating deposition to dietary intake, and assuming no increase in atmospheric testing programs, projected estimates of ⁹⁰Sr intakes in 1983 are 5.1 ± 0.1 pCi/day (0.189 ± 0.004 Bq/day) in New York and 2.5 ± 0.1 pCi/day (0.093 ± 0.004 Bq/day) in San Francisco.

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TABLE 1
STRONTIUM-90 IN THE DIET DURING 1982

Diet Category	kg/y*	gCa/y*	% of Yearly Intake of Ca	New York City			San Francisco		
				pCi 90Sr/kg	pCi 90Sr/y	% of Yearly Intake of 90Sr	pCi 90Sr/kg	pCi 90Sr/y	% of Yearly Intake of 90Sr
DAIRY PRODUCTS	200	216.0	58	3.2	641	32	1.0	200	21
FRESH VEGETABLES	48	18.7		8.8	422		2.4	116	
CANNED VEGETABLES	22	4.4		3.4	119		2.9	64	
ROOT VEGETABLES	10	3.8		3.4	34		3.8	38	
POTATOES	38	3.8		2.3	88		2.1	79	
DRY BEANS	3	2.1	9	15.9	48	36	7.9	54	36
FRESH FRUIT	59	9.4		2.6	152		1.3	77	
CANNED FRUIT	11	0.6		1.1	12		0.8	9	
FRUIT JUICE	28	2.5	3	1.7	48	11	1.4	40	13
BAKERY PRODUCTS	44	53.7		3.0	131		1.9	84	
FLOUR	34	6.5		4.5	153		3.5	119	
WHOLE GRAIN PRODUCTS	11	10.3		6.2	69		2.9	32	
MACARONI	3	0.6		2.4	7		2.3	7	
RICE	3	1.1	20	0.6	2	18	0.8	2	25
MEAT	79	12.6		0.4	35		0.4	31	
POULTRY	20	6.0		0.3	6		0.3	5	
EGGS	15	8.7		0.6	10		0.6	8	
FRESH FISH	8	7.6		0.2	1		0.1	1	
SHELL FISH	1	1.6	10	0.2	<1	3	0.7	1	5
YEARLY INTAKE		370 g			1978 pCi			967 pCi	
INTAKE					54 pCi/g Ca 54 pCi/day			2.6 pCi/g Ca 2.6 pCi/day	

*From U. S. Department of Agriculture (1967).

TABLE 2

CONTRIBUTION OF MAJOR FOOD CATEGORIES TO AVERAGE DAILY ^{90}Sr INTAKE

Year	% Contribution					Daily Intake pCi ⁹⁰ Sr/day
	Dairy Products	Grain Products	Vegetables	Fruit	Meat, Fish, Eggs	
<u>New York City</u>						
1960	43	22	24	7	4	11.3
61	47	19	22	11	3	9.6
62	48	19	20	10	4	12.7
1963	56	22	13	7	2	29.6
64	46	28	16	7	3	30.3
65	42	27	20	7	5	22.9
1966	42	24	21	8	5	17.5
67	35	14	33	14	3	16.4
68	37	13	26	20	3	14.3
1969	40	14	28	15	3	12.4
70	39	15	27	15	3	12.1
71	35	16	30	17	2	12.8
1972	35	15	30	18	2	10.7
73	31	14	32	21	2	9.7
74	32	11	33	22	2	9.5
1975	37	14	34	12	3	8.3
76	35	11	30	20	3	8.4
77	31	12	30	25	2	8.0
1978	36	15	25	21	3	7.5
79	33	13	30	19	5	8.3
80	34	17	29	16	4	6.0
1981	35	15	35	13	2	6.0
82	32	18	36	11	3	5.4

TABLE 2 (Cont'd)

Year	% Contribution					Daily Intake pCi 90Sr/day
	Dairy Products	Grain Products	Vegetables	Fruit	Meat, Fish, Eggs	
<u>San Francisco</u>						
1960	36	22	21	11	10	4.0
61	31	27	22	14	6	3.5
62	40	29	16	9	6	5.5
1963	47	30	11	6	6	13.3
64	39	39	10	6	6	12.5
65	46	25	15	9	6	10.8
1966	31	31	20	8	9	6.4
67	28	26	23	15	8	5.7
68	27	24	28	15	7	4.3
1969	29	27	23	15	6	4.2
70	28	27	26	13	6	4.2
71	29	27	21	16	7	4.0
1972	22	27	29	18	5	3.6
73	21	24	35	16	4	3.2
74	26	23	30	17	3	2.9
1975	31	22	25	17	5	3.3
76	23	22	30	19	6	3.1
77	22	25	33	16	4	2.5
1978	22	27	29	15	8	3.2
79	22	24	31	18	5	2.8
80	24	25	29	17	5	2.5
1981	22	25	28	17	8	2.4
82	21	25	36	13	5	2.6

