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AMCHITKA RADIOBIOLOGICAL PROGRAM PROGRESS REPORT

JANUARY 1978 TO DECEMBER 1978

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ABSTRACT

The Amchitka Radiobiological Program began in 1970 and is a continuing program to collect biological and environmental samples for radiometric analyses. An account of the program from July 1970, to December 1977, has been given in eight previous progress reports from the Laboratory of Radiation Ecology to the Nevada Operations Office of the U.S. Department of Energy. This report is an account of the program for calendar year 1978.

Results of analyses for samples collected in August 1978 have been added to the tables of Seymour and Johnson (1978) which summarize the Amchitka program from 1970 to 1977 and include analyses for: (1) gamma-emitting radionuclides in freshwater, birds, lichens, marine algae, marine invertebrates, fish, aufwuchs, and freshwater moss and plants; (2) strontium-90 (^{90}Sr) in rats, birds, and soil; (3) ^{239} ^{240}Pu in sand, soil, marine algae, and fish; and (4) tritium (^{3}H) in seawater, freshwater, and biological organisms. Monitoring of background radiation with survey instruments was added to the Laboratory's program in 1974, and the results of the five annual surveys since that date are included in this report.

Conclusions from the results of the recent analyses are a reiteration of the results stated in Nelson and Seymour (1975a); namely, "(1) no new radionuclides are present; (2) the most abundant radionuclides are naturally occurring beryllium-7 (^{7}Be) and potassium-40 (^{40}K); (3) the trace quantities of fission products and induced radionuclides are from world fallout; and (4) a trace of ^{3}H 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 1978 as reported in this and the eight 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. A relevant description of the present program is given in the 1972 Progress Report (Held et al., 1973), and selected portions from that report follow.

> "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. These indicator organisms are 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 fallout, nuclear-powered vessels, or from nuclear detonations at Amchitka Island.

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 to eighth progress reports reiterated the above conclusion and extended the account of the program through September 1977. Major conclusions of the eighth report, as stated by Seymour and Johnson (1978) are as follows:

a. "Two natural radionuclides, ^{7}Be and ^{40}K, were the most abundant radionuclides in most samples."

b. "Some fission products, induced radionuclides, and plutonium have been detected in quantities that range from the limits of detection to a few pCi/g of dry sample."

c. "Values for ^{95}Zr and ^{95}Nb in freshwater moss and algae from Amchitka Island and the Columbia River were similar in amounts and peaks of abundance."

d. "Peaks of abundance of fission product radionuclides occurred in 1970-71, 1974 and 1977 and followed major Chinese nuclear detonations."

e. "Two fission products of short half life, ^{95}Zr and ^{95}Nb, were the dominant fallout radionuclides in the samples and their date of origin was much more recent than the last Amchitka nuclear detonation."

f. "The radioactivity from fallout radionuclides, generally, was greater for freshwater than for marine organisms."

g. "There has been no increase in ^{3}H, ^{90}Sr, or $^{239,240}Pu$ values. Tritium is a potential radionuclide indicator of radionuclide leakage from underground sites."

h. "The background radiation survey meter readings were at or near the lower limits of detection for the instrument."

i. "The laboratory detection and measurement system for the radiological analyses of the samples was sensitive to small perturbations in the amounts and species of radionuclides in the environment."

j. "The results of analyses of the 1977 samples complemented the results of analyses of samples collected previously and did not reveal any unexpected information."

In this, the ninth progress report, the format is the same as for the eighth progress report except for minor changes as follows: (1) the table reporting gamma-emitting radionuclides on air filters at ground level at the Amchitka Island Base Camp has been deleted because data since 1974 are not available; (2) the concentrations of tritium in seawater and freshwater samples are presented in two tables, Table 15 documents the tritium concentrations in samples from all areas except Long Shot and Table 16 presents data from the Long Shot mud pits and drainage system; (3) new data from the analyses of the samples collected in August 1978, were added to the appropriate tables of the previous report.

Figure 1 of this report 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 areas shown in Figure 2. Peak years of fallout radionuclides are shown in Figure 7.

2. METHODS

Most samples collected prior to July 1972, and fish, marine invertebrates, and birds collected through 1977 were analyzed by gamma spectrometry with systems using 3 x 3 inch or 4 x 5 inch NaI 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. To determine the ^{90}Sr content of selected samples, ^{90}Y was chemically separated from ^{90}Sr, collected on filter paper and counted with a low-level beta counting system. Plutonium was extracted by ion exchange, electroplated on platinum discs and analyzed by alpha spectrometry with systems using surface barrier alpha detectors and pulse-height analyzers. Chemical yield was determined by use of ^{242}Pu as a tracer. Tritium in seawater and freshwater samples was determined by vacuum distillation of the samples and liquid scintillation counting of

