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AMCHITKA RADIOBIOLOGICAL PROGRAM PROGRESS REPORT

JANUARY 1974 TO DECEMBER 1974

By

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ABSTRACT

The Amchitka Radiobiological Program is a continuing program that began in 1970 to collect biological and environmental samples for radiometric analyses. An account of the program from July, 1970, to December, 1973, has been given in four previous progress reports: Held (1971), Held (1972), Held *et al.* (1973), and Nelson and Seymour (1974). This report is an account of the program for Calendar Year 1974.

Recent results, analyses for samples collected in 1974, have been added to the tables in Nelson and Seymour (1974) that summarize the results of analyses of samples collected from 1970 to 1974 and include analyses for: (1) gamma-emitting radionuclides in air filters, seawater, freshwater, birds, lichens, marine algae, marine invertebrates, fish, aufwuchs, and freshwater moss and plants; (2) strontium-90 (^{90}Sr) in rats and birds; and (3) tritium (^3H) in seawater, freshwater, and biological organisms. Monitoring of background radiation with survey instruments was added to the Laboratory's 1974 program and the results of the survey are included in this report.

Conclusions from the results of the recent analyses are a reiteration of the results stated in Nelson and Seymour (1974); namely, "1) no new radionuclides are present; 2) the most abundant radionuclides are naturally occurring beryllium-7 (^7Be) and potassium-40 (^{40}K); 3) the trace quantities of fission products, induced radionuclides, and ^3H present are from world fallout; and 4) a trace of ^3H contamination remains in some Long Shot ponds, as previously reported." It is concluded from the results of analyses of samples collected between September 1969 and December 1974, as reported in this and the four previous progress reports, that there were no radionuclides of Milrow or Cannikin origin in the water, plants, or animals of Amchitka Island.

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1. INTRODUCTION

The present Amchitka radiobiological program began in 1970 but was preceded by the Long Shot radiobiological program in 1965. The description of the present program, as given in the 1972 Progress Report (Held *et al.*, 1973), is relevant to the 1974 program, and selected portions from that report are as follows:

"The present Amchitka Radiobiological Program was initiated in July 1970, by the University of Washington's Laboratory of Radiation Ecology at the request of the U.S. Atomic Energy Commission, Nevada Operations Office. The program is designed to provide a periodic documentation of radionuclides, both naturally occurring and man-made, in biological and environmental samples from Amchitka and its environs. Seafoods and radionuclides potentially available to man through the food web are emphasized. However, organisms other than food organisms are also collected and analyzed in a search for indicator organisms (species that significantly concentrate one or more radionuclides). Concentrations of radionuclides other than those potentially hazardous to man are measured as a means of providing clues to the origin of radionuclides at Amchitka. Unexpected combinations or concentrations of radionuclides would indicate the presence of newly added radionuclides to the environment, presumably from fresh world fallout, nuclear-powered vessels, or from nuclear detonations at Amchitka Island. The program is complemented by other Amchitka radiological surveillance studies being conducted by the U.S. Geological Survey, who is primarily concerned with the measurement of ^3H as the most likely indicator of seepage from the underground tests."

The first two Amchitka Radiobiological Program Progress Reports covered the period July 1970 to February 1972. These reports have been summarized by Held (1972), who concluded, "Artificial or man-made radionuclides (found at Amchitka) did not originate at Amchitka except for tritium, which has previously been reported to be present in pond water and test holes near the Long Shot SGZ site."

The third and fourth progress reports reiterated the above conclusion and extended the account of the program through December 1973. Major conclusions of the fourth report, as stated by Nelson and Seymour (1974), are as follows:

- "a. Some of the ponds in the immediate vicinity of the Long Shot Surface Ground Zero remain contaminated with ^3H .
- "b. An extensive search with sensitive instruments for radionuclides in biological and environmental samples--marine, terrestrial, freshwater--collected during the first 26 months after the

Cannikin detonation of November 6, 1971, indicates that no other radionuclides have escaped to the surface environment."

In this, the fifth progress report, the format of the fourth progress report has been changed to reduce the repetition of material already presented in that report. This has been accomplished by three general procedures: (1) deletion of eight tables for which there were no 1974 data, (2) within the remaining tables, deletion of sample types or sampling stations for which there were no 1974 data, and (3) summarization of the remaining data by pooling comparable samples within one pre-Cannikin time period, July 1970 to November 6, 1971, and two post-Cannikin time periods, November 7, 1971, through 1972, and through 1973. In addition to these steps, Tables 16 and 17 (water samples) in the 1973 report were combined in Table 16 of this report, while Table 9 (marine fish) of the 1973 report was split into two tables for this report: Table 9, halibut, and Table 10, greenling. After the above changes were completed, the data from the analyses of the samples collected in May and August 1974 were added to the appropriate tables in this report. New tables added were Table 18, "Tritium Concentration in Biological Samples Collected at Amchitka Island," and Table 19 "Results of Radiation Surveys of Selected Sites on Amchitka Island."

Figure 1 shows the geographical location of Amchitka Island. Figure 2 shows general collection sites for the radiobiological program, while Figures 3 through 6 present the specific collection sites for the shaded area shown in Figure 2.

2. METHODS

Most samples collected prior to July 1972 and fish, marine invertebrates, and birds collected through 1974 were analyzed by gamma spectrometry with systems using 3x3-inch NaI(Tl) crystals and 200-channel, pulse-height analyzers. Samples (except fish, marine invertebrates, and birds as noted above) collected since July 1972 have been analyzed with systems using Ge(Li) diode detectors and 4096-channel, pulse-height analyzers. Chemical separation and X-ray spectrometry were used for ^{55}Fe determinations, while chemical separation and liquid scintillation counting of beta particles emitted by decay of ^{90}Y when at equilibrium with ^{90}Sr were used for ^{90}Sr determinations. Tritium in seawater and freshwater samples was determined by vacuum distillation of the samples and liquid scintillation counting of the distillate, as discussed in Held *et al.* (1973); free and bound ^3H in water samples from fish and aquatic plant samples was determined by azeotropic distillation and liquid scintillation counting. A discussion of the procedure for processing biological samples for analyses of bound ^3H follows, since the procedure has not been discussed in previous reports.

FIGURE 1. Location Map

FIGURE 2. Location of Collection Sites on and near Amchitka Island, Alaska

FIGURE 3. Amchitka Island Base Camp Area

FIGURE 4. Collection Sites in the Milrow Area (Overlay of LLL Chart of January 1971, UTM Coordinates 49-55 & 96-02)

FIGURE 5. Long Shot Ground Zero Vicinity

FIGURE 6. Collection Sites in the Cannikin Area (Overlay of LLL Charts of January 1971, UMT Coordinates, 43-48 & 07-01)

Tissue samples were dried and then combusted in the unit shown in the Figure 7 photograph and Figure 8 diagram. Major parts of this unit are the stainless steel sample holder, combustion furnace, vacuum pump, manifold system, oxygen and nitrogen supply, cold traps, and cooling dewars containing a slush of -70°C to -100°C acetone cooled by liquid nitrogen.

To begin the drying procedure, a frozen sample of tissue was placed in the sample holder, where it remained without exposure to the atmosphere during drying and combustion. The system was evacuated and initial water distilled from the sample (~ 10 ml) was collected in the cold trap and discarded, since it could contain water other than the free water of the sample, including water remaining in the system from previous use of the unit, or water from the external surface of the sample. To remove the free water, the sample was either vacuum lyophilized at ambient temperature or dried in a vacuum at 50 – 150°C for one to two days. When extraction of free water from the sample stopped, drying was terminated. The cold trap containing the free water was replaced with a clean and dry cold trap before combustion began. To combust a sample, the furnace temperature around the sample was raised to 500°C and oxygen was first passed over the sample and then below the sample. The products of combustion rise in the sample holder and pass through a layer of copper oxide (CuO) wire, heated to 600°C . The hot CuO zone converts CO to CO_2 and promotes complete oxidation of any remaining organic molecules before combustion products pass through the cooled water trap where bound water was collected. Combustion of a sample was usually completed in two to three hours. Water samples containing either free or bound tritium were then azeotropically distilled with toluene, and the purified water was analyzed for ^3H by the liquid scintillation method used to analyze freshwater and seawater samples.

Fresh and saltwater samples for analyses of radionuclides other than ^3H were collected by a system of filter and sorption beds developed by Battelle Northwest Laboratories and modified by our laboratory. The system consists of eight Millipore filters of 11.5-inch diameter and 0.3-micron porosity, arranged in parallel so that the water passes through the filters and then through two or more aluminum oxide beds in series.

All data presented in the tables have been corrected to the date of collection; this correction will introduce little or no error in the calculated values except for ^{95}Zr if the ^{95}Zr in the sample was produced at various unknown times and is not in equilibrium with its daughter, ^{95}Nb . In this case, an accurate decay correction factor cannot be made for ^{95}Nb , and the application of the standard decay correction factor for ^{95}Zr to the amount of ^{95}Nb present at the time of counting gives an estimate of the maximum possible amount of ^{95}Nb present at the time of collection. The problems of ^{95}Zr – ^{95}Nb analysis have been discussed in Held *et al.* (1973).

Figure 7. Combustion and drying unit used to extract free and bound water from tissue samples.

Figure 8.

Schematic drawing of the combustion chamber and cold trap sub-units of the combustion and drying unit (Figure 7) used for extracting free and bound water from tissue samples.

The error term in radionuclide concentration values for single samples is the combined counting error for the background, standard, and sample; hence, the term "propagated error." The error limits for the gamma-emitting radionuclides in single samples are "two-sigma" or two-standard deviation counting errors, while for the ^3H , ^{55}Fe , and ^{90}Sr data, error limits are one-standard deviation counting errors. The error term for the mean of more than one sample is one-standard deviation of the mean. This statistical error disregards counting error.

Environmental radiation surveys were made in May and August 1974 with an Eberline survey meter, Model E-510. A probe with a 30-mg/cm² window was used on both surveys and a second probe with a 2-g/cm² window was also used on the August survey.

3. RESULTS AND DISCUSSION

The results of the analyses of the samples collected in 1974 are presented in Tables 2 through 18. These tables also contain summarized data for samples collected and analyzed from 1970 through 1973. Results of these earlier analyses were presented in greater detail in the four previous progress reports.