TABLE 3

 ^{90}Sr DEPOSITION AND CONTAMINATION OF MILK IN NEW YORK

Year	Deposition* (mCi/km ²)	^{90}Sr Ratio in Milk (pCi/g Ca)		% of ^{90}Sr in milk attributable to uptake from soil
		Observed**	Calculated	
1954	2.76	1.4	1.9	0
55	3.57	2.8	3.5	13
56	4.43	3.9	4.8	21
57	4.44	4.5	5.6	29
1958	6.16	7.6	7.4	30
59	8.68	11.0	10.2	29
60	1.58	8.0	7.0	58
61	7.43	6.7	5.8	66
1962	12.33	12.1	12.7	29
63	12.79	25.6	24.4	22
64	15.85	23.2	24.8	36
65	5.53	19.1	17.5	59
1966	2.43	12.1	12.8	78
67	1.64	10.0	10.7	85
68	1.32	9.0	9.5	87
69	1.43	9.0	8.7	85
1970	1.48	8.4	8.1	84
71	1.41	7.6	7.5	83
72	0.75	6.2	6.5	87
73	0.42	5.4	5.6	92
1974	0.93	5.0	5.3	86
75	0.69	4.8	4.8	86
76	0.26	4.7	4.1	92
77	0.78	4.1	3.9	85
1978	0.92	4.5	3.9	79
79	0.29	4.5	3.5	88
80	0.14	3.4	2.9	94
81	0.36	3.4	3.0	91
82	0.04	2.8	2.6	95

* Deposition data see Appendix A.

** Observed milk data see Appendix B.

TABLE 4

PARAMETERS OBTAINED BY FITTING $^{90}\text{Sr}/\text{Ca}$ RATIOS
IN FOOD CATEGORIES AND TOTAL DIET IN NEW YORK
TO ^{90}Sr DEPOSITION

Parameter	Dairy Products	Grain Products	Meat, Fish Eggs	Vegetables	Fruit	Total Diet
P ₁	0.68	0.87	0.006	0.96	1.06	0.90
P ₂	0.26	1.99	0.34	0.42	0.00	0.63
P ₃	0.16	0.23	0.14	1.02	1.09	0.31
μ	0.11	0.09	0.14	0.07	0.055	0.08
P ₂₃	2.37	5.30	1.31	15.43	20.51	5.25
W _j	0.582	0.179	0.111	0.089	0.039	
P ₂₃ W _j	1.38	0.95	0.15	1.37	0.80	
Total Diet P ₂₃	-----		4.65	-----		5.25

NOTE: The units for parameters p_1 , p_2 , p_3 are pCi/g Ca per mCi/km² yr; parameter μ is yr⁻¹; the transfer coefficient P_{23} is pCi yr/g Ca per mCi/km²; W_j is the fractional contribution of component j to the total Ca diet.

Figure 1. ^{90}Sr in total diet - quarterly sampling results.

Figure 2. ^{90}Sr intake in New York.

Figure 3. ^{90}Sr intake in San Francisco

Figure 4. Average annual ^{90}Sr concentration in milk in New York City.

Figure 5. ^{90}Sr in total diet in New York with estimates based on levels in milk.

Figure 6. ^{90}Sr in food groups in New York observed and fits from deposition model.

Figure 7. Deposition model fit to ^{90}Sr in total diet in New York.

APPENDIX A

PREVIOUS PUBLICATIONS

Diet Intake

Rivera, J. and J. H. Harley

'HASL Contribution to the Study of Fallout in Food Chains'
USAEC Report HASL-147, July (1964)

Rivera, J.

'Strontium-90 in the Diet: Verification of Prediction for 1964
and 1965 and Prediction for 1966 and 1967'
USAEC Report HASL-173, p. I-75, October (1966)

Rivera, J.

'Strontium-90 in Tri-City Diets: Results for 1966 and 1967
and Comparison with Predictions'
USAEC Report HASL-193, p. I-217, April (1968)

Rivera, J.

'Strontium-90 in the Diet During 1968 and Projected Levels
for 1969'
USAEC Report HASL-207, p. I-33, April (1969)

Rivera, J.