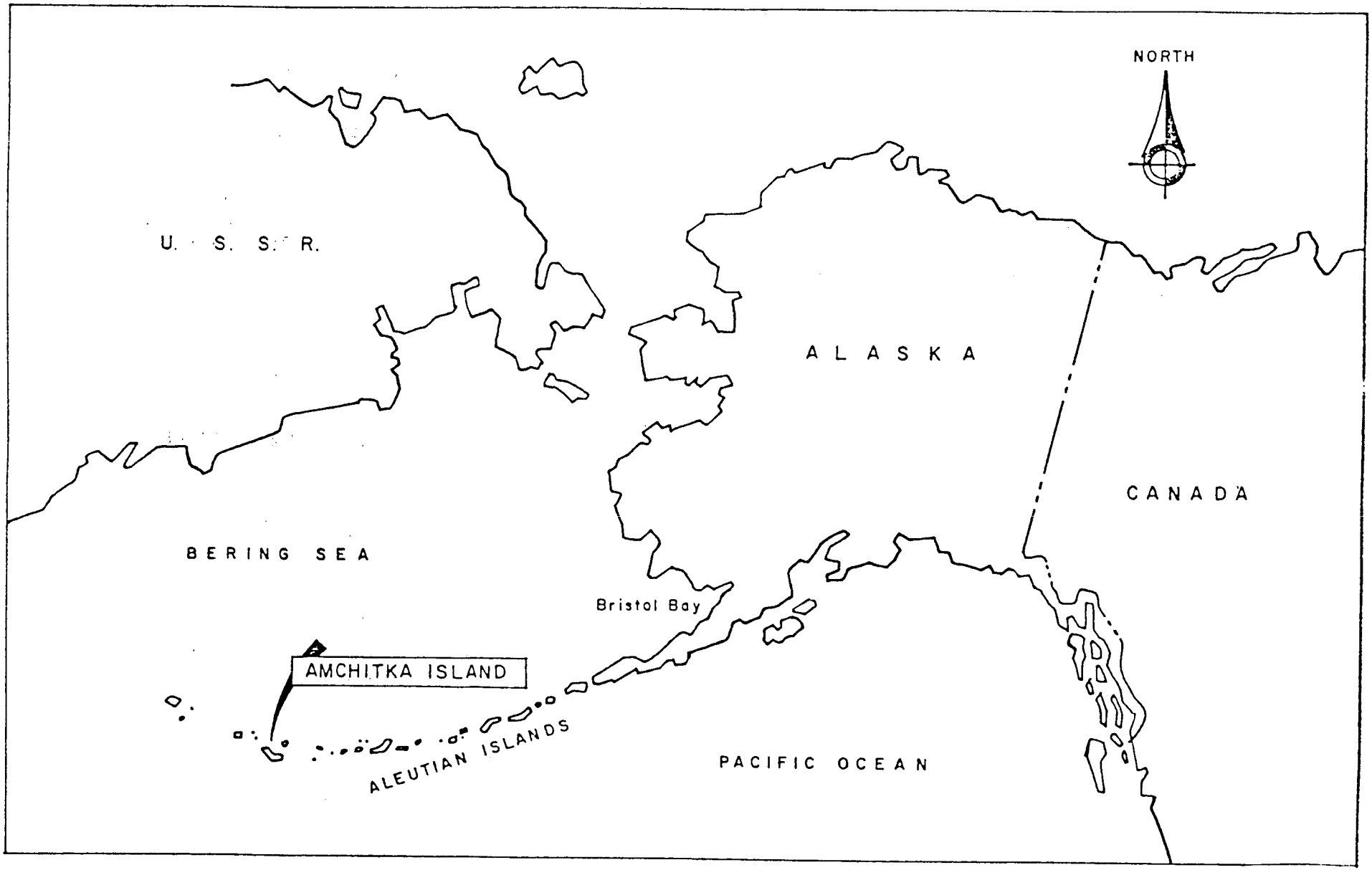

FIGURE 1. Location Map

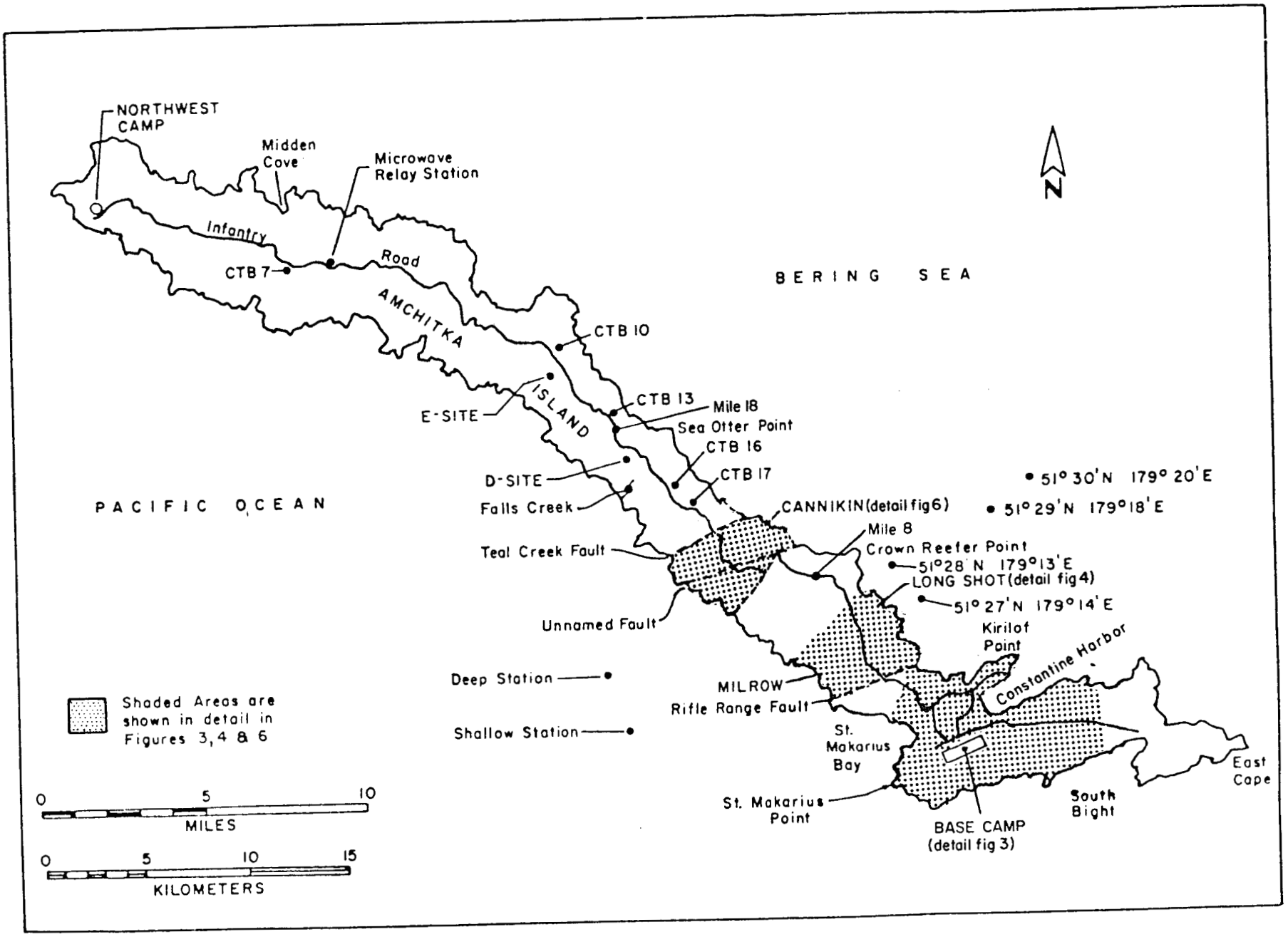

FIGURE 2. Location of Collection Sites on and near Amchitka Island, Alaska

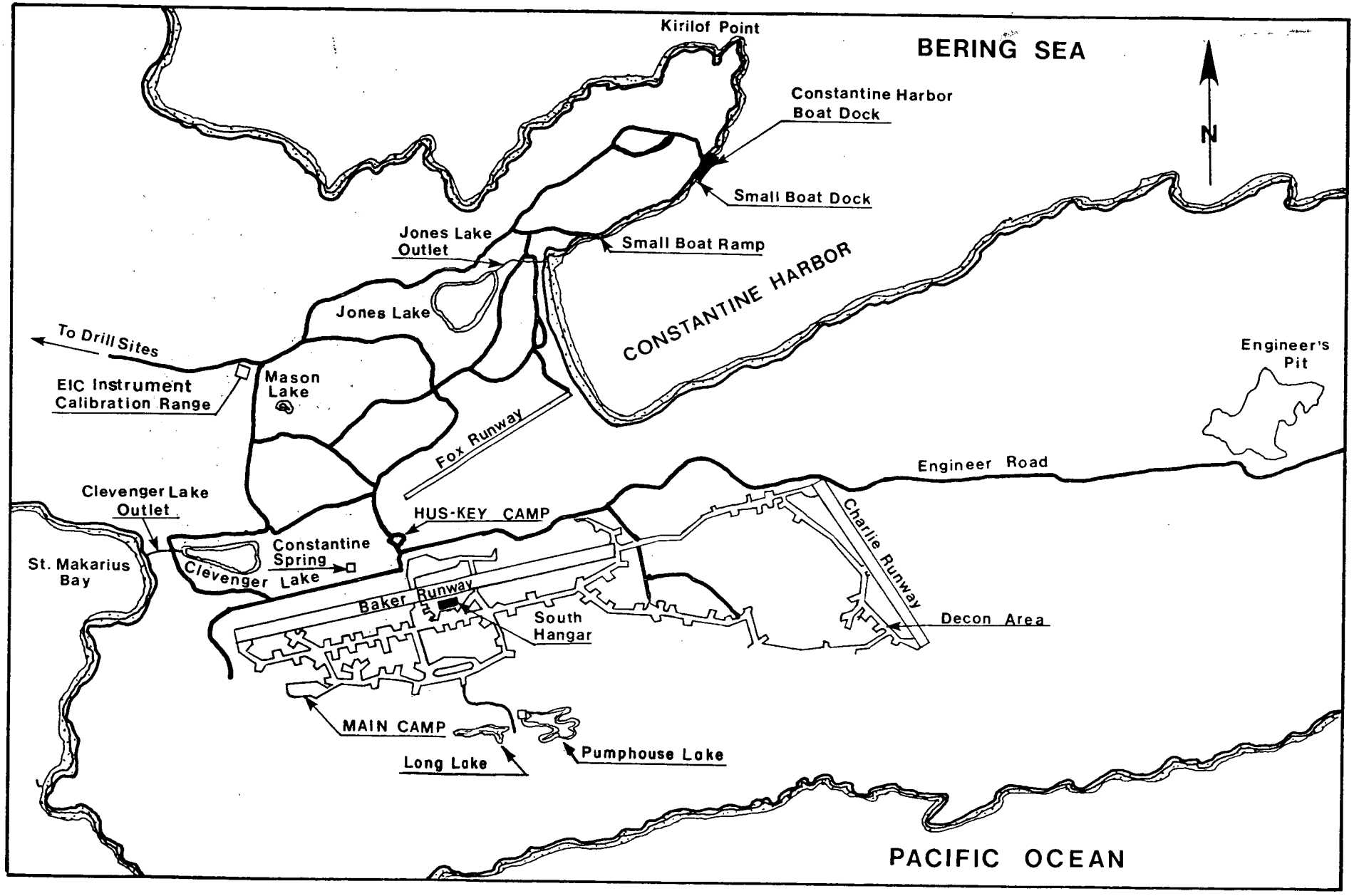

FIGURE 3. Collection Sites and Other Prominent Features in the Amchitka Island Base Camp Area

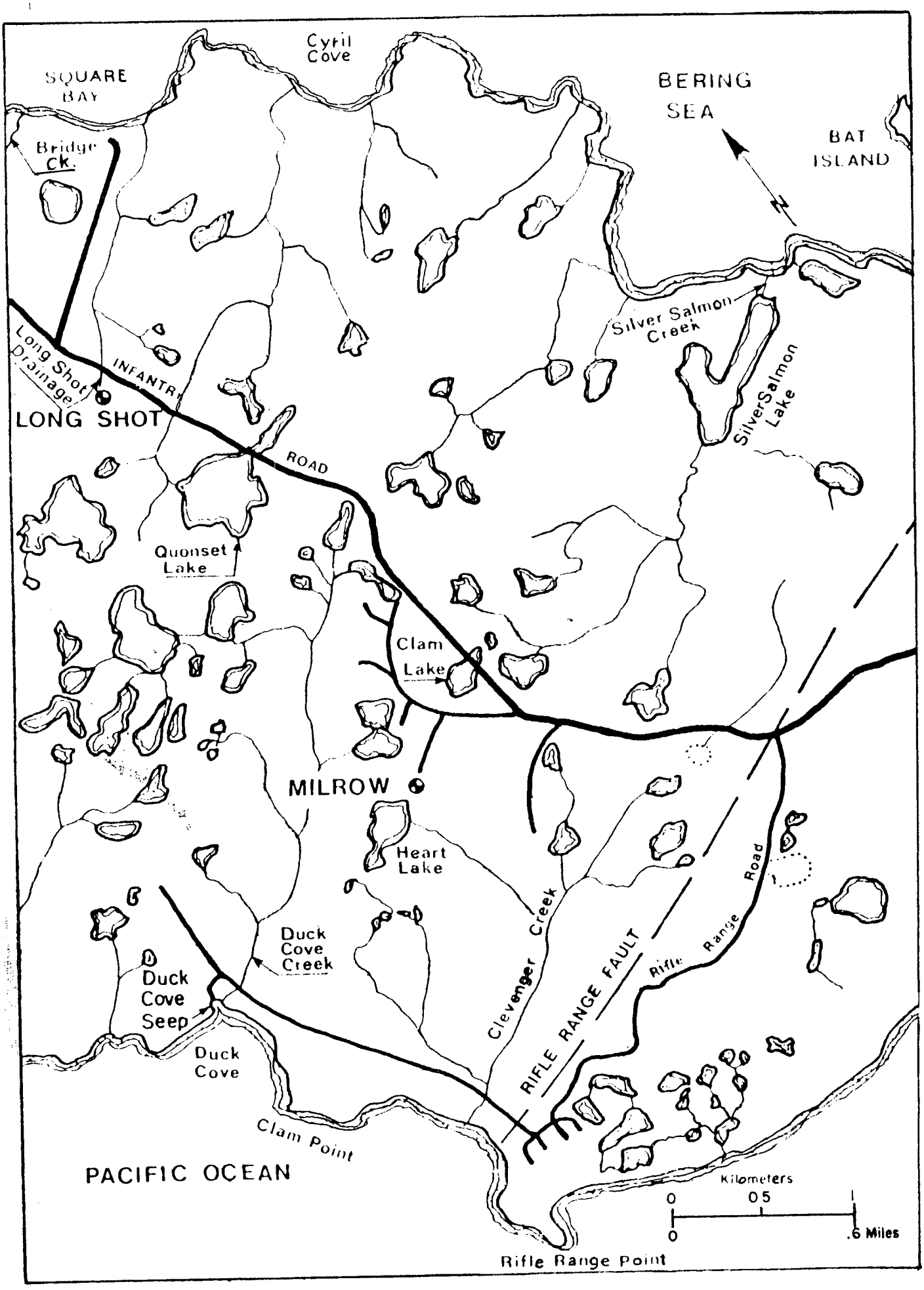

FIGURE 4. Collection Sites and Other Prominent Features in the Milrow Area.