The air sampling program at Amchitka which had been continuous since February 1972 was discontinued in August 1973, prior to closing the camp in September. One air particulate sampler (three were formerly used) was reactivated for an eight-day period during the August-September 1974 field trip. No radionuclides were detected by gamma-spectrum analysis of this sample (Table 2). This was possibly the result of two factors: a low level of fallout radionuclides during this eight-day period in 1974 (rate of fallout is naturally lower in late summer than in spring) and the smaller volume of air filtered in 1974 (30 percent of the 1973 sample size).

Results of the analyses of biological samples are given in Tables 2 through 14 and Table 18. As noted above, the concentration of many of gamma-emitting fallout radionuclides in the biological samples collected in May and August 1974 was greater in 1974 than in 1973 but less than naturally occurring ^{40}K , and in some instances, the values were greater than values for similar samples collected in 1972. Furthermore, radionuclide levels in biological samples collected in May 1974 were greater than in August 1974 by factors of ten or more in some instances, but were more commonly greater by factors of two to five. These relationships hold for all biological samples discussed below; hence, they are not repeated in discussions of the results for specific organisms. Radionuclides usually detected in the 1974 samples of freshwater moss, *Fontinalis* (Table 3), and the freshwater plant, *Ranunculus* (Table 4), were the naturally occurring

radionuclides ^7Be and ^{40}K , and the fallout radionuclides ^{95}Zr , ^{95}Nb , ^{103}Ru , ^{106}Ru , ^{125}Sb , ^{137}Cs , ^{144}Ce , and ^{155}Eu . Of these radionuclides, ^7Be and ^{40}K were present in the greatest concentration (1 to 30 pCi/g, dry), while ^{95}Nb , ^{106}Ru , ^{137}Cs , and ^{144}Ce were often present in concentrations of 1 to 6 pCi/g, dry tissue. Radionuclides commonly detected in aquatic vegetation samples collected prior to 1973, but only sporadically in 1973 and 1974, include ^{54}Mn and ^{60}Co . The pattern of radionuclide species and concentrations that was present in *Fontinalis* and *Ranunculus* samples in 1974 was also seen in aufwuchs and filamentous algae (Table 5) and in the lichens (Table 6), with three exceptions: (1) ^{155}Eu was not detected in the aufwuchs, (2) higher concentrations of ^{144}Ce were present in the May 1974 aufwuchs and lichen samples (4 to 12 pCi/g, dry), and (3) higher concentrations of ^{137}Cs were present in the lichen samples (8 to 13 pCi/g, dry).

The marine algae, *Fucus*, had fewer fallout radionuclides present and lower concentrations of those fallout radionuclides that were present than did freshwater and terrestrial vegetation samples (Table 7). The naturally occurring radionuclide, ^{40}K , was present in concentrations that ranged from 27 to 39 pCi/g, dry, which is 20 to over 100 times greater than the values for any of the four fallout radionuclides, ^{95}Zr , ^{95}Nb , ^{137}Cs , and ^{144}Ce , detected in *Fucus* samples.

Radionuclide values for the green sponge, a marine invertebrate, in terms of pCi per gram of dry sample were < 1.2 for ^{95}Zr , ^{95}Nb , and ^{144}Ce , < 1.4 for ^7Be and 6.8 to 12 for ^{40}K (Table 8).

As in previous years, naturally occurring ^{40}K , neutron-induced ^{55}Fe , and fission-produced ^{137}Cs were the three radionuclides detected in fish (Tables 9-12). In the four species of fish analyzed--halibut, Dolly Varden, pink salmon, and greenling-- ^{137}Cs concentrations were highest (0.17 to 0.35 pCi/g, dry) in muscle of Dolly Varden, while ^{55}Fe concentrations were highest in viscera of pink salmon (13 pCi/g, dry). Iron-55 levels in 1974 samples were slightly greater than levels in comparable samples from 1973. Potassium-40 was, as in 1973, the predominant radionuclide in all fish samples analyzed.

Other than fish, birds and rats were the two vertebrates that were analyzed. Potassium-40, ^{137}Cs , and ^{90}Sr were the predominant radionuclides in birds (Tables 13 and 14) and, although ^{137}Cs values increased slightly in 1974, ^{40}K concentrations are still greater than ^{137}Cs concentrations by a factor of ten or more. Rat bone samples had ^{90}Sr concentrations (Tables 14) of 0.8 and 2.3 pCi/g, dry, levels similar to those in 1973 samples.

Some radionuclides on filter papers and on resins obtained from water filtered through the large-volume water sampler also show an increase in 1974 when compared to 1973. This is especially true for the May 1974 samples from the four freshwater sites which had

much greater concentrations of ^{95}Zr and ^{95}Nb than were present in comparable samples from either the 1973 or August 1974 collections. Cesium-137 values for the water samples decreased in 1974, whereas the concentration of ^{137}Cs in many biological samples from 1974 were similar or greater than comparable samples from 1973. As in previous years, fresh water continued to have greater radionuclide concentrations than seawater. Of the freshwater sites, Long Shot Mud Pit No. 1 had the highest concentration of fallout radionuclides in water samples which, as previously reported by Held (1972), is probably due to the unusually high concentration in the Long Shot Mud Pits of suspended organic material which may accumulate radionuclides by adsorption.

The ^3H values in seawater and freshwater samples (Table 17) collected in 1974 decreased from 1973 values. The amount in seawater ranged from less than 39 to 48 pCi/liter (< 12 to 15 tritium units). In fresh water, the average value was about 240 pCi/liter (74 TU) except at the Long Shot Mud Pits where the maximum value was 9,400 pCi/liter (2,900 TU) in Mud Pit No. 3 and 4,700 pCi/liter (1,450 TU) in Mud Pit No. 1. Tritium concentrations in water samples from stations other than the Long Shot Mud Pits are within the range of values expected for tritium in samples collected at the same latitude as Amchitka. The ^3H value for the Long Shot Mud Pits are the values to be expected from values obtained in previous years.

The United States Geological Survey, Department of the Interior, has also analyzed Amchitka water samples for ^3H . Results for 1973, the most recent data available, are reported in Ballance (1974). He reports seawater ^3H concentrations ranging from 54 to 202 pCi/liter and averaging 97 ± 29 pCi/liter, while we have reported (Table 17) an average seawater concentration of 71 ± 42 pCi/liter, a value within the range of the error reported by Ballance. Freshwater ^3H concentrations are not comparable, since a minimum detection limit of 480 pCi/liter is the only value given by Ballance (1974) for freshwater samples from areas other than the Long Shot Mud Pits, well, or ponds. Our values for freshwater samples from 1973 averaged 162 ± 55 pCi/liter and are well below the limits of detection reported by Ballance.

Samples of aquatic vegetation, greenling, and Dolly Varden were analyzed for bound and unbound tritium. The results of the analyses for unbound tritium are presented in Table 18. Results of the analyses for bound ^3H are not presented, since the analytical techniques which we are using to extract bound ^3H are still being refined and some samples exhibiting anomalous levels of bound ^3H will need to be reanalyzed, using slightly different procedures. In general, the bound ^3H values in the samples analyzed to date seem to be slightly higher than the free ^3H values. Analyses planned for the remainder of this year will provide additional information on the concentration of free and bound tritium in biological samples. The value of 162 ± 52 tritium units for

the Dolly Varden sample from White Alice Creek raises a question about both the between-sample and the within-sample error. The value of 162 is considerably larger than values for similar samples in the same table and about three or four times greater than the average for tritium in White Alice Creek water samples collected previously. If the ^3H values for the Dolly Varden sample and for creek water are correct, they suggest a concentration factor for Dolly Varden of three or four, and this is difficult to accept. However, there is a possibility that 162 may be near the true value and without benefit of a concentration factor, since Figure 9 in NVO-269-19 indicates that ^3H in rainwater at Valentia, the marine station, varied from about 30 to 140 TU in 1970. In this case, if the sample represented the annual peak fallout and the biological half-life for ^3H is a few days, both reasonable assumptions, then the value of 162 TU may not be far from the truth. The within-sample error as measured by the coefficient of variation ranges from 5 percent to 79 percent, which suggests inconstancy in analyses. This error is believed to be due to contamination of the system and/or on the surface of the sample. In practice, the first 10 ml of the distillate is discarded as being potentially contaminated and samples for analyses are withdrawn from the distillate that follows. Perhaps more than the first 10 ml needs to be discarded and this is what is to be checked.

Results of the radiation survey are given in Table 19. The survey was performed with an Eberline survey meter (Model E-510), using two probes. Window thickness for the probes were either 30 mg/cm² or less than 2 mg/cm². Measurements were made in two ways: first in order to compare the May and August 1974 measurements, readings were taken for both periods with the beta shield (1/16-inch brass) closed on the probe with the 30 mg/cm² window; and, secondly, for greater sensitivity, readings were taken with an unshielded probe with a window thickness of less than 2 mg/cm². The 21 locations surveyed were between Charlie Runway and E-site and included the Long Shot, Milrow, and Cannikin surface ground zeros and adjacent areas. The Cannikin drillback site and Sand Beach Cove were also surveyed. Maximum values recorded while holding the survey instrument one meter above the ground ranged from 0.02 mR/hr to 0.04 mR/hr, using the probe with the 30 mg/cm² window, covered by the beta shield, and from 0.03 to 0.05 mR/hr when using the probe with the window of less than 2 mg/cm² without a beta shield. Average levels at all sites were about 0.01 mR/hr or less. These values are similar to results of comparable surveys in other areas of the United States.

The additions to the old tables, plus the new tables, extend radiobiological data through December 1974. These new data in no way change the major conclusions of the four previous progress reports; namely, the radionuclides present in the biological and environmental samples analyzed are not of Cannikin or Milrow origin, and only some ponds and mud pits in the immediate vicinity of the Long Shot surface ground zero remain contaminated with ^3H . The amounts and types of fission products and induced radionuclides detected point to their origin from worldwide fallout.

Two other factors support these conclusions: (1) The increases in radionuclide values in 1974 on Amchitka Island were found in samples collected from all areas of the island, not from any one location; and (2) fallout elsewhere in North America in 1974 was greater than in 1973. If leakage from one or more of the underground detonations on Amchitka were occurring, we would expect that the elevated radionuclide concentrations in organisms or water would be limited to specific locations on the island, e.g., a stream draining an area near one of the surface ground zeros, and that values would decrease as the distance from the source increased, until background values were reached. In contrast, we have seen only a general increase in radionuclide value in organisms collected throughout the island, with no one area or organism having unexpectedly high radionuclide levels.