'⁹⁰Sr to Ca Ratios in the U.S. Diet from 1954 to 1959'
USAEC Report HASL-214, p. I-29, October (1969)

Bennett, B. G.

'Strontium-90 in the Diet - Results through 1970'
USAEC Report HASL-242, p. I-108, April (1971)

Bennett, B. G.

'Estimation of ⁹⁰Sr Levels in the Diet'
USAEC Report HASL-246, p. I-107, January (1972)

Bennett, B. G.

'Strontium-90 in the Diet - Results through 1971'
USAEC Report HASL-249, p. I-95, April (1972)

Bennett, B. G.

'Strontium-90 in the Diet - Results through 1972'
USAEC Report HASL-273, p. I-64, April (1973)

Bennett, B. G.

'Strontium-90 in the Diet - Results through 1973'
USAEC Report HASL-284, p. I-34, April (1974)

Bennett, B. G.

'Strontium-90 in the Diet - Results through 1974'
USERDA Report HASL-294, p. I-143, July (1975)

Bennett, B. G.
'Strontium-90 in the Diet - Results through 1975'
USERDA Report HASL-306, p. I-95, July (1976)

Bennett, B. G. and C. Evans
'Strontium-90 in the Diet - Results through 1976'
USERDA Report HASL-321, p. I-39, July (1977)

Bennett, B. G. and C. S. Klusek
'Strontium-90 in the Diet - Results through 1977'
USDOE Report EML-342, p. I-105, July (1978)

Klusek, C. S.
'Strontium-90 in the Diet - Results through 1978'
USDOE Report EML-356, p. I-351, July (1979)

Klusek, C. S.
'Strontium-90 in the Diet - Results through 1979'
USDOE Report EML-374, p. I-25, July (1980)

Klusek, C. S.
'Strontium-90 in the Diet - Results through 1980'
USDOE Report EML-395, p. I-31, November (1981)

Klusek, C. S.
'Strontium-90 in the Diet - Results through 1981'
USDOE Report EML-412, p. I-3, November (1982)

Deposition Data

Volchok, H. L. and M. T. Kleinman
'Global ⁹⁰Sr Fallout and Precipitation: Summary
of the Data by 10 Degree Bands of Latitude'
USAEC Report HASL-245, p. I-2, October (1971)

Volchok, H. L.
'Worldwide Deposition of ⁹⁰Sr through 1971'
USAEC Report HASL-259, p. I-2, October (1972)

Volchok, H. L.
'Worldwide Deposition of ⁹⁰Sr through 1972'
USAEC Report HASL-276, p. I-3, October (1973)

Volchok, H. L.
'Worldwide Deposition of ⁹⁰Sr through 1973'
USAEC Report HASL-286, p. I-17, October (1974)

Volchok, H. L.

'Worldwide Deposition of ^{90}Sr through 1974'
USAEC Report HASL-297, p. I-2, October (1975)

Feely, H. W.

'Worldwide Deposition of ^{90}Sr through 1975'
USERDA Report HASL-308, p. I-121, October (1976)

Feely, H. W.

'Worldwide Deposition of ^{90}Sr through 1976'
USERDA Report HASL-328, p. I-85, October (1977)

Feely, H. W. and L. E. Toonkel

'Worldwide Deposition of ^{90}Sr through 1977'
USDOE Report EML-344, p. I-19, October (1978)

Feely, H. W. and L. E. Toonkel

'Worldwide Deposition of ^{90}Sr through 1978'
USDOE Report EML-363, p. I-87, October (1979)

Toonkel, L. E.

'Worldwide Deposition of ^{90}Sr through 1979'
USDOE Report EML-381, p. I-153, October (1980)

Toonkel, L. E.

'Worldwide Deposition of ^{90}Sr through 1980'
USDOE Report EML-395, p. I-49, November (1981)

Larsen, R. J.

'Worldwide Deposition of ^{90}Sr through 1981'
USDOE Report EML-415, June (1983)

APPENDIX B

STRONTIUM-90 IN MILK AND TAP WATER

STRONTIUM-90 IN MILK

In 1954, the Environmental Measurements Laboratory (EML) began monitoring liquid whole milk in New York City for ^{90}Sr in order to estimate the dietary contribution from this source. Although a more complete study of the ^{90}Sr content of the diet in New York was started in March 1960, milk analyses were continued in order to provide a detailed and continuous history of the contamination of this staple dietary component. Pasteurized milk purchased week days at retail stores are composited monthly. The ^{90}Sr to calcium ratios for New York City since the inception of the sampling program are presented in Table B1 and graphically in Figure B1.