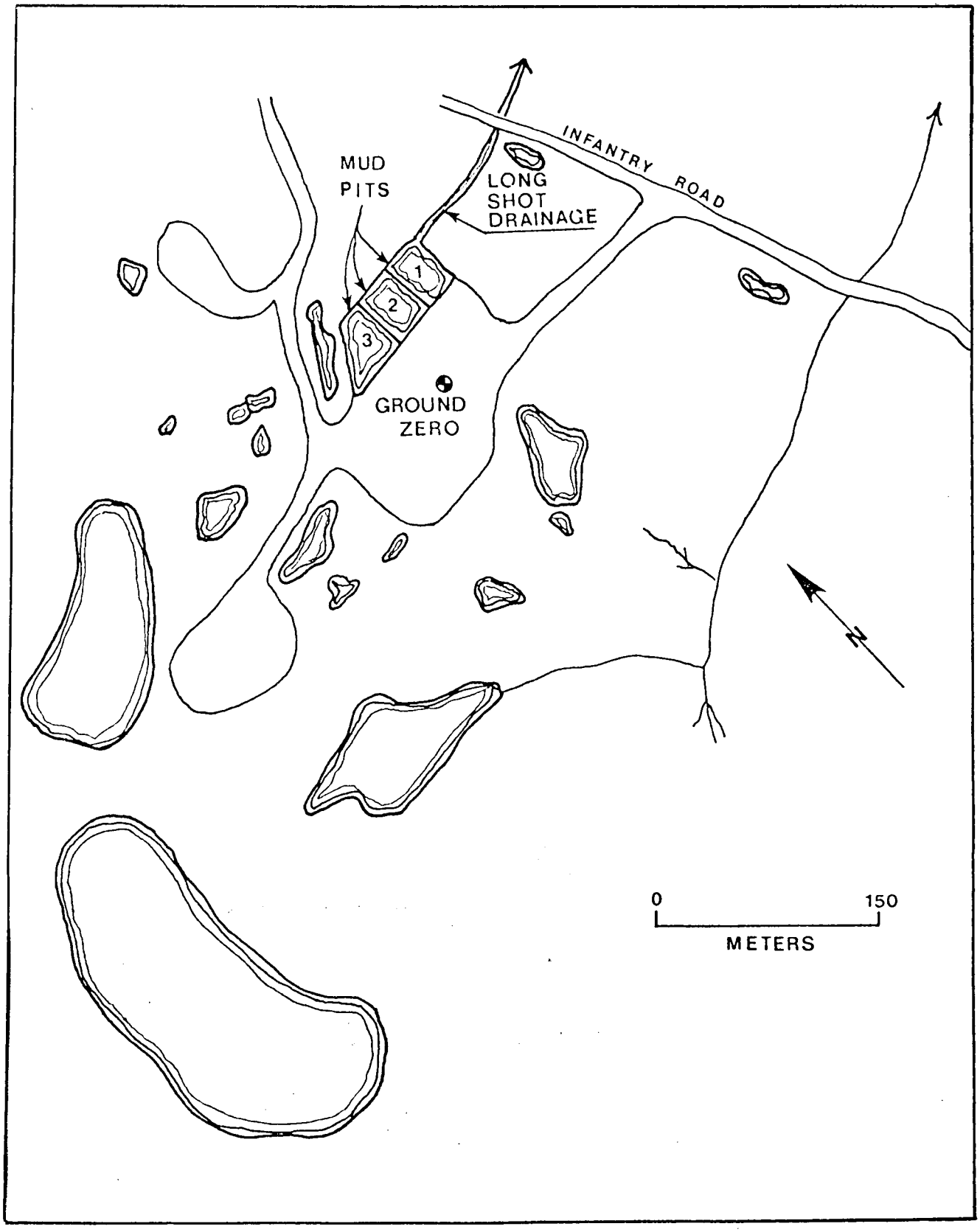

FIGURE 5. Collection Sites and Other Prominent Features in the Long Shot Ground Zero Vicinity.

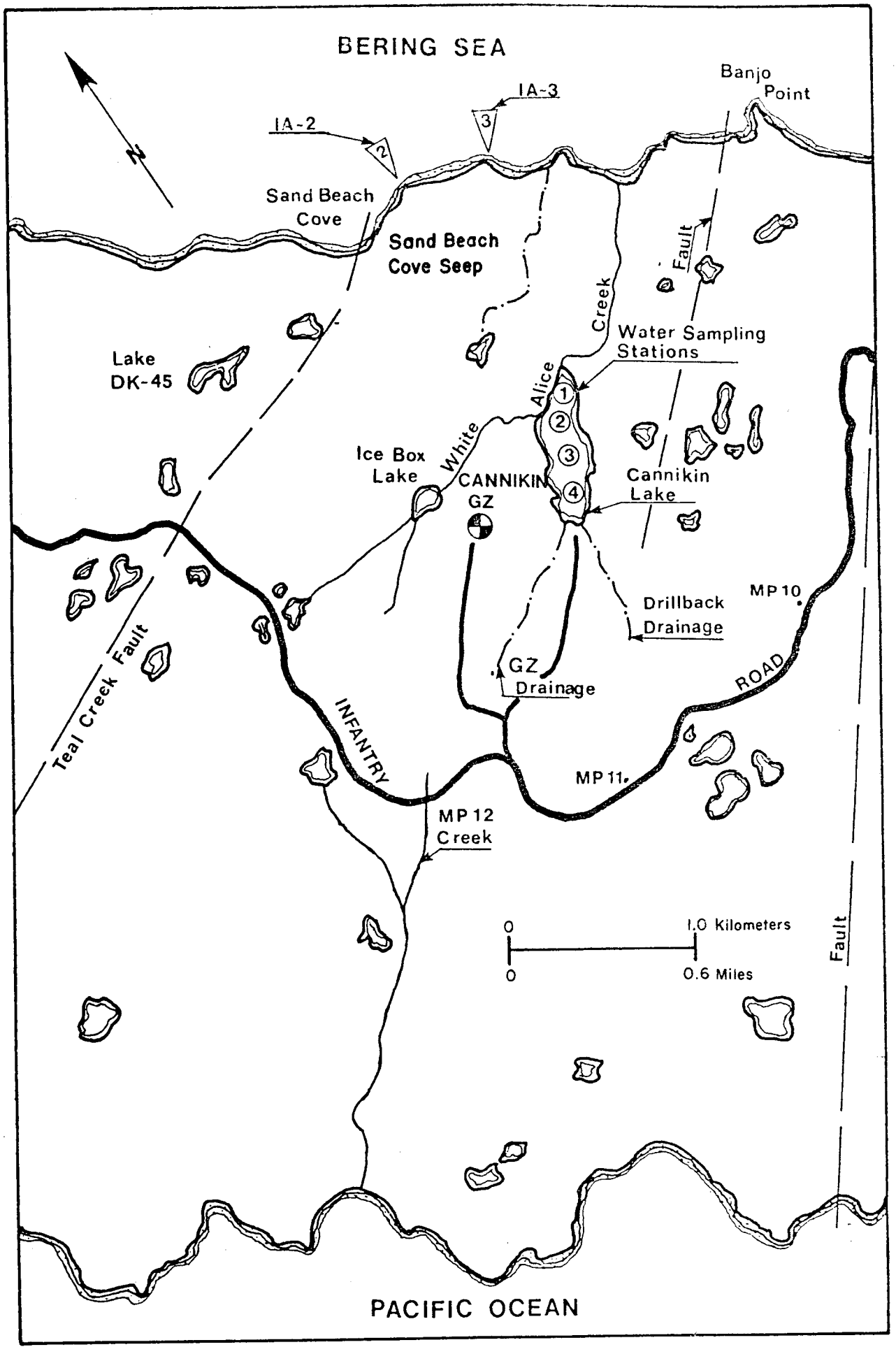

FIGURE 6. Collection Sites and Other Prominent Features in the Cannikin Area

the distillate, or by azeotropic distillation and liquid scintillation counting. The free tritium in samples from fish, ptarmigan, and aquatic plants was determined by freeze-drying the samples, azeotropic distillation and liquid scintillation counting. Freshwater samples (34 liters or more) for analyses of radionuclides other than tritium were evaporated on the island and the residue was later counted for gamma-emitting radionuclides using the Ge(Li) detectors.

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}Nb 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).

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 ^{3}H data, error limits are one-standard deviation counting errors. Errors for ^{90}Sr and all Pu analyses are two-sigma counting errors. The error term for the mean of more than one sample is one-standard deviation of the mean.