Concerning the second factor--increased fallout in North America--our laboratory and others have noted greater radionuclide values in air, water, or pasture grass collected during 1974 than in similar samples collected in 1973. During a preliminary radiological survey begun by our laboratory in July 1973 near Satsop, Washington, 35 miles inland from the Pacific Ocean, we have noted a significant increase in levels of fallout radionuclides present in air particulates and pasture grass collected in April and September 1974, compared to similar samples collected in July and November 1973. Gross beta values ranged up to 0.10 pCi/m^3 and several radionuclides such as ^{95}Zr , ^{95}Nb , ^{106}Ru , and ^{144}Ce , which were easily detectable ($.002$ to $.024 \text{ pCi/m}^3$) in 1974 air particulates from Satsop, were not even detected in 1973 (LRE, unpublished data). Data from reports of the Environmental Protection Agency's Radiation Alert Network and the Radiation Protection Division of Canada also indicated increased levels (1974 > 1973) of radionuclides in airborne particles and precipitation from most stations in Alaska, Canada, and the United States. In air particulates from Canadian and United States stations, gross beta values which averaged about 0.02 pCi/m^3 during 1973 ranged from 0.04 pCi/m^3 in February 1974 to 0.23 pCi/m^3 in June 1974, the last month for which data are available. Similar increases were noted in gross beta values in precipitation samples. Although levels of fallout radionuclides have increased in 1974, the present levels of fallout in Canada and in the United States, including Amchitka, are still less than mid-1960's fallout levels.

4. SUMMARY AND CONCLUSIONS

The present program for periodical collection of biological and environmental samples at Amchitka and for analyses of these samples for radionuclide content began in July 1970. Four previous progress reports gave an account of the results of this program through December 1973, 26 months after the Cannikin detonation. In this, the fifth progress report, the account of the program is extended

through December 1974. In addition, the results of radiation surveys performed in May and August 1974 are given.

Data in those tables from the 1973 progress report that were relevant to the 1974 program were summarized, and the new 1974 data were then added to the tables. These tables included those related to: (1) gamma-emitting radionuclides in air filters, the freshwater moss *Fontinalis*, the freshwater plant *Ranunculus*, the marine alga *Fucus*, lichens, green sponge, fish, birds, seawater, and freshwater; (2) ^{90}Sr in rats and ptarmigan; and (3) ^3H in seawater, freshwater, and biological organisms.

Concentrations of gamma-emitting fallout radionuclides in samples collected in 1974 were generally greater than concentrations in samples collected in 1973, but still less than the values for naturally occurring ^{40}K . This reversed a trend of decreasing abundance which had been evident from 1970 to 1973, the previous years of this study. Two radionuclides, ^{95}Zr and ^{95}Nb , which were usually absent in 1973 were present in 1974, and this strongly implies fallout radionuclides of recent origin. For this reason and because the increase was general and not at a specific locality, the most likely explanation of the slight increase of fallout radionuclides in the samples is fallout from Chinese nuclear detonations, rather than underground leakage of 1971 or earlier nuclear detonations at Amchitka. Levels of naturally occurring ^7Be and ^{40}K in 1974 were similar to levels present in 1973. The new data acquired during 1974 does not change the important conclusions of the previous progress reports. As stated in Held *et al.* (1973), namely:

- "a. The most abundant radionuclides present were naturally occurring ^7Be and ^{40}K .
- "b. Trace quantities of fission products and induced radionuclides have been detected in amounts that would be expected from world fallout.
- "c. No new or unexpected radionuclides or radionuclide ratios have been detected.
- "d. Tritium values in seawater and in freshwater are no different than the values that would be expected at an island station at the same latitude in the northern hemisphere.
- "e. Some of the ponds in the immediate vicinity of the Long Shot Surface Ground Zero remain contaminated with ^3H . The concentration is less than in the rainfall at Vienna, Austria, in 1963, and about twice as great as at Valentia, Ireland, in the same year.
- "f. An extensive search with sensitive instruments for radionuclides in biological and environmental samples--marine, terrestrial, and freshwater--collected during the first 38 months after the Cannikin detonation of November 6, 1971, indicates that no other radionuclides have escaped to the surface environment."

TABLE 1

Scientific and Common Names and Wet Weight to Dry
Weight Ratios of Some Amchitka Island Organisms

Species	Tissue	Wet/Dry Ratio	Standard Deviation
<u>VERTEBRATES</u>			
<u>MAMMALS</u>			
<i>Rattus norvegicus</i>			
Rat	Bone	(a)	—
<u>FISH</u> (b)			
<i>Salvelinus malma</i>			
Dolly Varden	Muscle	3.62	0.70
	Viscera	4.20	0.42
<i>Oncorhynchus gorbuscha</i>			
Pink Salmon	Gonad	4.51	—
	Muscle	4.33	—
	Liver	4.49	0.69
<i>Hippoglossus stenolepis</i>			
Halibut	Muscle	4.01	0.58
	Liver	3.63	0.04
<i>Hexagrammos lagocephalus</i>			
Rock Greenling	Liver	3.43	0.41
	Muscle	4.83	0.14
	Viscera	2.13	0.04
<u>BIRDS</u>			
<i>Lagopus mutus</i>			
Rock Ptarmigan	Liver	3.52	0.32
	Muscle	3.54	0.08
<u>INVERTEBRATES</u>			
Sponge (green)	Entire	9.5	—
<u>MARINE ALGAE</u>			
<i>Fucus distichus</i>			
Marine algae	Entire	4.94	1.4

See footnotes at end of table.

TABLE 1 (continued)

Species	Tissue	Wet/Dry Ratio	Standard Deviation
<u>FRESHWATER VEGETATION</u>			
<i>Cladophora</i> sp. Filamentous algae	Entire	5.1	_____
<i>Fontinalis</i> sp. Moss	Entire	4.83	0.89
<i>Ranunculus</i> sp. Freshwater plant	Entire	12.2	4.10
<u>AUFWUCHS</u>			
<i>Periphyton</i> and other organisms	Entire	7.27	2.40
<u>TERRESTRIAL VEGETATION</u>			
<i>Cladonia</i> sp. Lichens	Entire	3.75	0.87
<i>Empetra</i> sp. Crowberry	Entire	2.07	_____

- (a) After drying, bone samples are cleaned of attached muscle tissue by Dermestid beetles; hence, no wet weight is recorded.
- (b) Names are from "Common and Scientific Names of Fishes From the United States and Canada" (Third Edition), 1970 American Fisheries Society Special Pub. No. 6.

TABLE 2

Some Gamma-Emitting Radionuclides on Air Filters at Ground Level
at the Amchitka Island Base Camp

Collection Period	n ^b	Mean Volume 10 ³ m ³	Gamma-Emitting Radionuclides (pCi/thousand cubic meters) ^a					
			⁷ Be	⁹⁵ Zr	⁹⁵ Nb	¹⁰³ Ru	¹³⁷ Cs	¹⁴⁴ Ce
Pre-Cannikin								
1970-71	28	24.5 ± 3.7	20 ± 9	2.8 ± 2.1	5.9 ± 4.5	0.7 ± 1.1	0.7 ± 0.3	NA
Post-Cannikin								
1972	45	11.3 ± 1.6	17 ± 11	0.7 ± 1.2	1.3 ± 1.6	0.37 ± 0.59	0.24 ± 0.24	NA
1973	34	11.1 ± 1.4	16 ± 10	---	0.04 ± 0.09	0.04 ± 0.07	0.16 ± 0.13	0.42 ± 0.53
1974	1	~ 3	---	---	---	---	---	---

a. Single sample (n = 1) errors are two-sigma, propagated, counting errors, while the error shown for more than one sample (n > 1) is one standard deviation of the mean. Dashes in the table indicate the sample count is not significant and NA indicates the radionuclide was not included in the gamma-spectrum analysis.

b. Number of pooled samples.

TABLE 3

Gamma-Emitting Radionuclides in the Freshwater Moss *Fontinalis* Sp.
Collected at Amchitka Island

		Gamma-Emitting Radionuclides (pCi/g, dry) ^a									
Location and Date	n	⁷ Be	⁴⁰ K	⁹⁵ Zr	⁹⁵ Nb	¹⁰³ Ru	¹⁰⁶ Ru	¹²⁵ Sb	¹³⁷ Cs	¹⁴⁴ Ce	¹⁵⁵ Eu
Clevenger Creek											
1970-71 ^b	4	8 ± 4	5.8±3.0	1.4 ±1.0	2.9 ±2.3	0.28±0.54	3.2 ±1.2	1.4 ±.6	4.0±1.5	NA	NA
1971-72	5	2.7± 4.3	6.2±2.1	0.6 ±0.3	2.0 ±2.0	0.67±0.87	0.54±0.75	0.18±.4	1.9±1.2	1.1 ±1.6	---
1973	2	4.5± 1.1	5.4±0.2	---	0.15±0.21	0.07±0.10	0.74±0.18	0.23±.03	2.3±1.1	0.84±0.37	0.22±.01
May '74	1	17 ±11	3.9±1.8	2.4 ±1.2	3.4 ±0.8	---	3.1 ±0.9	0.55±.16	1.2±0.1	2.8 ±0.3	0.26±.10
Aug '74	1	4.3± 1.9	5.7±1.4	0.7 ±0.3	1.5 ±0.2	---	2.5 ±0.5	0.31±.10	1.5±0.1	3.9 ±0.3	0.27±.06
Bridge Creek											
1970-71 ^b	3	10 ± 5	7.3±3.2	1.7 ±1.4	3.9 ±3.1	---	4.4 ±2.5	1.2 ±.8	4.1±3.0	NA	NA
1971-72	5	6.2± 2.8	6.8±1.0	1.0 ±0.6	2.2 ±1.5	0.6 ±0.8	1.1 ±1.3	0.4 ±.6	3.3±1.3	0.52±1.2	---
1973	2	5.1± 1.4	5.8±0.4	---	0.08±0.11	---	---	0.14±.19	2.3±1.9	1.1 ±0.5	0.11±.15
May '74	1	5.2± 0.9	7.9±1.6	2.1 ±0.2	4.4 ±0.2	0.24±0.10	3.5 ±0.6	0.33±.11	1.9±0.1	4.5 ±0.3	0.18±.06
Aug '74	1	3.6± 2.5	5.2±1.8	1.0 ±0.3	2.1 ±0.3	---	2.3 ±0.7	0.20±.15	1.0±0.1	4.6 ±0.4	0.23±.09
Duck Cove Creek											
1970-71 ^b	3	8 ± 3	6.6±2.6	1.3 ±1.1	2.7 ±2.3	0.5 ±0.6	2.8 ±1.5	1.4 ±.5	2.6±1.1	NA	NA
1971-72	5	6.4± 5.4	6.1±0.8	0.5 ±0.2	1.3 ±0.8	0.9 ±1.2	1.2 ±1.0	1.1 ±.5	1.7±0.9	0.32±0.72	---
1973	2	7.1± 7.0	6.4±0.4	---	---	---	0.65±0.92	0.32±.23	1.2±0.5	0.9 ±1.3	0.09±.13
May '74	1	7.4± 1.0	5.4±1.2	1.6 ±0.2	3.5 ±0.2	0.36±0.11	3.4 ±0.6	0.53±.13	2.2±0.1	5.7 ±0.3	0.16±.05
Aug '74	1	1.4± 0.8	<6	---	0.21±0.08	---	0.29±0.19	---	0.8±0.1	0.34±0.1	---
MP-12 Creek											
1973	2	9.0± 8.6	4.7±2.0	---	0.17±0.23	---	0.7 ±0.9	0.12±.17	2.0±1.2	1.4 ±0.8	0.09±.12
May '74	1	13 ± 1.0	6.0±1.1	1.4 ±0.13	3.4 ±0.18	0.20±0.05	4.1 ±0.6	0.23±.10	2.1±0.1	6.0 ±0.3	0.16±.04
Aug '74	1	4.5± 2.0	5.8±1.2	0.8 ±0.3	1.3 ±0.3	---	1.9 ±0.6	---	0.7±0.1	3.9 ±0.3	0.13±.06