In addition to sampling in New York City, the following milk programs were conducted by EML.

1. Powdered milk monitoring was initiated at a main processing plant in Perry, New York in 1954 and continued through 1969. These data are summarized in (Hardy, 1973).
2. Liquid milk from two large dairies serving Honolulu was monitored from the summer of 1959 until the end of June 1965. On the island of Oahu the dairy cows are on pasture throughout the year and it was of interest to know how well the ^{90}Sr levels in milk in this area reflect changes in deposition rate. These data were summarized in tabular and graphical form in (Hardy, 1966).
3. Sampling of powdered buttermilk from the Mandan, North Dakota area was begun in 1955. The powdered buttermilk is used as cattle feed and it was of interest to have a continuous record of the ^{90}Sr levels in this animal dietary supplement. Sampling at Mandan was also terminated at the end of June 1965 and reported in (Hardy, 1966).

STRONTIUM-90 IN TAP WATER

In 1954, tap water sampling and analysis was begun on a routine basis at EML laboratory, which receives its supply from one of the main reservoirs servicing New York City. Samples of New York City tap water were taken daily at EML so that by the end of the month, approximately 100 liters were collected. Water sampling and analysis were terminated in October 1981. Final summaries and graphical presentations of ^{90}Sr concentrations and ^{90}Sr to ^{137}Cs ratios were presented in Hardy (1981). Tap water sampling and analyses were also carried out at Richmond, CA from 1959 through the first half of 1963 and were reported in Hardy et al. (1964).

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Hardy, E. and J. Rivera
'Fallout Program Quarterly Summary Report'
USERDA Report HASL-171, pp. 210-216, April (1966)

Hardy, E.
'Fallout Program Quarterly Summary Report'
USERDA Report HASL-274, pp. II-18 to II-20, July (1973)

Hardy, E.
Environmental Report
USDOE Report EML-395, Appendix, pp. D-5 to D-7, November (1981)

TABLE B1
THE STRONTIUM TO CALCIUM RATIO IN MILK

New York City Liquid Milk, pCi ⁹⁰ Sr/g Ca													
Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Ann. Avg.
1954	*	*	*	*	*	0.5	0.9	0.6	2.3	1.8	1.7	1.8	-
1955	1.5	0.9	1.1	0.9	2.4	3.7	5.2	2.4	4.0	3.9	3.6	3.8	2.8
1956	4.2	3.7	3.7	3.5	4.2	*	*	*	*	*	*	*	-
1957	3.2	4.1	3.8	3.7	4.0	5.5	6.6	4.6	4.9	5.7	4.7	2.9	4.5
1958	3.6	4.0	3.2	4.1	3.9	10.2	11.3	10.9	10.6	9.9	11.7	8.2	7.6
1959	8.2	8.4	8.0	7.7	13.4	24.2	14.1	10.7	9.8	8.3	10.2	9.2	11.0
1960	8.1	8.9	9.1	8.7	8.8	10.1	9.8	8.6	6.1	6.1	5.9	6.3	8.0
1961	6.7	7.3	8.1	6.5	8.1	8.4	7.0	5.4	5.2	6.0	6.1	5.7	6.7
1962	5.7	6.1	4.0	9.1	14.8	14.5	23.2	17.4	15.3	13.6	10.3	10.9	12.1
1963	8.3	11.2	13.4	12.1	40.6	42.4	35.8	40.5	27.1	29.6	25.9	20.7	25.6
1964	21.1	23.9	27.2	26.1	30.8	30.9	22.0	24.9	17.1	14.8	19.7	19.3	23.2
1965	20.8	18.0	21.1	19.0	22.9	18.0	18.0	22.2	16.5	17.6	17.6	17.1	19.1
1966	13.9	14.3	13.0	11.5	13.8	17.0	12.4	13.6	13.2	7.4	9.0	7.2	12.1
1967	13.5	9.6	11.1	10.9	9.7	*	*	*	12.2	7.6	7.8	7.4	10.0
1968	7.0	7.6	7.4	7.8	7.8	12.7	11.6	10.2	9.0	8.6	9.4	8.5	9.0
1969	9.3	7.3	6.7	6.7	8.3	10.8	13.1	10.4	10.4	8.0	8.5	8.5	9.0
1970	8.2	7.0	6.7	7.4	10.0	11.6	11.0	8.5	7.9	7.4	7.2	7.5	8.4
1971	7.3	8.5	6.6	8.5	9.2	10.3	8.8	7.3	7.6	6.2	6.0	5.1	7.6
1972	5.9	5.5	5.6	6.1	7.7	7.3	7.7	6.0	5.0	6.2	6.4	5.4	6.2
1973	6.6	6.6	5.9	5.6	3.6	5.0	6.0	5.7	4.8	5.0	4.8	5.3	5.4
1974	3.4	3.8	3.7	4.1	5.4	7.5	6.4	6.6	5.7	4.4	4.6	4.3	5.0
1975	3.2	7.2	4.6	5.2	5.8	6.4	4.5	4.5	4.9	3.2	4.3	4.3	4.8
1976	3.4	4.4	5.9	5.9	4.6	4.1	4.3	4.3	4.5	5.8	4.2	5.0	4.7
1977	3.6	3.0	2.9	4.8	5.3	5.9	4.4	5.1	5.2	3.3	3.2	2.4	4.1
1978	3.8	3.8	4.3	5.2	5.2	4.3	6.3	4.9	4.1	4.5	3.4	3.9	4.5
1979	4.2	4.5	4.4	5.4	5.2	3.9	5.3	4.8	5.5	3.8	3.2	3.5	4.5
1980	3.2	3.2	3.7	3.8	4.3	3.8	3.4	3.3	3.3	2.9	2.9	2.5	3.4
1981	3.5	3.8	3.1	2.8	2.6	3.5	4.0	4.0	2.8	4.3	3.3	3.1	3.4
1982	3.4	2.9	2.4	3.0	2.7	3.5	3.2	2.8	1.8	2.7	2.8	*	2.8