Limits of detection are important since they govern the amount of a radionuclide that can be detected if it is present in a sample. Many factors influence the limit of detection, including the type of detector and analyzer, the presence of other radionuclides, the duration of the counting period, the size and density of the sample, and the geometry relationship of the sample and detector. Hence, the actual limits of detection can vary considerably for various radionuclides and types of samples, but can be summarized by stating that the detection limits were approximately as follows:

By gamma detection	
^{40}K	2.1 pCi/g or less
^{7}Be, ^{103}Ru, ^{106}Ru, ^{144}Ce, ^{228}Th, ^{238}U	0.41 " "
^{95}Nb, ^{95}Zr, ^{125}Sb, ^{137}Cs, ^{155}Eu, ^{226}Ra	0.12 " "
By beta detection	
^{3}H	48 pCi/liter or less
^{90}Sr	0.2 pCi/g or less
By X-ray detection	
^{55}Fe	0.04 pCi/g or less

By alpha detection

$^{239,240}Pu$	0.02 pCi/g or less

In addition to the radiometric analyses made on the biological and environmental samples, environmental radiation surveys of selected areas on Amchitka Island have been conducted since August, 1974. An Eberline survey meter, Model E-410, and a pancake probe with a <2 mg/cm^2 window was used in the surveys.

3. RESULTS AND DISCUSSION

The results of the analyses of the samples collected in 1978 are presented in Tables 2 through 18. These tables also summarize the results of analyses from previous years although more detail can be found in earlier progress reports. An excellent summary of the radiobiological studies at Amchitka from 1965 to 1975 can be found in Chapter 24, "Radionuclides in Air, Water, and Biota (Seymour and Nelson, 1977), of the book, "The Environment of Amchitka Island" (Merrit and Fuller, ed., 1977). Other chapters of the book provide additional information about the Amchitka environment based upon extensive studies by many investigators.

The samples collected in August 1978 were of the same type and from the same locations as in previous years and included biological indicator species, water, soil or sand from freshwater, terrestrial, and marine environments. The only changes in the 1978 schedule of sample collections and analyses were as follows:

1. Ranunculus was collected from Long Shot Mud Pit #3 and analyzed for tritium and gamma-emitting radionuclides. This is the first record of this aquatic plant being available at this location.

2. Pink salmon (Oncorhynchus gorbusha) were returning in relatively large numbers to many streams during August, 1978. Muscle samples from two salmon caught in Constantine Harbor were analyzed for gamma-emitting radionuclides.

The results of gamma spectrum analysis for three vascular or nonvascular plants collected in freshwater are given in Tables 2 to 4. The sample types were Fontinalis (a moss), Ranunculus (a plant) and aufwuchs (bottom adhering micro-organisms) with filamentous algae. Samples were collected at seven stations but only Fontinalis was present at all locations. The data from the tables indicate that the values for the naturally occurring beryllium-7 (^7Be) and potassium-40 (^{40}K) generally are greater than the values for the fission products and that there is a distinct "year of collection" effect with peak years in 1970-71, 1974, and 1977.

Seymour and Johnson (1978) investigated the "year of collection" effect by comparing the values for the amount of zirconium-95 (^{95}Zr) plus niobium-95 (^{95}Nb) in Fontinalis from Amchitka with the amount of ^{95}Zr plus ^{95}Nb in freshwater moss and algae samples from Columbia River stations on the Oregon shoreline. These ^{95}Zr plus ^{95}Nb values were correlated with the schedule of

atmospheric detonation of nuclear devices of 20 kiloton or greater fission yield in China. The source of information about the Chinese nuclear detonations was Telegadas (1977) and Carter (1979). The data for the years 1970 through 1978 are presented in Figure 7.

The variables in Figure 7 were selected for the following reasons: ^{95}Zr and ^{95}Nb are indicators of fresh fallout radionuclides and were the most abundant fission products in the Amchitka samples; Fontinalis was selected as an excellent biological indicator species; moss and algae from the Columbia River were selected as comparable samples to Amchitka Fontinalis samples from a location at approximately the same latitude as Amchitka; and the schedule of Chinese nuclear detonations was selected for comparison with the ^{95}Zr plus ^{95}Nb values because this is the probable source of fallout radionuclides in the samples from both areas. The results of analyses of the Columbia River samples (a moss, Callierogonella cuspidata and/or an alga, Cladophora) were provided by Toombs (1978, 1979). The Columbia River samples were collected monthly and it should be noted in Figure 7 that the results of analyses have been smoothed by a moving average of three. Also, the Columbia River samples were reported in terms of wet weight and for this reason the Amchitka samples in Figure 7 also are given in terms of wet weight. Prior to 1978 the wet weight values were calculated from the wet weight-dry weight ratio of 8.1 as determined from the measurements of 15 samples in 1977. The wet-weight ratio for samples of 1978 used the measured ratio of each individual sample. The Amchitka Fontinalis data for 1978 is derived from 2 samples in February, 2 samples in May, 17 samples in August, and 2 samples in November. Inspection of Figure 7 provides evidence for the following comments (Seymour and Johnson, 1978): (1) the trends for the Amchitka and Columbia River values are similar; (2) the peaks in the curves occur after Chinese nuclear detonations of 20 kiloton or greater fission yield; (3) there is a "year of collection" effect with peaks in 1970-71, 1974, and 1977; and (4) the detection and measurement systems are sensitive to small perturbations in the amounts of fallout radionuclides in the environment.

From comments (1) and (2) above, the obvious conclusion is that the source of radionuclides at Amchitka is world fallout, principally from the Chinese nuclear detonations. Another method of determining the source of the radionuclides is to determine the date of origin of the radionuclides and/or the presence of short half lived fallout radionuclides in the samples. The date of origin of radionuclides can be determined from the ratio of fission product radionuclides if the parent radionuclide is known, little or no fractionation of any kind occurs, and reliable fission product radionuclide ratios can be established. For the Amchitka data, there was insufficient information to calculate date of origin by the radionuclide ratio method. However, the presence of short half life ^{95}Zr and ^{95}Nb (65 and 35 days respectively) as the dominant fission product radionuclides in the samples means that these radionuclides are of more recent origin than the last nuclear detonation at Amchitka (November 1971) and hence from world fallout.

There has been no strong evidence from the radiological data for a "collection location" effect, i.e. the radioactivity of the sample is related to the collection location on Amchitka Island. The values for Fontinalis from the Cannikin area in September of 1977 were two to three times greater than for samples from the Milrow or Long Shot areas but the differences were not

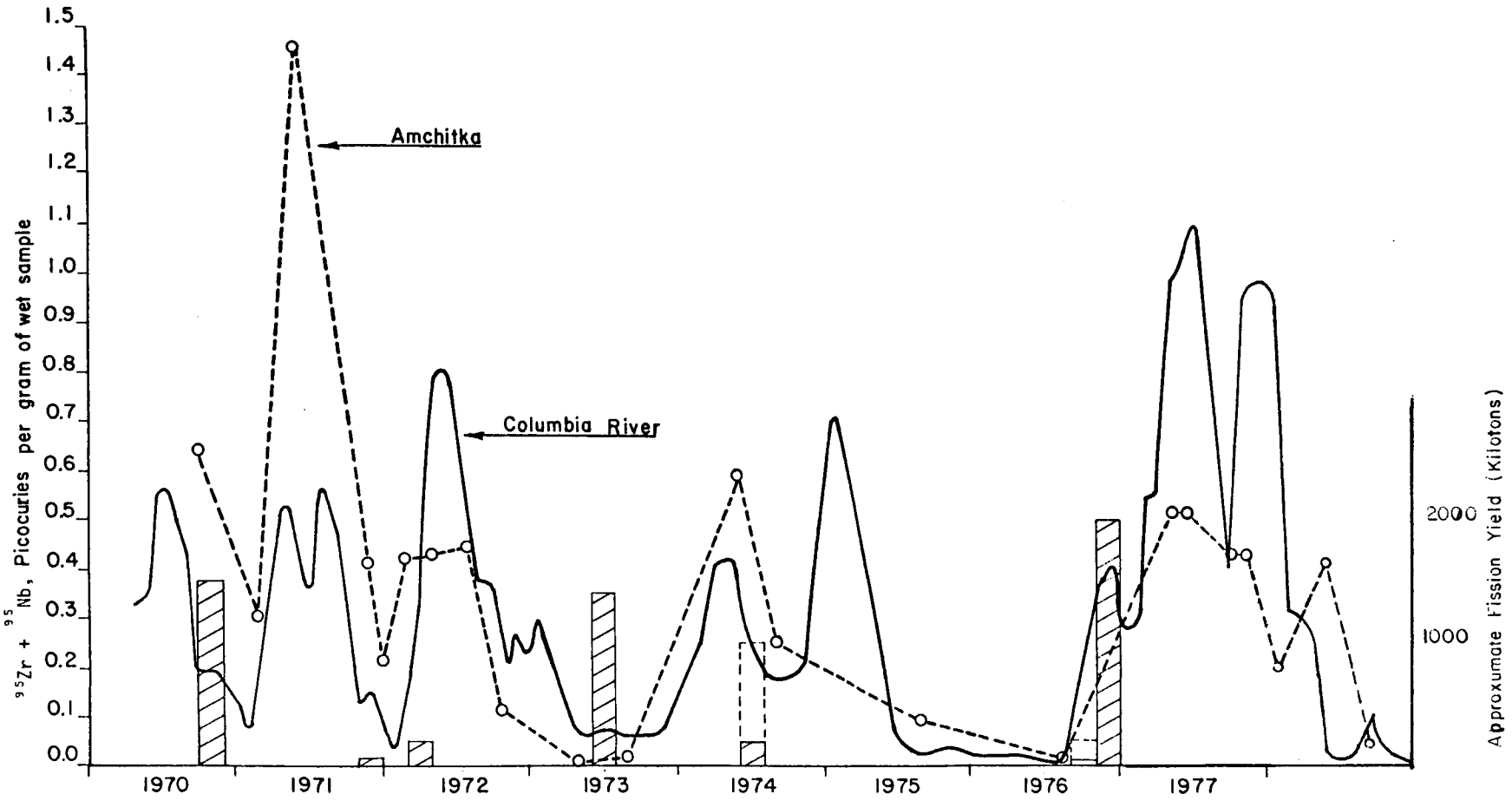

Figure 7. Zirconium-95 plus niobium-95 in freshwater vegetation from Amchitka Island and from the Columbia River and the fission yield of Chinese atmospheric nuclear detonations, 1970 to 1977. The Amchitka samples were the moss, Fontinalis. The Columbia River samples were the moss Calliergonella cuspidata, the algae Cladophora sp., or a combination of the two species collected at Goble, Oregon in 1970-71, at Rainier, Oregon in 1972-77, and at Goble, Rainier, and Prescott, Oregon in 1978. The three locations are ten miles apart. The Oregon samples were collected monthly and the values smoothed by a moving average of three. The fission yield of Chinese detonations greater than 20 kiloton are shown as bars (Telegadas, 1977).

statistically significant. The magnitude of difference in the values for Fontinalis from Cannikin and the Milrow or Long Shot areas in 1977 was not present in samples collected during 1978.