TABLE 3 (continued)

		Gamma-Emitting Radionuclides (pCi/g, dry) ^a									
Location and Date	n	⁷ Be	⁴⁰ K	⁹⁵ Zr	⁹⁵ Nb	¹⁰³ Ru	¹⁰⁶ Ru	¹²⁵ Sb	¹³⁷ Cs	¹⁴⁴ Ce	¹⁵⁵ Eu
Ice Box Lake Inlet											
1973	2	4.1±0.8	5.7±1.0	---	0.08±0.11	---	0.5±0.0	0.28±0.06	1.5±0.6	0.87±.12	0.17±.08
May '74	1	3.7±0.6	5.0±1.0	0.70±.09	1.2 ±0.11	---	1.0±0.4	0.20±.09	3.1±0.1	2.4 ±.21	0.13±.04
Aug '74	1	2.3±0.8	5.9±0.5	0.17±.14	0.6 ±0.1	---	0.9±0.3	0.23±.08	1.0±0.1	1.6 ±.2	---
Cannikin Lake Outlet											
1973	2	7.3±0.5	6.2±0.7	0.09±.12	0.16±0.23	0.07±.09	0.6±0.8	0.30±.18	3.9±4.6	1.1 ±.4	0.15±.21
May '74	1	10 ±1.0	2.4±0.6	1.2 ±.12	2.7 ±0.15	0.24±.13	2.2±0.3	0.29±.05	1.1±0.1	6.3 ±.2	0.13±.03
Aug '74	1	---	4.2±0.6	1.2 ±.15	2.3 ±0.17	0.21±.11	2.6±0.5	0.33±.12	1.6±0.1	6.4 ±.3	---

a. Single sample (n = 1) errors are two-sigma, propagated, counting errors, while the error shown for more than one sample (n > 1) is one standard deviation of the mean. Dashes in the table indicate the sample count is not significant and NA indicates the radionuclide was not included in the gamma-spectrum analysis.

b. Pre-Cannikin.

TABLE 4
Gamma-Emitting Radionuclides in the Freshwater Plant *Ranunculus* Sp.
Collected at Amchitka Island

		Gamma-Emitting Radionuclides (pCi/g, dry) ^a										
Location and Date	n	⁷ Be	⁴⁰ K	⁹⁵ Zr	⁹⁵ Nb	¹⁰³ Ru	¹⁰⁶ Ru	¹²⁵ Sb	¹³⁷ Cs	¹⁴⁴ Ce	¹⁵⁵ Eu	
Clevenger Creek												
1970-71 ^b	4	4.1± 4.7	21 ±4	0.6 ±0.8	1.3 ±1.6	---	1.9 ±1.8	0.3 ±.6	1.7 ±1.1	NA	NA	
1971-72	5	5.0± 8.7	16 ±1.6	0.36±0.49	0.99±0.96	0.54±0.53	0.6 ±0.8	0.5 ±.54	1.6 ±0.7	NA	NA	
1973	2	1.9± 2.7	22 ±3.5	---	---	---	---	---	0.8 ±0.5	0.3 ±0.4	---	
May '74	1	3.1± 0.6	24 ±1.6	0.80±0.10	1.8 ±0.1	0.12±0.08	1.0 ±0.4	0.14±.09	0.87±0.07	2.3 ±0.2	---	
Aug '74	1	1.4± 1.4	15 ±1.3	---	---	---	---	---	0.24±0.07	0.5 ±0.3	---	
Bridge Creek												
1970-71 ^b	3	8.4± 5.8	17 ±3	1.0 ±0.4	2.3 ±1.0	---	2.1 ±0.5	0.5 ±.5	3.2 ±0.2	NA	NA	
1971-72	5	3.6± 5.0	21 ±7.6	0.36±0.22	0.78±0.48	0.19±0.30	0.62±0.91	0.3 ±.4	2.2 ±1.4	NA	NA	
1973	1	4.7± 1.5	29 ±2.3	---	---	---	---	---	1.2 ±0.1	0.7 ±0.2	0.15 ±0.10	
May '74	1	3.8± 0.8	19 ±2.5	1.1 ±0.2	2.4 ±0.2	0.15±0.09	1.5 ±0.6	0.23±.12	1.6 ±0.1	3.4 ±0.3	---	
Aug '74	1	2.0± 0.8	19 ±0.8	0.4 ±0.1	0.7 ±0.1	---	0.94±0.32	0.16±.08	0.85±0.06	1.7 ±0.2	---	
Duck Cove Creek												
1970-71 ^b	2	4.0± 3.5	15 ±8	0.41±0.15	0.86±0.32	---	1.0 ±1.0	0.7 ±.5	1.3 ±0.4	NA	NA	
1971-72	5	6.2± 8.9	20 ±5	0.42±0.24	0.94±0.57	0.52±0.66	0.87±0.80	0.6 ±.4	1.6 ±0.9	NA	NA	
1973	1	6.0± 1.5	20 ±1.5	---	---	---	---	0.26±.09	2.9 ±0.1	0.9 ±0.2	0.14 ±0.08	
May '74	1	3.1± 0.7	14 ±1.5	0.46±0.09	1.2 ±0.1	0.16±0.08	0.81±0.36	---	4.0 ±0.2	1.8 ±0.2	---	
Aug '74	1	---	21 ±2	---	0.47±0.19	---	---	---	0.67±0.08	0.78±0.22	---	
Clevenger Lake Outlet												
1970-71 ^b	2	2.5± 2.2	5.3±3.5	0.39±0.07	0.81±0.16	0.4 ±0.5	0.5 ±0.6	0.6 ±0.1	0.6 ±0.8	NA	NA	
1971-72	5	12 ±14	10 ±9	0.78±0.86	2.5 ±2.4	0.9 ±1.3	1.2 ±0.4	0.1 ±0.2	1.1 ±0.1	NA	NA	

TABLE 4 (continued)

Location and Date	n	Gamma-Emitting Radionuclides (pCi/g, dry) ^a									
		⁷ Be	⁴⁰ K	⁹⁵ Zr	⁹⁵ Nb	¹⁰³ Ru	¹⁰⁶ Ru	¹²⁵ Sb	¹³⁷ Cs	¹⁴⁴ Ce	¹⁵⁵ Eu
1973	1	3.4 ± 1.0	20 ± 2.1	---	---	---	---	---	0.3 ± 0.1	---	---
Aug '74	1	---	24 ± 1.1	0.45 ± 0.20	0.80 ± 0.19	---	---	---	0.7 ± 0.1	1.4 ± 0.3	---
Cannikin Lake Outlet											
May '74	1	13 ± 1.2	17 ± 1.8	1.6 ± 0.2	3.9 ± 0.2	0.45 ± 0.13	3.4 ± 0.6	---	1.3 ± 0.1	6.4 ± 0.3	0.20 ± 0.06
Aug '74	1	3.5 ± 1.3	28 ± 3.3	0.31 ± 0.19	0.60 ± 0.16	---	1.2 ± 0.8	---	1.4 ± 0.1	2.0 ± 0.3	---

a. Single sample (n = 1) errors are two-sigma, propagated, counting errors, while the error shown for more than one sample (n > 1) is one standard deviation of the mean. Dashes in the table indicate the sample count is not significant and NA indicates the radionuclide was not included in the gamma-spectrum analysis.

b. Pre-Cannikin.