* Samples not collected

Figure B1. Strontium-90 in liquid whole milk in New York City.

APPENDIX C

QUALITY CONTROL PROGRAM

Each group of food samples submitted for ^{90}Sr analysis at EML include check samples that are used to assess the quality of the data, and they usually constitute about 10% of the total number of samples. The check samples consist of: blanks, reference samples that have been analyzed repeatedly over a number of years, and blind duplicates. Results for quality control samples submitted with food samples from New York and San Francisco have been presented on an annual basis since 1961 (Harley, 1961, Hardy, 1962-1982).

This appendix is a summary of the quality control data for milk and food ash analyzed during 1982. Results of individual analyses and average values for 1) blanks, 2) reference samples, and 3) duplicates are given in Tables C1 through C3, respectively. The results for 1982 can be summarized as follows.

1. Blanks - Eight calcium phosphate samples (10 g each) were analyzed for ^{90}Sr at EML during 1982. The average concentration was 0.020 ± 0.012 dpm $^{90}\text{Sr}/\text{g}$. The error term is one standard deviation from the mean. The average value is much lower than that reported during the previous five years (Hardy, 1978-82).
2. Reference samples - The milk and vegetable ash samples (9231 and VO360) have been used in the quality control program at EML for 10 or more years. The averages of the ^{90}Sr measurements performed in 1982 were not significantly different than the averages of all analyses for these reference samples. The average % deviation from the mean was 9 for both samples for values reported in the current year, 20 for milk 9231, and 10% for vegetation VO360 for all values reported since their initiation as check samples. All ^{90}Sr values have been decay-corrected to October 1, 1983.

Two new vegetation ash reference samples, potato and fruit cocktail, with much lower ^{90}Sr concentrations, were prepared in 1981 and are reported here for the first time. The ^{90}Sr levels in these new reference samples of ~ 1 dpm/g ash reflect the lower ^{90}Sr content in food in more recent years. The higher concentration, ~ 12 dpm/g ash, in vegetation ash VO360 was no longer considered to be an adequate check on the analytical procedures and as of August 1982, VO360 has been phased out of the quality control program for ^{90}Sr in U. S. diet.

3. Duplicates - Thirteen sets of blind duplicate 10 g aliquots of food ash were analyzed with the 1982 food samples. The average % deviation from the mean was 6.

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USAEC Report HASL-122, p. 197, April (1962)
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USAEC Report HASL-165, p. 332, January (1966)
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'Analysis of Interlaboratory Comparison Samples, Blind Duplicates and Blanks at HASL and Other Laboratories During 1966'
USAEC Report HASL-174, p. I-16, January (1967)
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'Analysis of Quality Control Samples at HASL and Other Laboratories During 1967'
USAEC Report HASL-184, p. I-224, January (1968)
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'Analysis of Quality Control Samples at HASL and a Contractor Laboratory During 1968'
USAEC Report HASL-204, p. I-47, January (1969)
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'Analysis of Quality Control Samples at HASL and a Contractor Laboratory During 1969'
USAEC Report HASL-217, p. I-130, January (1970)
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USAEC Report HASL-239, p. I-23, January (1971)

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USAEC Report HASL-246, p. I-18, January (1972)

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USAEC Report HASL-268, p. I-24, January (1973)

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USDOE Reports EML-370, p. I-35, January (1980)

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Laboratory During 1980'
USDOE Reports EML-390, p. I-437, May (1981)

Hardy, E. P.