Radionuclide values for Ranunculus are given in Table 3, for aufwuchs in Table 4, and for lichens in Table 5. Ranunculus, a freshwater plant, and aufwuchs, bottom adhering micro-organisms, are good biological indicator species but not present at as many locations as Fontinalis. The radionuclide values for Ranunculus, aufwuchs, and Fontinalis are similar. The lichens are well known for the collection and retention of fallout radionuclides and are the single, best indicator species for the terrestrial environment. The lichen values for ^{137}Cs and ^{144}Ce are greater than for the freshwater indicator species but otherwise similar.

Samples of the marine alga, Fucus (Table 6), had fewer fallout radionuclides present and at lower concentrations in 1978 and all other years than the two freshwater vegetation types, Fontinalis and Ranunculus. Small amounts of ^{137}Cs and ^{144}Ce were the only fission products present in Fucus samples collected during 1978. The naturally occurring radionuclide, ^{40}K, was present in concentrations that ranged from 19 to 39 pCi/g, dry, which is 25 times or more greater than the most abundant fission product.

Maximum radionuclide values for the green sponge, a marine invertebrate, in terms of pCi/g of dry sample, as given in Table 7, were 11 for ^{40}K, 0.48 for ^{95}Nb and 1.2 for ^{144}Ce. Niobium-95 and cerium-144 were the only detectable fission products present in the green sponge collected in 1978.

Naturally occurring ^{40}K and fission-produced ^{137}Cs were the two radionuclides most commonly detected in fish (Tables 8-10). Cesium-137 was found in the muscle and/or viscera of halibut, greenling and Dolly Varden in concentrations which ranged from 0.04 to 0.51 pCi/g, dry. A relatively large number of pink salmon, Oncorhynchus gorbuscha returned to most of the nagivable streams on Amchitka Island during August and September 1978. Muscle samples from two salmon caught near Constantine Harbor were analyzed and 0.06 pCi/g, dry ^{137}Cs was found in one sample and the other had no detectable ^{137}Cs. Both salmon muscle samples had relatively large amounts of ^{40}K, 13 and 15 pCi/g, dry. Potassium-40 was the predominant radionuclide in all fish samples in all years and in marine fishes was usually present in concentrations 50 or more times greater than ^{137}Cs.

Potassium-40 and ^{137}Cs also were the predominant gamma-emitting radionuclides in ptarmigan samples for all years (Table 11) and as for fish, the ^{40}K values were significantly greater than the ^{137}Cs values. The values for both radionuclides in ptarmigan collected in 1978 fell within the range of values for other years.

The samples analyzed for ^{90}Sr were the bones of rats and ptarmigan, and soils (Table 12). In samples collected since 1971 the ^{90}Sr values for ptarmigan bones ranged from 9.6 to 27 pCi/g of dry sample; the values for rat bones ranged from the limits of detection to 5.8 pCi/g, dry. Soil samples from Main Camp and the Cannikin area have been collected and analyzed for ^{90}Sr since 1975. All values for ^{90}Sr in soils were 1 pCi/g, dry or less.

Environmental samples which have been collected for gamma spectrum analysis include sand, soil, and water (Tables 13 and 14). The surface (0 - 2.5 cm) soil samples were collected at Main Camp and in the Cannikin area; the surface sand samples were from Constantine Harbor and Sand Beach Cove. The radionuclide present in the largest amount was ^{40}K. Other radionuclides which were present in trace amounts (<1 pCi/g, dry) included ^{226}Ra, ^{228}Th, ^{238}U and the fallout radionuclides, ^{137}Cs, ^{141}Ce and ^{144}Ce. Similar types and levels of fallout radionuclides were seen in soil samples collected in Washington State during 1974 and 1975 (Nelson and Seymour, 1975b). Freshwater samples have been collected for gamma spectrum analysis since 1970-71 at four sites - Jones Lake, Heart Lake, Cannikin Lake, and Long Shot Mud Pit No. 1 - and in 1977 at three additional sites (Constantine Springs, Long Lake and Sand Beach Cove Seep. In addition, a rain water sample also was collected for gamma spectrum analysis in 1977. All sites were sampled in 1978 except the Sand Beach Cove Seep. The results of analyses of the residue from the evaporation of 34-50 liter samples are presented in Table 14. The most abundant gamma-emitting fallout radionuclides in the 1977 freshwater samples were ^{95}Zr and ^{95}Nb in the Long Shot Mud Pit No. 1 sample and in the September 1977 rainwater sample. The presence of short-lived ^{95}Zr and ^{95}Nb was presumed to be from world fallout. If the source of ^{95}Zr and ^{95}Nb observed in the 1977 sample was from rainfall, then it would be expected that Long Shot Mud Pit No. 1 sample would be greater than for lakes because of greater dilution in the lakes.

Radionuclides detected in the August 1978 fifty-liter rainwater sample included ^{7}Be, ^{95}Zr, ^{95}Nb, ^{137}Cs, and ^{144}Ce. The fifty-four samples collected from the other six sites on the island contained small amounts of ^{7}Be, ^{137}Cs or ^{144}Ce and no ^{95}Zr or ^{95}Nb. The amount of ^{137}Cs in rainwater was approximately four times greater than the average value for ^{137}Cs contained in the lake samples, and the amount of ^{144}Ce was one order of magnitude greater in rainwater than in the lake samples.

The concentrations of tritium (^{3}H) in seawater and freshwater samples from all areas except the Long Shot mud pits and drainage system are recorded in Table 15. The ^{3}H values for seawater have declined from 103 pCi/liter in 1970-71 (pre-Cannikin) to an average value of 51 pCi/liter for 8 samples collected in 1978. The ^{3}H values for freshwater samples have been greater than for seawater samples, but like seawater, the values have constantly declined. The average value of 298 pCi/liter in 1970-71 for freshwater samples other than those from the Long Shot area has declined to a 1978 average of 84 pCi/liter. Rainwater samples collected during 1978 had an average ^{3}H concentration of 96 pCi/liter. A "season of the year" effect upon the amount of ^{3}H in precipitation samples collected during 1978 is evident from the data. The peak value of 346 pCi/liter during early spring decreased to less than the detectable limit of 48 pCi/liter by the end of May and the ^{3}H concentration in precipitation samples remained near the limit of detection for the rest of the year.

The water samples collected from the Long Shot Mud Pits for ^{3}H analysis have always been considered separately from other samples because this area was found to be slightly contaminated with ^{3}H a few months after the Long Shot nuclear detonation in 1965. The extent of the contamination has been well documented in previous progress reports and in other publications (see Nelson, 1975; Merrit and Fuller, 1977; and Seymour and Nelson, 1977). Table 16 records the values for tritium in water samples from Long Shot Drainage

for the years 1970-1978. During this period the average ^{3}H values for water samples from the three mud pits have declined from 11.3×10^{3} to 2.0×10^{3} pCi/liter. These values are well below the Maximum Permissible Concentration for ^{3}H in water (MPC_w) for occupational exposure. The MPC_w value as established by the International Commission on Radiological Protection (ICRP, 1959) and the U.S. National Committee on Radiation Protection (NCRP, 1959) is 3×10^{7} pCi/liter. For an individual member of the population in an uncontrolled area, the Radiation Protection Guide (RPG) value is one-tenth the MPC for occupational exposure, or 3×10^{6} pCi/liter (Energy Research and Development Administration, 1975a). The MPC_w for the general population is 10^{6} pCi/liter (ICRP, 1959). The 1.6 km course of the drainage stream has been sampled annually since 1975 for tritium analysis. The ^{3}H values have decreased from values comparable to the Mud Pit values to values near the mouth of the stream which are slightly greater than the 1978 ^{3}H values in freshwater samples from other areas of Amchitka Island. Samples collected in 1978 at locations below Infantry Road had ^{3}H values which were greater than similar samples collected in 1977. Replicate measurements were made on the 1978 set of samples and the ^{3}H values were confirmed. In 1978 the values decreased in regular order from 1700 pCi/liter near the Mud Pits to 200 pCi/liter twenty meters above Square Bay. The contribution of ^{3}H from the Long Shot Mud Pits to the ocean was insignificant.

The results of ^{3}H analyses of free water extracted from biological samples are presented in Table 16. Thirty-three samples from the marine, freshwater, and the terrestrial environments were measured for ^{3}H during 1978. Fucus and Greenling muscle from the marine environment had ^{3}H values which were near the limits of detection; Ranunculus and Fontinalis were the best indicator organisms in the freshwater environment; and ptarmigan muscle from the terrestrial environment had ^{3}H values close to the detection limit. The greatest tritium concentrations were in the Fontinalis and Ranunculus samples and the average value for 1978 other than samples from the Long Shot Area was 94 and 90 pCi/liter, respectively. Ranunculus was collected in Long Shot Mud Pit #3 for the first time in 1978. The tritium values decreased in the Ranunculus samples along the Long Shot drainage from 2500 pCi/liter at Mud Pit #3 to 233 pCi/liter from four hundred meters below Infantry Road. These values correlate well with the ^{3}H values for water collected from the same location.