TABLE 5

Gamma-Emitting Radionuclides in Freshwater Aufwuchs and Filamentous Algae
Collected at Amchitka Island^a

		Gamma-Emitting Radionuclides (pCi/g, dry) ^b								
Location and Date	n	⁷ Be	⁴⁰ K	⁹⁵ Zr	⁹⁵ Nb	¹⁰³ Ru	¹⁰⁶ Ru	¹²⁵ Sb	¹³⁷ Cs	¹⁴⁴ Ce
Long Shot Pond										
1970-71 ^c	7	15 ±12	9 ±4	3.1 ±1.9	6.7 ±3.9	2.1 ±2.7	5.8 ±4.1	1.5 ±0.9	1.8 ±0.9	NA
1971-72	5	3.2± 3.4	10 ±1.4	0.8 ±1.0	2.2 ±2.9	0.39±0.56	0.2 ±0.4	0.4 ±0.3	0.5 ±0.1	1.1 ±1.6
1973	2	3.7± 2.1	9.8±0.4	---	0.09±0.12	---	---	---	0.27±0.02	0.42±0.26
May '74	1	26 ± 9	4.9±1.4	---	4.6 ±1.0	---	2.5 ±0.8	0.39±0.13	0.40±0.07	7.7 ±0.6
Aug '74	1	3.4± 1.0	9.4±0.8	0.55±0.15	0.92±0.14	---	1.3 ±0.4	0.24±0.09	0.34±0.05	1.2 ±0.2
MP-12 Creek										
July '72	1	7.8± 1.7	5.2±0.5	3.5 ±0.4	6.4 ±0.5	1.7 ±0.3	0.76±0.28	---	2.0 ±0.2	3.8 ±0.4
Aug '73	1	8.3± 0.9	9.6±1.6	0.29±0.11	0.34±0.08	0.24±0.09	---	---	2.7 ±0.1	0.36±0.17
May '74	1	9.1± 1.1	8.9±1.6	4.0 ±0.2	7.6 ±0.3	0.28±0.13	2.9 ±0.7	0.79±0.13	2.5 ±0.2	12 ±0.5
White Alice Inlet to Cannikin Lake										
Aug '73	1	23 ± 1.5	6.1±1.4	0.59±0.13	1.1 ±0.14	0.91±0.15	---	---	0.72±0.09	1.4 ±0.2
Aug '74	1	12 ± 1.2	9.8±0.6	0.99±0.14	2.0 ±0.15	0.43±0.08	1.7 ±0.4	---	1.1 ±0.08	4.3 ±0.2

- a. Aufwuchs samples were collected from Long Shot Pond and MP-12 Creek, while the algae samples were collected from White Alice Inlet to Cannikin Lake.
- b. Single sample (n = 1) errors are two-sigma, propagated, counting errors, while the error shown for more than one sample (n > 1) is one standard deviation of the mean. Dashes in the table indicate the sample count is not significant and NA indicates the radionuclide was included in the gamma-spectrum analysis.
- c. Pre-Cannikin.

TABLE 6
Gamma-Emitting Radionuclides in Lichens Collected at Amchitka Island

		Gamma-Emitting Radionuclides (pCi/g, dry) ^a									
Location and Date	n	⁷ Be	⁴⁰ K	⁹⁵ Zr	⁹⁵ Nb	¹⁰³ Ru	¹⁰⁶ Ru	¹²⁵ Sb	¹³⁷ Cs	¹⁴⁴ Ce	¹⁵⁵ Eu
Clam Lake											
1970-71 ^b	7	15 ±6.1	4.5±6.4	1.0 ±1.0	2.1±1.9	1.5 ±3.1	5.4±3.2	5.6 ±7.2	37±39	NA	NA
1971-72	5 ^c	9.7±8.2	6.2±5.5	0.7 ±0.7	1.7±1.4	0.5 ±0.7	3.6±3.8	3.4 ±3.5	27±23	9 ±0.4	1.5 ±0.14
1973	3	5.3±0.5	3.5±0.3	0.03±0.05	0.1±0.1	0.03±0.06	1.1±0.2	0.60±0.12	7±6.9	3.7±1.3	0.56±0.32
May '74	1	4.5±0.9	2.4±0.9	0.48±0.09	1.2±0.1	---	1.4±0.5	0.56±0.11	12±0.3	4.0±0.3	0.38±0.05
Aug '74	1	5.2±1.2	3.7±0.4	0.23±0.18	0.9±0.1	---	1.3±0.4	0.33±0.09	9±0.2	4.1±0.2	0.33±0.09
Ice Box Lake											
Oct '72	1	---	2.8±1.2	0.7 ±0.1	1.4±0.3	3.8 ±2.0	---	2.6 ±0.7	14±0.2	NA	NA
1973	2	5.7±0.3	0.6±0.8	---	---	---	1.3±0.1	0.86±0.12	16±0.7	4.3±1.1	0.63±0.18
May '74	1	8.6±1.1	1.4±0.9	0.80±0.12	2.1±0.2	---	2.1±0.5	0.59±0.13	13±0.3	8.1±0.4	0.40±0.06
Aug '74	1	5.7±1.5	1.3±0.5	0.49±0.19	0.8±0.1	---	2.2±0.5	0.64±0.13	9±0.2	6.0±0.3	0.43±0.07
Cannikin Lake											
July '72	1	5.3±1.7	2.0±0.7	0.7 ±0.1	1.6±0.1	0.6 ±0.3	---	0.2 ±0.4	21±0.2	NA	NA
1973	2	5.3±1.3	2.3±0.1	---	---	0.07±0.09	1.3±0.1	0.90±0.06	16±0.7	4.1±1.6	0.73±0.17
May '74	1	6.7±0.6	1.6±0.6	0.62±0.07	1.6±0.1	0.09±0.06	1.6±0.3	0.65±0.08	11±0.2	5.8±0.2	0.39±0.03
Aug '74	1	5.1±1.3	2.5±0.6	0.30±0.15	0.7±0.1	---	1.7±0.5	0.34±0.12	8±0.2	4.3±0.3	0.30±0.06

a. Single sample (n = 1) errors are two-sigma, propagated, counting errors, while the error shown for more than one sample (n > 1) is one standard deviation of the mean. Dashes in the table indicate the sample count is not significant and NA indicates that radionuclide was not included in the gamma-spectrum analysis.

b. Pre-Cannikin.

c. n equals 1 for ¹⁴⁴Ce and ¹⁵⁵Eu.

TABLE 7

Some Gamma-Emitting Radionuclides in the Marine Algae *Fucus* Collected at
Amchitka Island

		Gamma-Emitting Radionuclides (pCi/g, dry) ^a					
Location and Date	n	⁷ Be	⁴⁰ K	⁹⁵ Zr	⁹⁵ Nb	¹³⁷ Cs	¹⁴⁴ Ce
Constantine Harbor							
1970-71 ^b	3	0.52±0.18	25±6	0.10±0.08	0.21±0.17	0.05±0.02	NA
1972	4	2.5 ±2.0	34±2	0.04±0.04	0.07±0.08	---	---
1973	2	---	34±0.7	---	---	0.03±0.04	---
May '74	1	1.0 ±0.4	32±2.0	0.36±0.04	0.73±0.09	0.05±0.03	1.5 ±0.2
Duck Cove							
1970-71 ^b	3	0.8 ±0.3	23±2	0.07±0.04	0.15±0.10	0.04±0.02	NA
1971-72	5	1.9 ±1.5	35±4.5	0.05±0.03	0.10±0.07	0.01±0.03	---
1973	3	0.47±0.41	35±9.9	---	---	0.03±0.05	0.08±0.14
May '74	1	---	38±1.2	0.08±0.06	0.22±0.05	0.07±0.02	0.91±0.10
Aug '74	1	---	36±2.3	---	---	0.07±0.04	0.35±0.21
IA-2 or -3							
1970-71 ^b	5	0.09±0.09	26±6	0.08±0.06	0.17±0.14	0.06±0.03	NA
1971-72	6	3.8 ±3.2	26±4.6	0.22±0.20	0.45±0.43	0.01±0.02	---
1973	2	---	35±2.1	---	---	---	0.16±0.23
May '74	1	0.61±0.45	39±2.3	0.23±0.09	0.34±0.08	---	0.92±0.19
Aug '74	1	---	27±1.4	---	---	---	0.25±0.19

a. Single sample (n = 1) errors are two-sigma, propagated, counting errors, while the error shown for more than one (n > 1) is one standard deviation of the mean. Dashes in the table indicate the sample count is not significant and NA indicates the radionuclide was not included in the gamma-spectrum analysis.

b. Pre-Cannikin.

TABLE 8

Some Gamma-Emitting Radionuclides in Green Sponge Collected at Amchitka Island

		Gamma-Emitting Radionuclides (pCi/g, dry) ^a				
Location and Date	n	⁷ Be	⁴⁰ K	⁹⁵ Zr	⁹⁵ Nb	¹⁴⁴ Ce
Duck Cove						
1971-72	4	2.7±2.7	11 ±3	0.05±0.07	0.11±0.14	NA
1973	2	1.5±0.6	9.8±0.1	---	---	0.42±0.04
May '74	1	1.0±0.4	10 ±1.5	0.16±0.07	0.36±0.07	1.1 ±0.17
Aug '74	1	---	7.2±1.3	---	---	1.2 ±0.23
Sand Beach Cove						
June '72	1	---	6.8±1.7	0.24±0.13	0.54±0.28	NA
April '73	1	---	12 ±1.7	---	---	0.31±0.17
May '74	1	1.1±0.4	9.0±1.5	0.10±0.07	0.26±0.07	0.60±0.16
Aug '74	1	---	9.6±1.4	---	---	1.2 ±0.2
Square Bay						
1973	2	0.7±0.9	9.7±0.5	---	---	0.35±0.12

- a. Single sample (n = 1) errors are two-sigma, propagated, counting errors, while the error shown for more than one (n > 1) is one standard deviation of the mean. Dashes in the table indicate the sample count is not significant and NA indicates the radionuclide was not included in the gamma-spectrum analysis.

TABLE 9

 ^{40}K and ^{137}Cs in Halibut Collected off Amchitka Island

Location and Date	Tissue	n ^b	Gamma-Emitting Radionuclides (pCi/g, dry) ^a	
			⁴⁰ K	¹³⁷ Cs
Bering Sea (Off C-Site)				
1971 ^c	Muscle	4/4	18 ± 1.7	0.06 ± 0.08
1971-72	"	9/9	17 ± 1.7	0.02 ± 0.03
1973	"	5/5	18 ± 1.1	0.11 ± 0.02
1971 ^c	Liver	4/4	13 ± 5.9	0.27 ± 0.28
1971-72	"	8/8	6.7 ± 2.1	---
1973	"	5/5	6.9 ± 1.3	0.04 ± 0.05
(Constantine Harbor)				
Aug '74 ^d	"	5/5	7.5 ± 2.6	0.06 ± 0.07

a. Values are given as the mean ± one standard deviation. The dashes in the body of the table indicate the mean was not significant; i.e., all the net sample counts in that group were less than their two-sigma, propagated, counting errors.

b. Number of pooled samples/total number of fish in all samples.

c. Pre-Cannikin.

d. Cobalt-60 was present (0.03 ± 0.02 pCi/g, dry) in one liver sample.