'Analysis of Quality Control Samples at EML and a Contractor
Laboratory During 1981'

USDOE Reports EML-405, p. I-3, May (1982)

TABLE C1

BLANKS

EML No.	dpm ⁹⁰ Sr/g
F5547	0.006
F5577	0.006
F5602	0.02
F5627	0.025
F5688	0.031
F5713	0.023
F5738	0.01
F5763	0.037
Avg. $\pm$ SD	0.020 $\pm$ 0.012

TABLE C2
REFERENCE SAMPLES

EML No.	dpm $^{90}\text{Sr/g}$ decay corrected to	% Ca
	10/1/83 3/1/59	

A. Milk Ash (Orig. EML No. 9231)

M1590	0.30	0.54	
M1595	0.32	0.58	16.6
M1600	-	-	16.3
M1605	0.36	0.64	16.1
Avg. $\pm$ SD	0.33 $\pm$ 0.03	0.59 $\pm$ 0.05(9%)	16.3 $\pm$ 0.2(1%)

Avg. of results from March 1959 through September 1983:

0.38 $\pm$ 0.08(20%)	0.67 $\pm$ 0.08(12%)	15.5 $\pm$ 0.8(5%)
(54 analyses)	(54 analyses)	(47 analyses)

B. Vegetation Ash (Orig. EML No. V0360)

F5546	13.16	19.1	
F5575	12.81	18.6	
F5601	15.09	21.9	
Avg. $\pm$ SD	13.7 $\pm$ 1.2	19.7 $\pm$ 1.8(9%)	

Avg. of 60 Analyses from May 1968 through September 1983:

11.7 $\pm$ 1.2	17.1 $\pm$ 1.7(10%)
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TABLE C2 (Cont'd)

EML No.	dpm $^{90}\text{Sr/g}$ decay corrected to	
	10/1/83	1/1/82
C. Potato Ash (Orig. EML No. F5380)		
F5499	0.90	0.94
F5500	0.84	0.88
F5523	0.85	0.89
F5524	0.90	0.94
F5551	0.91	0.95
F5549	0.83	0.87
F5577	0.74	0.77
F5578	0.74	0.90
F5554	0.85	0.89
F5603	0.91	0.95
F5604	0.89	0.93
F5628	0.88	0.92
F5629	0.87	0.91
F5689	0.80	0.83
F5690	0.80	0.83
F5716	0.87	0.91
F5717	0.80	0.83
F5739	0.98	1.02
F5740	0.90	0.94
F5764	0.85	0.89
F5765	0.75	0.78
Avg. $\pm$ SD	0.86 $\pm$ 0.06	0.89 $\pm$ 0.06 (7%)

TABLE C2 (Cont'd)

EML No.	dpm $^{90}\text{Sr/g}$	
	decay corrected to 10/1/83	1/1/82
<u>D. Fruit Cocktail Ash (Orig. EML No. F5525)</u>		
F5550	1.18	1.23
F5548	1.11	1.16
F5579	1.19	1.24
F5580	1.12	1.17
F5605	1.12	1.17
F5606	1.22	1.27
F5630	1.09	1.14
F5631	1.16	1.21
F5691	1.10	1.15
F5692	1.02	1.06
F5714	0.94	0.98
F5715	0.88	0.92
F5741	1.23	1.28
F5742	1.21	1.26
F5766	0.99	1.03
F5767	1.03	1.07
Avg. $\pm$ SD	1.10 $\pm$ 0.10	1.15 $\pm$ 0.11(9%)

TABLE C3
 DUPLICATES

FML No.	dpm ⁹⁰ Sr/g
F5526	0.91
F5544	0.98
F5532	0.50
F5545	0.64
F5561	0.61
F5574	0.62
F5581	2.84
F5599	2.84
F5587	0.67
F5600	0.63
F5613	0.88
F5626	0.80
F5668	3.39
F5686	3.69
F5674	0.64
F5687	0.59
F5693	0.86
F5711	0.71
F5699	0.95
F5712	0.71
F5718	3.01
F5736	3.07
F5724	0.61
F5737	0.68
F5743	0.79
F5761	0.80

Avg. % deviation from mean: 6, range: 1-20.