Samples of soil, sand, Fucus and greenling muscle were analyzed for $^{239,240}Pu$ and the results of these analyses are given in Table 18. The general conclusions from inspection of the table were that the maximum value was 0.015 pCi per gram dry for a soil sample and that there were no obvious differences related to year of collection. The $^{239,240}Pu$ values at Amchitka were compared with the results of analyses of comparable samples from the Atlantic Coast (Noshkin, et. al., 1973), California (Wong, et. al., 1972), and Washington (Nelson and Seymour, 1975b) and were found to be similar, i.e. some of the Amchitka values were slightly less, some slightly greater than the values from other areas (Nelson and Seymour, 1977). For this reason the source of $^{239,240}Pu$ at Amchitka is believed to be the same as for other areas, i.e. world fallout.

In 1974 a background radiation survey program with a Geiger-Muller detector (window thickness $<2 mg/cm^2$) was initiated and the results of the survey for the last five years are presented in Table 19. Observations were made at 14 locations and in no instance was the average value greater than 0.02 mR per

hour, although occasionally pulses of radiation would momentarily deflect the needle on the dial to values as much as 0.06 mR per hour. The survey meter readings for all years are similar and if there were annual differences, the instrument which was operating near the lower limits of detection was insensitive to the changes in background radiation.

4. SUMMARY AND CONCLUSIONS

The objective of the program is to determine the extent of radionuclide contamination on Amchitka Island. The objective is achieved, principally, by the collection and radiological analyses of biological and environmental samples but also by background radiation measurements. If the contamination was significantly greater than would be expected from world fallout, then leakage of radionuclides from the underground sites of the Amchitka nuclear detonations would be suspected. The results of analyses of the samples collected in August 1978 and the background radiation measurements of that date lead to the same conclusions as in previous years, i.e. there is no evidence that the radionuclide contamination at Amchitka Island is greater than would be expected from world fallout except for a slight contamination of the Long Shot Mud Pits with tritium.

Following are summary statements from which the conclusion is made that there is little radionuclide contamination at Amchitka Island and what is there, with the exception of tritium seeping into the Long Shot Mud Pits and drainage system, is of world fallout origin.

1. Two natural radionuclides, ^{7}Be and ^{40}K, were the most abundant radionuclides in most samples.

2. Some fission products, induced radionuclides, and plutonium have been detected in quantities that range from the limits of detection to a few pCi/g of dry samples.

3. Values for ^{95}Zr and ^{95}Nb in freshwater moss and algae from Amchitka Island and the Columbia River were similar in amounts and peaks of abundance.

4. Peaks of abundance of fission product radionuclides occurred in 1970-71, 1974 and 1977 and followed major Chinese nuclear detonations.

5. There is no strong evidence from the gamma spectrum analysis that the radioactivity of the samples is related to the collection location on Amchitka Island.

6. The radioactivity from fallout radionuclides, generally, was greater for freshwater than for marine organisms.

7. There has been no significant increase in ^{3}H, ^{90}Sr, or $^{239,240}Pu$ values. Tritium is a potential radionuclide indicator of radionuclide leakage from underground sites.

8. The background radiation survey meter readings were at or near the lower limits of detection for the instrument.

9. The laboratory detection and measurement system for the radiological analyses of the samples was sensitive to small perturbations in the amounts and species of radionuclides in the environment.

10. The results of analyses of the 1978 samples complemented the results of analyses of samples collected previously and did not reveal any unexpected information.

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
	VERTEBRATES		
MAMMALS			
Rattus norvegicus Rat	Bone	———	———
FISH[a]			
Salvelinus malma Dolly Varden	Muscle	3.62	0.70
	Viscera	4.20	0.42
Oncorhynchus gorbuscha Pink Salmon	Gonad	4.51	———
	Muscle	4.71	0.81
	Liver	4.49	0.69
Hippoglossus stenolepis Halibut	Muscle	4.01	0.58
	Liver	3.63	0.04
Hexagrammos lagocephalus Rock Greenling	Liver	3.43	0.41
	Muscle	4.83	0.14
	Viscera	2.13	0.04
BIRDS			
Lagopus mutus Rock Ptarmigan	Liver	3.52	0.32
	Muscle	3.54	0.08
	INVERTEBRATES		
Halichondria panicea Sponge (green)	Entire	4.55	0.91
	MARINE ALGAE		
Fucus distichus Marine algae	Entire	4.94	1.40
	FRESHWATER VEGETATION		
Cladophora sp. Filamentous algae	Entire	7.82	3.51
Fontinalis sp. Moss	Entire	4.83[b]	0.89
Ranunculus sp. Freshwater plant	Entire	12.2	4.10

Table 1 (continued)

Species	Tissue	Wet/Dry Ratio	Standard Deviation
	AUFWUCHS		
Periphyton & other organisms	Entire	7.27	2.40
	TERRESTRIAL VEGETATION		
Cladonia sp. Lichens	entire	3.75	0.87

a. 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.

b. Value calculated from 15 samples in 1977 is 8.1.

Table 2. Some gamma-emitting radionuclides in the freshwater moss, Fontinalis sp., collected at Amchitka Island

Location and Date	n	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
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 ±0.6	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±0.4	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±0.03	2.3 ±1.1	0.84±0.37	0.22±0.01
May '74	1	17 ±11	3.9±1.8	2.4 ±1.2	3.4 ±0.8	---	3.1 ±0.9	0.55±0.16	1.2 ±0.1	2.8 ±0.3	0.26±0.10
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±0.10	1.5 ±0.1	3.9 ±0.3	0.27±0.06
Aug '75	1	4.2±2.0	6.3±1.4	---	0.44±0.18	---	0.88±0.47	0.17±0.09	0.7 ±0.1	2.3 ±0.3	0.08±0.06
Aug '76	3	4.0±2.4	9.2±3.2	---	---	0.21±0.36	0.15±0.27	---	1.2 ±0.8	0.52±0.21	0.05±0.08
April '77	1	20 ±1.3	5.5±1.4	1.5 ±0.2	3.0 ±0.2	1.2 ±0.2	0.78±0.43	0.23±0.12	2.9 ±0.1	1.5 ±0.2	0.28±0.09
May '77	1	12 ±7.7	4.7±1.6	2.3 ±0.9	3.7 ±0.9	---	1.4 ±0.8	---	1.7 ±0.2	1.1 ±0.4	---
Aug '77	1	---	4.8±2.3	0.83±0.37	1.6 ±0.4	---	---	0.28±0.15	0.75±0.12	2.2 ±0.4	0.18±0.14
Sept '77	3	3.9±1.8	5.1±2.3	---	1.4 ±0.19	---	0.92±0.84	0.28±0.19	0.8 ±0.3	2.0 ±0.6	---
Feb '78	1	7.0±5.8	4.4±1.4	---	1.2 ±0.42	---	1.6 ±0.58	0.18±0.11	1.8 ±0.11	2.9 ±0.32	---
May '78	1	3.3±2.5	6.3±1.5	0.50±0.26	0.59±0.22	---	2.3 ±0.51	0.27±0.10	2.8 ±0.13	3.4 ±0.28	---
Aug '78	3	2.1±1.8	5.8±0.83	0.07±0.13	0.11±0.10	---	1.8 ±0.74	0.06±0.10	1.1 ±0.22	1.9 ±0.56	0.13±0.12
Nov '78	1	4.7±1.3	4.4±2.0	---	---	---	1.4 ±0.58	---	1.7 ±0.13	1.2 ±0.3	0.13±0.12
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 ±0.8	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 ±0.6	3.3 ±1.3	0.52±1.2	---
1973	2	5.1±1.4	5.8±0.4	---	0.08±0.11	---	---	0.14±0.19	2.3 ±1.9	1.1 ±0.5	0.11±0.15
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±0.11	1.9 ±0.1	4.5 ±0.3	0.18±0.06
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±0.15	1.0 ±0.1	4.6 ±0.4	0.23±0.09
Aug '75	1	3.3±2.2	5.8±1.7	0.3 ±0.3	0.6 ±0.23	---	1.7 ±0.7	0.25±0.14	1.1 ±0.1	3.1 ±0.4	0.10±0.08
Aug '76	2	5.2±0.6	6.0±0.3	---	0.10±0.13	0.24±0.34	0.4 ±0.6	0.08±0.11	1.4 ±0.4	0.9 ±0.6	0.08±0.11
April '77	1	21 ±1.6	5.5±1.2	1.2 ±0.2	2.6 ±0.2	1.1 ±0.2	0.71±0.42	0.24±0.12	5.1 ±0.2	1.3 ±0.2	0.14±0.07
May '77	1	12 ±9.3	5.7±1.8	---	2.3 ±0.8	---	0.93±0.78	0.33±0.16	2.3 ±0.2	1.5 ±0.5	0.16±0.10
Aug '77	1	3.9±3.3	2.3±1.7	1.5 ±0.4	3.0 ±0.5	0.53±0.49	2.0 ±0.8	0.38±0.18	2.7 ±0.2	3.0 ±0.5	0.14±0.10
Sept '77	3	3.5±0.3	6.9±1.4	1.5 ±0.4	2.3 ±1.4	---	1.7 ±0.8	0.26±0.16	1.6 ±0.3	2.3 ±0.7	0.24±0.15
Feb '78	1	---	3.0±1.1	---	1.3 ±0.50	---	2.7 ±0.65	0.28±0.14	3.2 ±0.17	4.2 ±0.43	0.19±0.07
May '78	1	11 ±2.7	6.1±1.6	0.85±0.29	1.4 ±0.27	0.65±0.53	4.7 ±0.72	0.44±0.11	1.4 ±0.10	5.0 ±0.34	0.14±0.11
Aug '78	3	2.4±0.76	5.5±1.4	---	0.28±0.03	---	1.9 ±0.11	0.16±0.14	1.1 ±0.17	3.3 ±0.73	0.04±0.08
Nov '78	1	3.7±1.3	5.6±1.6	---	---	---	1.4 ±0.58	---	1.7 ±0.16	1.9 ±0.33	0.11±0.07