TABLE 10

 ^{40}K and ^{137}Cs in Greenling Collected off Amchitka Island

Location and Date	Tissue	n ^b	Gamma-Emitting Radionuclides (pCi/g, dry) ^a	
			⁴⁰ K	¹³⁷ Cs
Constantine Harbor				
1971 ^c	Muscle	2/19	16 ± 0.7	0.37 ± 0.42
1971-72	"	15/29	15 ± 1.3	0.04 ± 0.04
1973	"	2/9	17 ± 2.8	0.05 ± 0.06
May '74	"	1/5	18 ± 1.5	0.06 ± 0.03
Aug '74	"	1/5	16 ± 0.8	0.07 ± 0.05
1971 ^c	Viscera	2/19	13 ± 0.7	0.15 ± 0.05
Dec '71	Liver	1/10	13 ± 1.6	0.21 ± 0.12
1973	Viscera	1/4	9.1 ± 0.6	---
May '74	"	1/5	15 ± 1.0	0.03 ± 0.02
Aug '74	"	1/5	9.2 ± 0.8	---
Sand Beach Cove				
1971 ^c	Muscle	3/27	15 ± 1.2	0.07 ± 0.02
1971-72	"	15/26	15 ± 1.6	0.03 ± 0.05
1973	"	2/12	17 ± 1.4	0.05 ± 0.06
May '74 ^d	"	1/5	21 ± 1.9	0.05 ± 0.04
Aug '74 ^d	"	1/4	15 ± 0.7	---
1971 ^c	Viscera	3/27	13 ± 0.6	0.02 ± 0.02
1972	Liver	1/6	21 ± 2.9	---
1973	Viscera	1/6	11 ± 0.4	---
1973	Liver	1/6	13 ± 0.6	---
May '74	Viscera	1/5	9.1 ± 1.1	---
Aug '74	"	1/4	8.1 ± 2.1	---

TABLE 10 (continued)

Location and Date	Tissue	n ^b	Gamma-Emitting Radionuclides (pCi/g, dry) ^a	
			⁴⁰ K	¹³⁷ Cs
Duck Cove				
1972	Muscle	8/14	16 ± 1.1	0.06 ± 0.06
1973	"	2/8	15 ± 2.8	0.08 ± 0.01
May '74	"	1/3	18 ± 1.6	0.06 ± 0.03
Aug '74 ^e	"	2/6	15 ± 1.8	0.07 ± 0.02
1973	Viscera	1/4	12 ± 0.5	0.13 ± 0.03
May '74	"	1/3	7.7 ± 0.8	0.04 ± 0.02
Aug '74	"	2/6	9.5 ± 0.1	0.15 ± 0.05

a. Single sample (n = 1) errors are two-sigma, propagated, counting errors, while the error shown for more than one sample (n > 1) is one standard deviation of the mean. Dashes in the table indicate the sample count is not significant.

b. Number of pooled samples/total number of fish in all samples.

c. Pre-Cannikin.

d. Cobalt-60 (0.07 ± 0.04 pCi/g) was also detected in this sample.

e. Cobalt-60 (0.03 ± 0.02 pCi/g) was also detected in this sample.

TABLE 11

 ^{40}K and ^{137}Cs in Dolly Varden and Pink Salmon Collected at Amchitka Island

				Gamma-Emitting Radionuclides (pCi/g, dry) ^a	
Collection Date	Location	Tissue	n ^b	⁴⁰ K	¹³⁷ Cs
I. Pink Salmon					
1971 ^c	Bering Sea	Muscle	1/1	15 ± 0.8	0.10 ± 0.05
1972	Bering Sea	"	8/8	14 ± 3.1	---
Aug '74	Chapel Cove Stream	"	1/1	15 ± 0.9	---
Aug '74	Signal Cove Stream	"	1/1	15 ± 0.5	0.09 ± 0.03
II. Dolly Varden					
1971 ^c	Jones Lake	Muscle	1/1	15 ± 0.8	0.35 ± 0.05
1972	DK-45 Lake	"	3/8	16 ± 1.0	5.7 ± 3.9
1973	Jones Lake	"	1/2	16 ± 0.5	0.28 ± 0.03
1973	Bridge Creek	"	1/1	15 ± 0.9	0.13 ± 0.06
1973	Silver Salmon Outlet	"	1/4	16 ± 0.4	0.13 ± 0.02
May '74	Jones Lake	"	1/5	14 ± 1.7	0.28 ± 0.05
Aug '74	Cannikin Lake	"	1/9	14 ± 0.5	0.31 ± 0.03
Aug '74	Jones Lake	"	3/10	13 ± 0.9	0.17 ± 0.10
Aug '74	Duck Cove	"	1/4	17 ± 0.5	0.35 ± 0.03

a. Single sample (n = 1) errors are two-sigma, propagated, counting errors, while the error shown for more than one (n > 1) is one standard deviation of the mean. Dashes in the table indicate the sample count is not significant and NA indicates the radionuclide was not included in the gamma-spectrum analysis.

b. Number of pooled samples/total number of fish in all samples.

c. Pre-Cannikin.

TABLE 12

Iron-55 in Fish Collected at Amchitka Island

Species and Tissue	Collection Year	n ^a	pCi ⁵⁵ Fe/g, dry ^b	pCi ⁵⁵ Fe/mg Fe
Halibut				
Muscle	1969-70	2/27	0.21 ± 0.14	11 ± 1.8
"	1972	2/2	0.36 ± 0.01	8.7 ± 2.6
"	1973	2/2	0.09 ± 0.10	2.7 ± 2.3
Liver	1970	2/27	2.5 ± 0.03	13 ± 0.7
"	1972	2/2	3.1 ± 0.08	26 ± 7.1
"	1973	2/2	0.54 ± 0.37	5.3 ± 2.1
"	1974	2/2	2.2 ± 0.33	6.7 ± 2.4
Greenling				
Muscle	1970	5/60	0.75 ± 0.74	12 ± 6.7
"	1972	3/20	0.09 ± 0.07	1.1 ± 0.5
"	1973	3/15	0.04 ± 0.02	1.8 ± 1.0
"	1974	4/17	0.09 ± 0.07	4.5 ± 1.8
Liver	1970	5/60	8.3 ± 6.3	13 ± 11
"	1973	3/15	1.4 ± 1.5	0.7 ± 0.3
Viscera	1974	4/17	0.37 ± 0.18	0.2 ± 0.1
Pink Salmon				
Muscle	1969	2/2	6.7 ± 4.3	93 ± 6.6
"	1972	4/4	0.61 ± 0.30	18 ± 2.8
"	1974	2/2	0.39 ± 0.04	11 ± 1.5
Liver	1969-70	3/3	57 ± 2.7	82 ± 24
"	1972	1/8	15 ± 0.1	21 ± 1.1
Viscera	1974	1/1	13 ± 0.1	13 ± 0.7
Dolly Varden				
Muscle	1969-70	3/33	0.91 ± 1.0	50 ± 59
"	1972	2/2	0.36 ± 0.18	9.1 ± 5.0
"	1973	1/4	0.05 ± 0.01	1.6 ± 0.1
"	1974	4/19	0.06 ± 0.03	2.3 ± 0.5
Liver	1969-70	3/29	7.2 ± 5.0	47 ± 44 ^c
"	1973	1/4	2.1 ± 0.1	1.9 ± 0.1
Viscera	1974	4/19	0.35 ± 0.22	0.43 ± 0.23

- a. Number of pooled samples/total number of fish in all samples.
- b. The error for single samples in a one-sigma, propagated, counting error. The error for more than one sample is one standard deviation of the mean and disregards counting errors.
- c. n equals 2/11, as there was no stable Fe value for one group of 18 fish.

TABLE 13

Some Gamma-Emitting Radionuclides in Rock Ptarmigan
Collected at Amchitka Island

Collection Date	Collection Location	Tissue	Number of Birds	Radionuclides (pCi/g, dry) ^a	
				⁴⁰ K	¹³⁷ Cs
1970-71 ^b	South Bight	Muscle	4	11 ± 0.5	1.0 ± 0.6
1971-72	C-Site	"	3	11 ± 1.6	0.70 ± 0.04
1973	c	"	5	11 ± 0.8	0.43 ± 0.25
May '74	C-Site	"	2	11 ± 1.2	0.42 ± 0.05
Aug '74	C-Site	"	4	11 ± 1.5	0.90 ± 0.35
1970-71 ^b	South Bight	Liver	1	---	---
Aug '74	C-Site	Viscera	4	13 ± 1.2	1.6 ± 0.8

a. Values are given as the mean ± one standard deviation. The dashes in the body of the table indicate the sample counts were not significant for that group of samples.

b. Pre-Cannikin.

c. One each from Mason Lake, C-Site, and Mile 16; two from Mile 5.

TABLE 14

Strontium-90 in Bone From Rats and Ptarmigan Collected at Amchitka Island

Collection Date	Location	Organism	pCi ⁹⁰ Sr/g, dry ^a
Oct 1971 ^b	Sand Beach Cove	Rat	0.7 ± 0.2
Oct 1971 ^b	" " "	"	2.5 ± 0.2
Dec 1971	" " "	"	10.1 ± 0.4
Dec 1971	" " "	"	1.6 ± 0.2
April 1973	" " "	"	1.9 ± 0.5
Aug 1973	Main Dump	"	1.8 ± 0.1
Aug 1974	Main Camp	"	0.8 ± 0.7
Aug 1974	Duck Cove	"	2.3 ± 0.7
Nov 1971 ^b	Clevenger Creek	Ptarmigan	27.0 ± 0.8
Nov 1971 ^b	Baker Runway	"	35.2 ± 1.0
Dec 1971	Base Camp	"	18.3 ± 0.5
Dec 1971	C-Site	"	30.7 ± 0.9
Aug 1973	Silver Salmon Lake	"	13.9 ± 0.2
Sept 1973	Clam Lake	"	11.0 ± 0.2
Aug 1974	Mile Post 8	"	16.1 ± 2.3

a. Errors are one-sigma, propagated, counting errors for a single sample.

b. Pre-Cannikin.