APPENDIX D

STRONTIUM-90 IN DIET

Quarterly Summaries

TABLE D1
STRONTIUM-90 IN NEW YORK CITY AND SAN FRANCISCO DIETS
- First Quarter 1982 -

Diet Category ⁹⁰ Sr	kg/yr	gCa/yr	% of yearly intake of Ca	New York City - February			San Francisco - March		
				pCi ⁹⁰ Sr/kg	pCi ⁹⁰ Sr/yr	% of yearly intake of ⁹⁰ Sr	pCi ⁹⁰ Sr/kg	pCi ⁹⁰ Sr/yr	% of yearly intake of ⁹⁰ Sr
DAIRY PRODUCTS	200	216.0	58	3.3	652	39	0.8	171	20
FRESH VEGETABLES	48	18.7		3.0	142		*	116	
CANNED VEGETABLES	22	4.4		3.9	87		2.6	58	
ROOT VEGETABLES	10	3.8		5.4	54				
POTATOES	38	3.8		1.3	51		2.0	75	
DRY BEANS	3	2.1		16.9	51		21.6	65	
			9			23			41
FRESH FRUIT	59	9.4		1.8	108		*	77	
CANNED FRUIT	11	0.6		0.7	8		0.7	7	
FRUIT JUICE	28	2.5		2.1	60		1.2	35	
			3			11			14
BAKERY PRODUCTS	44	53.7		3.0	133				
FLOUR	34	6.5		5.3	180		1.7	57	
WHOLE GRAIN PRODUCTS	11	10.3		6.5	72		3.7	41	
MACARONI	3	0.6		2.5	7		2.3	7	
RICE	3	1.1		0.8	2		0.2	1	
			20			24			21
MEAT	79	12.6		0.5	37		0.3	27	
POULTRY	20	6.0		0.5	10		0.2	5	
EGGS	15	8.7		0.6	9		0.5	8	
FRESH FISH	8	7.6		0.1	1		0.2	1	
SHELL FISH	1	1.6		0.2	<1		0.8	1	
			10			3			5
YEARLY INTAKE 370 g				1664 pCi			868 pCi		
INTAKE				4.5 pCi/gCa			2.4 pCi/gCa		
				4.6 pCi/day			2.4 pCi/day		

*Fresh produce was not available due to the Mediterranean fruit fly quarantine;
pCi/yr have been estimated.

TABLE D2
STRONTIUM-90 IN NEW YORK CITY AND SAN FRANCISCO DIETS
- Second Quarter 1982 -

Diet Category ⁹⁰ Sr	New York City - May						San Francisco - June		
	kg/yr	gCa/yr	% of yearly intake of Ca	pCi ⁹⁰ Sr/kg	pCi ⁹⁰ Sr/yr	% of yearly intake of ⁹⁰ Sr	pCi ⁹⁰ Sr/kg	pCi ⁹⁰ Sr/yr	% of yearly intake of ⁹⁰ Sr
DAIRY PRODUCTS	200	216.0		3.4	671		0.8	169	
			58			33			17
FRESH VEGETABLES	48	18.7		8.1	388		•	116	
CANNED VEGETABLES	22	4.4		10.1	223		3.0	66	
ROOT VEGETABLES	10	3.8		3.4	34		•	38	
POTATOES	38	3.8		2.5	94		•	79	
DRY BEANS	3	2.1		4.9	15		•	54	
			9			37			35
FRESH FRUIT	59	9.4		1.5	90		•	77	
CANNED FRUIT	11	0.6		0.7	8		0.9	9	
FRUIT JUICE	28	2.5		2.7	77		1.6	46	
			3			8			13
BAKERY PRODUCTS	44	53.7		3.0	131		2.3	101	
FLOUR	34	6.5		6.1	209		4.9	167	
WHOLE GRAIN PRODUCTS	11	10.3		6.4	71		3.2	35	
MACARONI	3	0.6		2.4	7		2.1	6	
RICE	3	1.1		0.6	2		0.5	2	
			20			20			30
MEAT	79	12.6		0.2	17		0.4	35	
POULTRY	20	6.0		0.2	5		0.2	5	
EGGS	15	8.7		0.5	8		0.9	14	
FRESH FISH	8	7.6		0.2	1		0.0	1	
SHELL FISH	1	1.6		0.3	<1		-	-	5
			10						
YEARLY INTAKE	370 g				2051 pCi			1020 pCi	
DAILY INTAKE					5.5 pCi/gCa			2.8 pCi/gCa	
					5.6 pCi/day			2.8 pCi/day	