Table 2 (continued)

Location and Date	n	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
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 ±0.5	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 ±0.5	1.7 ±0.9	0.32±0.72	---
1973	2	7.1±7.0	6.4±0.4	---	---	---	0.65±0.92	0.32±0.23	1.2 ±0.5	0.9 ±1.3	0.09±0.13
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±0.13	2.2 ±0.1	5.7 ±0.3	1.16±0.05
Aug '74	1	1.4±0.8	<6	---	0.21±0.08	---	0.29±0.19	---	0.8 ±0.1	0.34±0.1	---
Aug '75	1	1.9±1.2	5.4±1.1	0.2 ±0.2	0.65±0.15	---	0.69±0.44	0.26±0.09	0.8 ±0.1	2.4 ±0.26	0.09±0.05
Aug '76	1	4.7±2.2	7.0±1.3	---	---	---	---	0.18±0.09	1.4 ±0.1	---	---
Sept '77	1	---	3.6±2.1	---	1.1 ±0.4	---	---	---	1.0 ±0.2	1.5 ±0.4	---
Aug '78	1	2.9±0.88	4.1±2.0	---	0.14±0.09	---	0.93±0.62	---	0.86±0.11	1.1 ±0.28	---
Long Shot Drainage											
Aug '75	1	4.4±1.2	4.0±1.3	0.2 ±0.1	0.61±0.13	---	2.3 ±0.4	0.27±0.01	1.2 ±0.1	3.2 ±0.2	0.2 ±0.08
Aug '76	1	4.7±1.6	5.3±1.2	---	---	---	---	0.12±0.09	0.7 ±0.1	0.26±0.21	0.10±0.05
Sept '77	2	4.2±0.1	4.8±0.04	0.8 ±0.3	1.1 ±0.7	---	1.3 ±0.7	---	0.7 ±0.1	1.4 ±1.1	---
Aug '78	2	2.2±0.05	5.7±1.8	---	0.18±0.05	0.05±0.07	1.4 ±1.1	0.27±0.19	1.3 ±0.46	2.0 ±0.9	0.05±0.07
MP-12 Creek											
1973	2	9.0±8.6	4.7±2.0	---	0.17±0.23	---	0.7 ±0.9	0.12±0.17	2.0 ±1.2	1.4 ±0.8	0.09±0.12
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±0.10	2.1 ±0.1	6.0 ±0.3	0.16±0.04
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±0.06
Aug '75	1	6.5±1.8	4.5±1.7	0.3 ±0.2	0.67±0.18	---	2.7 ±0.7	---	0.5 ±0.1	5.2 ±0.3	0.21±0.11
Aug '76	1	8.7±1.9	5.3±1.5	0.3 ±0.3	---	---	1.6 ±0.5	0.15±0.10	0.9 ±0.1	1.7 ±0.2	0.16±0.09
Sept '77	1	5.9±4.1	6.4±2.7	1.2 ±0.5	3.4 ±0.6	---	2.8 ±1.0	---	1.1 ±0.2	4.4 ±0.5	---
Aug '78	1	6.6±1.4	5.6±2.0	---	0.32±0.14	0.12±0.11	4.3 ±1.1	---	1.1 ±0.16	7.1 ±0.61	---
Ice Box Lake Inlet											
1973	2	4.1±0.8	5.7±1.0	---	0.08±0.11	---	0.5 ±0.9	0.28±0.06	1.5 ±0.6	0.87±0.12	0.17±0.08
May '74	1	3.7±0.6	5.0±1.0	0.70±0.09	1.2 ±0.11	---	1.0 ±0.4	0.20±0.09	3.1 ±0.1	2.4 ±0.21	0.13±0.04
Aug '74	1	2.3±0.8	5.9±0.5	0.17±0.14	0.6 ±0.1	---	0.9 ±0.3	0.23±0.08	1.0 ±0.1	1.6 ±0.2	---
Aug '75	1	---	4.7±1.3	---	0.27±0.16	---	0.7 ±0.5	0.20±0.11	1.3 ±0.1	1.8 ±0.3	0.09±0.07
Aug '76	3	4.8±1.8	4.0±0.8	0.15±0.26	---	---	0.2 ±0.4	0.21±0.08	1.4 ±0.5	0.75±0.13	0.13±0.05
Sept '77	3	3.0+2.9	4.8+1.6	---	1.9 +0.8	1.4 +1.0	1.3 +1.1	---	1.4 +0.7	2.5 +1.6	---
Aug '78	3	2.0±0.66	4.1±3.6	---	0.46±0.79	---	0.89±0.79	0.05±0.08	0.81±0.19	2.0 ±0.7	0.04±0.08

Table 2 (continued)

Location and Date	n	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
Cannikin Lake Outlet											
1973	2	7.3±0.5	6.2±0.7	0.09±0.12	0.16±0.23	0.07±0.09	0.6 ±0.8	0.30±0.18	3.9 ±4.6	1.1 ±0.4	0.15±0.21
May '74	1	10 ±1.0	2.4±0.6	1.2 ±0.12	2.7 ±0.15	0.24±0.13	2.2 ±0.3	0.29±0.05	1.1 ±0.1	6.3 ±0.2	0.13±0.03
Aug '74	1	---	4.2±0.6	1.2 ±0.15	2.3 ±0.17	0.21±0.11	2.6 ±0.5	0.33±0.12	1.6 ±0.1	6.4 ±0.3	---
Aug '75	1	7.9±1.9	5.1±1.1	---	0.52±0.16	---	1.8 ±0.5	0.24±0.09	2.0 ±0.1	2.1 ±0.3	---
Aug '76	3	3.8±0.6	3.6±0.3	---	---	0.15±0.27	0.3 ±0.3	0.05±0.09	1.0 ±0.4	---	0.06±0.05
Sept '77	3	19.5±0.5	5.3±1.8	3.1 ±0.2	6.6 ±1.1	0.66±0.35	4.0 ±1.7	0.23±0.20	1.0 ±0.2	9.0 ±0.7	0.37±0.21
Aug '78	3	13 ±4.3	3.2±0.62	---	0.19±0.03	---	1.7 ±0.5	0.25±0.09	1.3 ±0.47	3.6 ±1.5	0.08±0.09

a. Radionuclide values for a single sample (n=1) are a single count of the sample ± the two sigma, propagated, counting error. The radionuclide value shown for more than one sample is the mean ± one standard deviation of two or more single sample counts. Dashes in the table indicate the sample count is not significant and NA indicates the radionuclide was not included in the analyses.

b. Pre-Cannikin.

Table 3. Some gamma-emitting radionuclides in the freshwater plant, Ranunculus sp., collected at Amchitka Island

Location and Date	n	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
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 ±0.6	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 ±0.54	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±0.09	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	---
Aug '75	1	---	19 ±2.3	---	---	---	---	---	0.52±0.09	0.34±0.3	---
Aug '76	3	1.2 ±1.0	17 ±2.3	---	---	0.09±0.16	---	---	0.39±0.15	---	---
Sept '77	3	---	22 ±3.8	---	0.51±0.12	---	---	---	0.34±0.13	0.69±0.36	---
Aug '78	3	---	15 ±1.5	---	---	---	---	---	0.64±0.11	0.51±0.49	---
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 ±0.5	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 ±0.4	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±0.12	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±0.08	0.85±0.06	1.7 ±0.2	---
Aug '75	1	2.5 ±1.2	21 ±2.2	---	0.35±0.13	---	0.67±0.46	---	1.2 ±0.1	1.0 ±0.23	---
Aug '76	3	0.9 ±1.6	19 ±0.6	---	---	---	---	0.04±0.08	1.8 ±0.6	0.3 ±0.2	---
Sept '77	2	---	25 ±0.1	---	0.74±0.30	---	0.71±0.58	---	0.28±0.18	1.0 ±0.1	---
Aug '78	2	0.69±0.97	19 ±1.4	0.09±0.13	---	---	---	---	0.40±0.20	1.0 ±0.1	---
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 ±0.5	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 ±0.4	1.6 ±0.9	NA	NA
1973	1	6.0 ±1.5	20 ±1.5	---	---	---	---	0.26±0.09	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	---
Aug '75	1	---	13 ±1.8	---	---	---	0.63±0.43	---	1.6 ±0.13	0.85±0.24	---
Aug '76	1	3.5 ±2.9	18 ±2.3	---	---	---	---	---	1.5 ±0.1	0.25±0.24	---
Sept '77	1	sample lost									
Aug '78	1	---	12 ±2.4	---	---	---	---	0.18±0.13	0.11±0.12	0.61±0.25	---

Table 3 (continued)