TABLE 15

Gamma-Emitting Radionuclides in Samples Collected With a Filter and Sorption Bed
System From Intertidal Areas of Amchitka Island

Location and Date	Liters Sampled	Fraction	n	Gamma-Emitting Radionuclides (pCi/liter) ^a			
				⁷ Be	⁹⁵ Zr	⁹⁵ Nb	¹³⁷ Cs
Constantine Harbor							
1970-71 ^b	2590 ± 1800	Particulate	6	0.009 ± 0.011	0.002 ± 0.008	0.006 ± 0.007	0.001 ± 0.001
"	2590 ± 1800	Soluble	6	0.38 ± 0.81	0.003 ± 0.017	0.012 ± 0.015	0.002 ± 0.035
1971-72	730 ± 600	Particulate	5	---	0.001 ± 0.002	0.003 ± 0.006	0.02 ± 0.02
"	730 ± 600	Soluble	5	0.14 ± 0.21	0.002 ± 0.004	0.004 ± 0.009	0.02 ± 0.04
1973	1280 ± 770	Particulate	2	---	---	---	---
"	"	Soluble	2	---	---	---	---
May '74 ^c	534	Particulate	1	---	0.006 ± 0.005	0.009 ± 0.003	---
"	"	Soluble	1	---	---	---	---
Aug '74	1134	Particulate	1	---	---	---	---
"	"	Soluble	1	---	---	---	---
Duck Cove							
1971 ^b	660 ± 380	Particulate	2	0.018 ± 0.025	0.004 ± 0.005	0.008 ± 0.011	---
"	"	Soluble	2	---	0.002 ± 0.002	0.003 ± 0.004	---
1971-72	305 ± 182	Particulate	6	0.032 ± 0.078	0.001 ± 0.002	0.002 ± 0.005	0.005 ± 0.008
"	"	Soluble	6	---	0.002 ± 0.005	0.005 ± 0.011	---
1973	544 ± 557	Particulate	2	---	---	---	---
"	"	Soluble	2	---	---	---	---
May '74 ^d	98	Particulate	1	---	---	0.046 ± 0.025	0.016 ± 0.014
"	"	Soluble	1	---	---	---	---
Aug '74	437	Particulate	1	---	---	0.036 ± 0.013	---
"	"	Soluble	1	---	---	---	---

TABLE 15 (continued)

Location and Date	Liters Sampled	Fraction	n	Gamma-Emitting Radionuclides (pCi/liter) ^a			
				⁷ Be	⁹⁵ Zr	⁹⁵ Nb	¹³⁷ Cs
Sand Beach Cove							
1971-72	494 ± 233	Particulate	6	---	0.004 ± 0.006	0.008 ± 0.013	0.003 ± 0.004
"	"	Soluble	6	0.072 ± 0.18	---	---	0.003 ± 0.007
1973	462 ± 310	Particulate	2	---	---	---	---
"	"	Soluble	2	---	---	---	---
May '74 ^e	314	Particulate	1	---	---	0.028 ± 0.010	---
"	"	Soluble	1	---	---	---	---
Aug '74	310	Particulate	1	---	---	---	---
"	"	Soluble	1	---	---	---	---

a. Single sample error values are two-sigma, propagated, counting errors, while the value given for more than one sample is the mean ± one standard deviation. Dashes in the table indicate the sample count was not significant.

b. Pre-Cannikin.

c. Cerium-144 was also present, 0.014 ± 0.008 pCi/liter.

d. " " " " 0.13 ± 0.07 pCi/liter.

e. " " " " 0.035 ± 0.024 pCi/liter.

TABLE 16

Gamma-Emitting Radionuclides in Samples Collected With a Filter and Sorption Bed System
From Lakes on Amchitka Island

Location and Date	Liters Samples	Fraction	n	Gamma-Emitting Radionuclides (pCi/liter) ^a			
				⁷ Be	⁹⁵ Zr	⁹⁵ Nb	¹³⁷ Cs
Jones Lake							
1971 ^b	278±240	Particulate	4	---	0.05 ±0.04	0.11 ±0.08	0.02 ±0.04
"	"	Soluble	4	---	0.01 ±0.01	0.02 ±0.02	0.02 ±0.02
1971-72	154±103	Particulate	5	0.2 ±0.3	0.008±0.011	0.02 ±0.02	0.004±0.009
"	"	Soluble	5	1.3 ±2.9	0.07 ±0.15	0.16 ±0.33	0.05 ±0.10
1973	172±30	Particulate	2	---	---	---	0.042±0.015
"	"	Soluble	2	---	---	---	---
May '74 ^c	53	Particulate	1	---	0.084±0.062	0.19 ±0.06	0.039±0.029
"	"	Soluble	1	---	---	---	---
Aug '74	413	Particulate	1	---	---	---	---
"	"	Soluble	1	---	---	---	---
Lake DK-45							
1971-72	148±133	Particulate	5	0.16±0.22	0.07 ±0.09	0.15 ±0.20	0.07 ±0.15
"	"	Soluble	5	4 ±9	---	---	---
1973	110±57	Particulate	2	---	---	---	0.07 ±0.05
"	"	Soluble	2	--	---	---	---
May '74 ^d	170	Particulate	1	0.33±0.16	0.23 ±0.04	0.47 ±0.05	---
"	"	Soluble	1	---	0.20 ±0.17	0.24 ±0.13	---
Aug '74	174	Particulate	1	---	---	---	---
"	"	Soluble	1	---	---	---	---
Cannikin Lake							
1972	9±1.4	Particulate	2	---	0.17 ±0.23	0.34 ±0.48	---
1973	84±16	Particulate	2	---	---	---	0.04 ±0.057
"	"	Soluble	2	---	---	---	0.08 ±0.11

TABLE 16 (continued)

Location and Date	Liters Sampled	Fraction	n	Gamma-Emitting Radionuclides (pCi/liter) ^a			
				⁷ Be	⁹⁵ Zr	⁹⁵ Nb	¹³⁷ Cs
May '74 ^e	314	Particulate	1	---	0.20 ±0.04	0.25 ±0.03	0.019±0.013
"	"	Soluble	1	---	---	---	---
Aug '74	99	Particulate	1	---	---	---	---
"	"	Soluble	1	---	---	---	---
Long Shot Mud Pit No. 1							
1970-71 ^b	418±398	Particulate	6	4.0 ± 4.7	0.4 ±0.6	0.9 ±1.2	0.02 ±0.03
"	"	Soluble	6	11 ±18	0.002±0.003	0.006±0.009	0.08 ±0.18
1971-72	56±41	Particulate	5	1.2 ± 1.3	0.25 ±0.29	0.48 ±0.55	0.03 ±0.07
"	"	Soluble	5	0.44± 0.98	---	---	---
1973	35±5	Particulate	2	2.0 ± 1.0	---	---	0.04 ±0.06
"	"	Soluble	2	---	---	---	---
May '74 ^f	48	Particulate	1	4.0 ± 0.7	1.3 ±0.1	2.7 ±0.2	0.034±0.028
"	48	Soluble	1	---	---	---	---
Aug '74	189	Particulate	1	0.7 ± 0.2	0.06 ±0.03	0.14 ±0.02	---
"	189	Soluble	1	---	---	0.21 ±0.10	---

a. Single sample error values are two-sigma, propagated, counting errors, while the values given for more than one sample is the mean ± standard deviation. Dashes in the table indicate the sample count was not significant.

b. Pre-Cannikin.

c. Cerium-144 also present, 0.44 ± 0.14 pCi/liter.

d. " " " 0.52 ± 0.06 "

e. " " " 0.41 ± 0.07 "

f. " " " 4.9 ± 0.3 "

TABLE 17

Tritium Concentration in Water Samples Collected
at Amchitka Island

Date	Collection Site	Number of Samples	Tritium ^a Units	pCi/liter
I. Seawater				
1970-71 ^b	c	10	32 ± 19	103 ± 61
1972	c	16	28 ± 25	90 ± 81
1973	c	6	22 ± 13	71 ± 42
1974	c	6	<13	<42
May '74	Duck Cove	1	<13	<42
Aug '74	" "	1	<12	<39
May '74	Constantine Harbor	1	<13	<42
Aug '74	" "	1	<12	<39
May '74	Sand Beach Cove	1	15 ± 13	48 ± 42
Aug '74	" " "	1	12 ± 10	39 ± 32
II. Freshwater, Except Long Shot Mud Pits				
1970-71 ^b	c	12	92 ± 46	298 ± 149
1972	c	18	49 ± 14	158 ± 45
1973	c	46	50 ± 17	162 ± 55
1974	c	44	32 ± 18	103 ± 58
May '74	Jones Lake Outlet	1	14 ± 13	45 ± 42
Aug '74	" " "	1	39 ± 12	126 ± 39
May '74	Clevenger Lake Outlet	1	34 ± 13	110 ± 42
Aug '74	" " "	1	51 ± 10	165 ± 32
May '74	Clevenger Creek	1	34 ± 13	110 ± 42
Aug '74	" "	1	41 ± 10	132 ± 32
May '74	Clam Lake	1	21 ± 13	68 ± 42
Aug '74	" "	1	<12	<39
May '74	Duck Cove Creek	1	27 ± 13	87 ± 42
Aug '74	" " "	1	34 ± 10	110 ± 32
May '74	Bridge Creek	1	61 ± 12	197 ± 39
Aug '74	" "	1	45 ± 10	145 ± 32
May '74	MP 12 Creek	1	59 ± 13	191 ± 42
Aug '74	" " "	1	55 ± 10	178 ± 32
May '74	Cannikin Lake Inlet From Ground Zero	1	50 ± 13	162 ± 42
Aug '74	" " " " " "	1	<12	<39
May '74	Cannikin " " " Drillback	1	25 ± 13	81 ± 42
Aug '74	" " " " "	1	<12	<39
May '74	" " White Alice Inlet	1	40 ± 13	129 ± 42
Aug '74	" " " " "	1	28 ± 10	90 ± 32
May '74	Cannikin Lake Station #1 Surface	1	53 ± 13	171 ± 42
Aug '74	" " " #1 "	1	16 ± 10	52 ± 32
May '74	" " " #1 Bottom	1	53 ± 13	171 ± 42
Aug '74	" " " #1 "	1	<12	<39
May '74	" " " #2 Surface	1	22 ± 13	71 ± 42
Aug '74	" " " #2 "	1	<12	<39

TABLE 17 (continued)