*Fresh produce was not available due to the Mediterranean fruit fly quarantine;
pCi/yr have been estimated

TABLE D3
STRONTIUM-90 IN NEW YORK CITY AND SAN FRANCISCO DIETS
- Third Quarter 1982 -

Diet Category ⁹⁰ Sr	New York City - Aug.						San Francisco - Sept.		
	kg/yr	gCa/yr	% of yearly intake of Ca	pCi ⁹⁰ Sr/kg	pCi ⁹⁰ Sr/yr	% of yearly intake of ⁹⁰ Sr	pCi ⁹⁰ Sr/kg	pCi ⁹⁰ Sr/yr	% of yearly intake of ⁹⁰ Sr
DAIRY PRODUCTS	200	216.0	58	2.8	565	28	1.1	213	20
FRESH VEGETABLES	48	18.7		11.7	561		2.2	108	
CANNED VEGETABLES	22	4.4		5.5	122		3.1	68	
ROOT VEGETABLES	10	3.8		3.6	36		2.5	25	
POTATOES	38	3.8		2.8	107		2.2	82	
DRY BEANS	3	2.1	9	20.1	60	44	17.7	53	32
FRESH FRUIT	59	9.4		1.8	106		1.8	106	
CANNED FRUIT	11	0.6		2.3	26		1.0	11	
FRUIT JUICE	28	2.5	3	0.3	9	7	1.6	45	15
BAKERY PRODUCTS	44	53.7		3.2	140		2.2	96	
FLOUR	34	6.5		*	153		4.2	142	
WHOLE GRAIN PRODUCTS	11	10.3		6.8	74		3.0	33	
MACARONI	3	0.6		2.4	7		1.7	5	
RICE	3	1.1	20	0.6	2	19	1.0	3	26
MEAT	79	12.6		0.4	27		0.7	52	
POULTRY	20	6.0		0.3	6		0.2	4	
EGGS	15	8.7		0.8	12		0.4	6	
FRESH FISH	8	7.6		0.2	1		0.1	1	
SHELL FISH	1	1.6	10	*	<1	2	0.9	1	6
YEARLY INTAKE	370 g				2014 pCi			1054 pCi	
INTAKE					5.4 pCi/g Ca			2.8 pCi/gCa	
					5.5 pCi/day			2.9 pCi/day	

*Data suspect, pCi/yr estimated.

TABLE D4
STRONTIUM-90 IN NEW YORK CITY AND SAN FRANCISCO DIETS
- Fourth Quarter 1982 -

Diet Category 90Sr	kg/yr	gCa/yr	% of yearly intake of Ca	New York City - Nov.			San Francisco - Dec.		
				pCi 90Sr/kg	pCi 90Sr/yr	% of yearly intake of 90Sr	pCi 90Sr/kg	pCi 90Sr/yr	% of yearly intake of 90Sr
DAIRY PRODUCTS	200	216.0	58	3.4	677	31	1.2	246	27
FRESH VEGETABLES	48	18.7		12.4	598		2.6	125	
CANNED VEGETABLES	22	4.4		2.1	46		a	64	
ROOT VEGETABLES	10	3.8		1.2	12		5.1	51	
POTATOES	38	3.8		2.6	98		2.1	80	
DRY BEANS	3	2.1	9	21.8	65	37	14.4	43	39
FRESH FRUIT	59	9.4		5.1	303		0.8	48	
CANNED FRUIT	11	0.6		0.8	8		1	9	
FRUIT JUICE	28	2.5	3	1.7	47	16	1.2	32	10
BAKERY PRODUCTS	44	53.7		2.7	121		1.4	61	
FLOUR	34	6.6		2.1	71		3.3	111	
WHOLE GRAIN PRODUCTS	11	10.3		5.3	58		1.7	18	
MACARONI	3	0.6		2.1	6		2.8	8	
RICE	3	1.1	20	0.5	2	12	1.5	5	22
MEAT	79	12.6		0.7	58		0.1	11	
POULTRY	20	0.0		0.2	5		0.3	1	
EGGS	15	8.7		0.7	10		0.4	6	
FRESH FISH	8	7.6		0.2	2		a	1	
SHELL FISH	1	1.6	10	*	<1	3	0.2	<1	3
YEARLY INTAKE	370 g				2187 pCi			926 pCi	
DAILY INTAKE					5.9 pCi/g Ca 6.0 pCi/day			2.3 pCi/g Ca 2.5 pCi/day	

*Lost or suspect data, pCi/yr estimated.

Figure D1. ^{90}Sr in total diet.