Date	Collection Site				Number of Samples	Tritium ^a		
						Units	pCi/liter	
May '74	"	"	"	#2 Bottom	1	24 ± 13	78 ±	42
Aug '74	"	"	"	#2 "	1	21 ± 11	68 ±	36
Freshwater								
May '74	Cannikin Lake	Station	#3	Surface	1	45 ± 12	145 ±	39
Aug '74	"	"	"	#3 "	1	<12	<39	
May '74	"	"	"	#3 Bottom	1	51 ± 12	165 ±	39
Aug '74	"	"	"	#3 "	1	13 ± 11	42 ±	36
May '74	"	"	"	#4 Surface	1	51 ± 12	165 ±	39
Aug '74	"	"	"	#4 "	1	<12	<39	
May '74	"	"	"	#4 Bottom	1	60 ± 12	194 ±	39
Aug '74	"	"	"	#4 "	1	<12	<39	
May '74	Cannikin Lake	White Alice	Outlet		1	18 ± 13	58 ±	42
Aug '74	"	"	"	"	1	<12	<39	
May '74	Ice Box Lake	Inlet			1	74 ± 12	239 ±	39
Aug '74	"	"	"	"	1	23 ± 11	74 ±	36
May '74	"	"	"	Outlet	1	46 ± 13	149 ±	42
Aug '74	"	"	"	"	1	20 ± 11	65 ±	36
May '74	DK-45 Lake				1	36 ± 13	116 ±	42
Aug '74	"	"			1	26 ± 11	84 ±	36
III. Long Shot Mud Pits								
1970-71 ^b	Mud Pit	#1			3	1800 ± 260	5800 ±	840
1972	"	"	"		4	2050 ± 240	6600 ±	780
1973	"	"	"		2	1900 ± 420	6100 ±	1400
1974	"	"	"		2	1300 ± 250	4200 ±	810
1970-71 ^b	"	"	#3		3	3500 ± 460	11300 ±	1500
1974	"	"	"		1	2900 ± 50	9400 ±	160

a. The error shown for single samples is a one-sigma counting error, while the error for more than one sample is one standard deviation of the mean. One TU equals 3.23 pCi/liter.

b. Pre-Cannikin.

c. Samples pooled from several collection sites.

TABLE 18

Preliminary Results of Tritium Measurements in Free Water From Biological Samples^a

Collection Date	Collection Site	Organism	Tissue	n ^b	Tritium Units ^c	pCi/liter ^c
August 1973	Bridge Creek	Dolly Varden	Muscle	4	64 ± 3	207 ± 10
August 1973	White Alice Creek	Dolly Varden	Muscle	2	162 ± 52	523 ± 168
May 1974	Jones Lake	Dolly Varden	Muscle	3	68 ± 54	220 ± 174
May 1974	Constantine Harbor Boat Dock	Greenling	Muscle	2	48 ± 4	155 ± 13
May 1974	Sand Beach Cove	Greenling	Muscle	3	94 ± 39	304 ± 126
August 1973	Duck Cove Creek	Ranunculus	Entire	2	68 ± 35	220 ± 113
August 1973	White Alice Creek	Ranunculus	Entire	2	89 ± 28	288 ± 90

a. Further testing of new burning-type water extraction unit required before final results can be stated.

b. n equals the number of free water samples from a single tissue sample.

c. Error terms are one standard deviation of the mean. This statistical error disregards counting error which is normally ± 11 to 14 TU.

TABLE 19

Results of Radiation Surveys of Selected Sites on Amchitka Island in 1974

Radiation Level in mR/hr^a

Location	Date	Average Reading		Maximum Reading	
		Window <2 mg/cm ²	30 mg/cm ^{2b}	<2 mg/cm ²	30 mg/cm ^{2b}
Decon Area (Charlie Runway)	May	-- ^c	<0.01	--	0.03
"	August	0.01	<0.01	0.05	0.03
Inside D Barracks	May	--	<0.01	--	0.02
"	August	0.01	<0.01	0.04	0.03
Hus-Key Camp	May	--	<0.01	--	0.02
"	August	<0.01	<0.01	0.04	0.03
Jones Creek Effluence	May	--	<0.01	--	0.02
"	August	<0.01	<0.01	0.04	0.03
EIC Calibration Range	May	--	<0.01	--	0.03
"	August	<0.01	<0.01	0.04	0.03
Rifle Range Target Area	May	--	<0.01	--	0.02
"	August	0.01	<0.01	0.04	0.03
Duck Cove	May	--	<0.01	--	0.02
"	August	<0.01	<0.01	0.03	0.02
Milrow Surface GZ	May	--	<0.01	--	0.02
"	August	<0.01	<0.01	0.04	0.03
Milrow Northwest Side of Pad	May	--	<0.01	--	0.03
"	August	0.01	<0.01	0.04	0.03
Milrow--General Area	May	--	<0.01	--	0.03
"	August	0.01	<0.01	0.04	0.03
Long Shot Surface GZ	May	--	<0.01	--	0.02
"	August	0.01	<0.01	0.05	0.02
Long Shot Mud Pits	May	--	<0.01	--	0.02
"	August	0.01	<0.01	0.05	0.02
Long Shot Northwest Side of Pad	May	--	<0.01	--	0.02
"	August	0.01	<0.01	0.05	0.02
Long Shot General Area	May	--	<0.01	--	0.02
"	August	0.01	<0.01	0.05	0.02

TABLE 19 (continued)

		Radiation Level in mR/hr ^a			
		Average Reading		Maximum Reading	
Location	Date	Window <2 mg/cm ²	30 mg/cm ² ^b	<2 mg/cm ²	30 mg/cm ² ^b
Cannikin Surface GZ	May	--	<0.01	--	0.02
"	August	0.01	<0.01	0.04	0.04
Cannikin Northwest Side of Pad	May	--	<0.01	--	0.02
"	August	0.01	<0.01	0.04	0.04
Cannikin--General Area	May	--	<0.01	--	0.02
"	August	0.01	<0.01	0.04	0.04
Cannikin Drillback Pad	May	--	<0.01	--	0.02
"	August	0.01	<0.01	0.05	0.03
Sand Beach Cove	May	--	<0.01	--	0.03
"	August	<0.01	<0.01	0.04	0.03
D-Site	May	--	<0.01	--	0.03
"	August	0.01	<0.01	0.05	0.04
E-Site	May	--	<0.01	--	0.02
"	August	<0.01	<0.01	0.03	0.03

a. Eberline G-M detector, Model 510.

b. Beta shield closed.

c. No readings were taken in May with the <2 mg/cm² window probe.

5. REFERENCES

- Ballance, W. C. 1974. *Radiochemical Monitoring of Water After the Cannikin Event, Amchitka Island, Alaska, August 1973*. USGS-474-205. United States Department of the Interior Geological Survey, Federal Center, Lakewood, Colorado. 20 p.
- Held, E. E. 1971. *Amchitka Radiobiological Program Progress Report, July 1970 to April 1971*. NVO-269-11. University of Washington, College of Fisheries, Laboratory of Radiation Ecology. 36 p.
- Held, E. E. 1972. *Amchitka Radiobiological Program Progress Report, May 1971 to February 1972*. NVO-269-17. University of Washington, College of Fisheries, Laboratory of Radiation Ecology. 50 p.
- Held, E. E., V. A. Nelson, W. R. Schell, and A. H. Seymour. 1973. *Amchitka Radiobiological Program Progress Report, March 1972 to December 1972*. NVO-269-19. University of Washington, College of Fisheries, Laboratory of Radiation Ecology. 92 p.
- Nelson, V. A., and A. H. Seymour. 1974. *Amchitka Radiobiological Program Progress Report, January 1973 to December 1973*. NVO-269-21. University of Washington, College of Fisheries, Laboratory of Radiation Ecology. 98 p.
- U.S. Environmental Protection Agency. 1973 and 1974. Section III. *Air and Deposition, Radioactivity in Airborne Particulates and Precipitation*. Radiation Data and Reports, Volumes 13 and 14.

6. TABLE AND MAP INDEX

<u>Collection Site</u>	<u>Figure No.(s)</u>	<u>Table No.(s)</u>	<u>Remarks</u>
Baker Runway	3	14	Part of Base Camp
Base Camp	2 & 3	2,14,19	
Bering Sea	1 & 2	9,11	Collection sites located:
Bridge Creek	4	3,4,11,17,18	a) Off C-Site
Cannikin Lake Inlet			
From Drillback	6	17	
Cannikin Lake	6	6,11,16	
Cannikin Lake Outlet	6	3,4,17,18	
Cannikin Lake Inlet			
From GZ	6	17	
Cannikin Lake Inlet From			
White Alice Inlet	6	5,17	
Cannikin Site	2 & 6	19	
Chapel Cove Stream	2	11	
Clam Lake	4	6,17	
Clevenger Creek	4	3,4,17	
Clevenger Lake Outlet	3	4	
Constantine Harbor	2 & 3	7,9,10,15	
Constantine Harbor			
Boat Dock	3	14,18	
Crown Reefer Point	2 & 4	7	
D-Site	2	19	
Decon Area	3	19	
Duck Cove	4	7,8,10,11,15	
Duck Cove Creek	4	3,4,17	
E-Site	2	19	
EIC Calibration Range	3	19	
Hus-Key Camp	3	19	
IA-2 6	7		
IA-3 6	7		
Ice Box Lake	6	6,17	Lake 04-47
Ice Box Lake Inlet	6	3,17	
Infantry Road	2, 4-6	None	
Jones Lake	3	11,16,17,18	
Jones Lake Outlet	3	17,19	
Lake DK-45	6	11,16,17	
Lake DK-45 Outlet	6		
Long Shot	2, 4, 5	5,16,17,19	Collection sites located at:
			a) Mud Pits Nos. 1, 2 & 3;
Main Camp	3	14,19	Part of Base Camp

TABLE AND MAP INDEX (continued)

<u>Collection Site</u>	<u>Figure No.(s)</u>	<u>Table No.(s)</u>	<u>Remarks</u>
Milrow	2 & 4	19	
MP 12 Creek	6	3,14,17	
Rifle Range Target Area	4	19	
Sand Beach Cove	6, 7, 8	10,14,15,17,18,19	
Signal Cove Stream	2	1	
Small Boat Dock	3	17	Located in Constantine Harbor
Square Bay	4	8	

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