Location and Date	n	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
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
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	---
Aug '75	1	1.9±0.7	18 ±1.5	---	0.07±0.07	---	0.5±0.3	---	0.8 ±0.1	0.6 ±0.2	---
Long Shot Drainage											
Aug '75	1	5.3±2.4	19 ±3.0	---	0.42±0.26	---	1.3±0.8	---	1.0 ±0.1	1.4 ±0.4	---
Aug '76	2	1.8±2.5	26 ±5	---	---	---	---	---	0.6 ±0.3	0.2 ±0.3	---
Sept '77	1	---	18 ±2.8	0.72±0.50	0.91±0.31	---	---	---	0.69±0.11	0.87±0.33	---
Aug '78	3	4.3±4.8	16 ±2.7	---	0.11±0.10	---	1.3±1.1	---	0.57±0.26	1.9 ±0.78	---
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	---
Aug '75	1	2.3±0.9	10 ±1.5	---	0.18±0.09	---	---	0.22±0.1	2.9 ±0.2	1.5± 0.2	0.14±0.06
Aug '76	1	---	11 ±1.9	---	---	---	---	---	1.8 ±0.1	---	---

a. Radionuclide values for a single sample (n = 1) are a single count of the sample ± the two-sigma, propagated, counting error. The radionuclide value shown for more than one sample is the mean ± one standard deviation of two or more single sample counts. Dashes in the table indicate the sample count is not significant and NA indicates the radionuclide was not included in the analyses.

b. Pre-Cannikin

Table 4. Some gamma-emitting radionuclides in freshwater aufwuchs and filamentous algae collected at Amchitka Island[a]

Location and Date	n	Radionuclides pCi/g, dry[b]								
		^{7}Be	^{40}K	^{95}Zr	^{95}Nb	^{103}Ru	^{106}Ru	^{125}Sb	^{137}Cs	^{144}Ce
Long Shot Mud Pit #3										
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	---	0.9 ±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
Aug '75	1	2.8± 1.8	9.8±1.6	---	0.28±0.19	---	---	0.21±0.09	0.19±0.05	1.4 ±0.3
Aug '76	1	1.8± 1.4	8.6±1.6	---	---	---	---	0.16±0.08	0.25±0.05	---
Sept '77	1	---	10 ±2.7	---	0.72±0.37	0.54±0.51	0.69±0.63	---	---	1.5 ±0.4
Aug '78	1	---	7.5±2.5	---	---	---	---	---	0.09±0.07	0.31±0.29
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
Aug '75	1	13 ± 1.2	6.2±1.5	0.36±0.11	0.97±0.12	---	2.3 ±0.5	0.26±0.10	2.3 ±0.1	3.2 ±0.2
Sept '77	1	7.8± 2.8	5.1±2.3	2.5 ±0.4	5.3 ±0.5	---	2.4 ±1.0	---	1.7 ±0.2	3.0 ±0.4
Aug '78	1	8.9± 1.5	6.1±2.2		0.21±0.11	---	2.2 ±0.72	0.30±0.15	1.8 ±0.16	2.7 ±0.35
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
Aug '75	1	3.8± 0.9	5.1±1.3	---	0.2 ±0.08	---	0.89±0.4	0.16±0.09	0.75±0.09	2.0 ±0.3
Aug '76	1	3.3± 1.9	10 ±1.7	---	---	---	---	---	0.17±0.04	0.23± .20
Aug '78	1	---	21 ±20	---	---	---	---	---	1.6 ±0.69	---
Drillback Drainage to Cannikin Lake										
Sept '77	1	36 ± 5.1	4.8±3.0	4.1 ±0.62	8.7 ±0.80	---	5.0 ±1.3	---	1.0 ±0.17	9.1 ±0.7
Aug '78	1	10 ± 1.4	3.3±2.4	--	0.17±0.11	---	---	0.30±0.13	0.83±0.10	---

a. Aufwuchs samples were collected from Long Shot Pond, MP-12 Creek, and Drillback Drainage to Cannikin Lake and the algae samples from White Alice Inlet to Cannikin Lake.

b. Radionuclide values for a single sample (n = 1) are a single count of the sample ± the two-sigma, propagated, counting error. The radionuclide value shown for more than one sample is the mean ± one standard deviation of two or more single sample counts. Dashes in the tables indicate the sample count is not significant and NA indicates the radionuclide was not included in the analyses.

c. Pre-Cannikin.

Table 5. Some gamma-emitting radionuclides in lichens collected at Amchitka Island

Location and Date	n	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
Clam Lake											
1970-71b	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
Aug '75	1	4.6±1.7	2.5±1.1	---	0.5±0.1	---	1.0±0.6	0.28±0.14	6±0.2	5.5±0.4	0.23±0.08
Aug '76	1	8.0±1.5	2.0±1.5	---	---	---	0.6±0.4	0.41±0.11	7±0.2	2.0±0.3	0.11±0.10
Sept '77	1	8.1±3.3	1.9±1.4	1.1 ±0.4	2.4±0.5	---	2.1±0.8	0.36±0.19	2.8±0.2	6.2±0.6	0.18±0.10
Aug '78	1	6.5±1.5	---	0.28±0.18	0.17±0.11	---	1.9±0.69	0.35±0.14	3.9±0.25	10±0.63	0.24±0.10
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
Aug '75	1	5.2±1.5	1.9±1.6	---	0.4±0.1	---	1.5±0.6	0.48±0.14	11±0.3	5.4±0.3	0.38±0.13
Aug '76	1	8.1±3.7	---	---	0.2±0.2	---	0.87±0.55	0.56±0.13	11±0.3	2.1±0.3	0.48±0.12
Sept '77	1	14 ±3.8	1.7±1.3	1.5 ±0.4	3.8±0.6	---	2.0±0.9	0.37±0.17	3.6±0.3	10±0.7	---
Aug '78	1	8.3±2.0	---	0.32±0.14	0.39±0.14	---	2.2±0.80	---	9.5±4.2	9.0±0.66	0.18±0.12
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
Aug '75	1	6.1±2.1	---	---	0.4±0.2	---	1.4±0.5	0.40±0.10	7±0.2	4.6±0.3	0.26±0.11
Aug '76	1	6.4±1.6	1.4±1.0	---	---	---	0.52±0.45	0.40±0.11	5±0.2	2.4±0.3	0.19±0.07
Sept '77	1	13 ±3.6	---	1.3 ±0.4	3.6±0.5	---	2.0±0.7	0.38±0.15	3.5±0.2	7.6±0.5	---
Aug '78	1	7.3±1.4	---	---	0.32±0.12	---	1.6±0.65	0.52±0.14	4.0±0.23	7.5±0.46	0.23±0.14

a. Radionuclide values for a sinlge sample (n = 1) are a single count of the sample ± the two-sigma, propagated, counting error. The radionuclide value shown for more than one sample is the mean ± one standard deviation of two or more single sample counts. Dashes in the table indicate the sample count is not significant and NA indicates the radionuclide was not included in the analyses.

b. Pre-Cannikin

c. n equals 1 for ^{144}Ce and ^{155}Eu.

Table 6. Some gamma-emitting radionuclides in the marine alga Fucus collected at Amchitka Island

Location and Date	n	Radionuclides pCi/g, dry[a]					
		^{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
Aug '75	1	1.7 ± 1.3	32±2.3	---	---	0.04±0.04	---
Aug '76	1	---	28±2.2	---	---	0.05±0.04	---
Sept '77	1	---	23±3.2	---	---	---	0.38± 0.26
Aug '78	1	0.66± 0.47	28±2.3	---	---	---	0.38± 0.18
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
Aug '75	1	---	33±2.3	---	---	---	---
Aug '76	1	---	30±2.2	---	0.13±0.10	---	---
Sept '77	1	---	32±3.4	---	0.24±0.11	---	---
Aug '78	1	---	30±2.2	---	---	---	---
Square Bay							
Aug '75	1	---	38±2.4	---	---	---	---
Aug '76	1	---	22±2.0	---	---	---	---
Sept '77	1	---	31±3.4	---	0.34±0.12	---	0.69± 0.27
Aug '78	1	0.90± 0.45	19±1.7	---	---	0.08±0.04	0.27± 0.14
Sand Beach Cove							
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
Aug '75	1	---	34±2.2	---	0.16±0.12	0.04±0.04	---
Aug '76	1	---	24±2.1	---	---	---	---
Sept '77	1	0.95± 0.79	25±3.2	0.20±0.19	---	---	0.66± 0.27
Aug '78	1	---	23±2.9	---	---	0.07±0.04	0.21± 0.18

a. Radionuclide values for a single sample (n = 1) are a single count of the sample ± the two-sigma, propagated, counting error. The radionuclide value shown for more than one sample is the mean ± one standard deviation of two or more single sample counts. Dashes in the table indicate the sample count is not significant and NA indicates the radionuclide was not included in the analyses.

b. Pre-Cannikin.

Table 7. Some gamma-emitting radionuclides in the green sponge, Halichondria panicea, collected at Amchitka Island

Location and Date	n	Radionuclides pCi/g, dry [a]				
		^{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
Aug '75	1	---	7.7±1.4	---	---	0.73±0.20
Aug '76	1	4.3±4.2	20 ±1.3	---	---	---
Sept '77	1	---	8.2±1.5	0.41±0.34	0.45±0.16	1.1 ±0.2
Aug '78	1	0.9±0.6	10 ±1.5	-	-	1.1±0.20
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
Aug '75	1	---	10.0±1.6	---	---	0.56±0.2
Aug '76	1	1.0±0.7	8.5±1.4	---	---	0.22±0.16
Sept '77	1	---	7.4±2.3	---	0.40±0.26	1.0 ±0.3
Aug '78	1	1.1±0.58	11 ±1.5	-	-	1.1 ±0.19
Square Bay						
1973	2	0.7±0.9	9.7±0.5	---	---	0.35±0.12
Aug '75	1	1.2±0.9	9.5±1.7	---	0.11±0.09	0.61±0.20
Aug '76	1	---	10 ±1.7	---	---	0.21±0.18
Sept '77	1	---	7.8±2.3	---	0.48±0.25	1.2 ±0.3

a. Radionuclide values for a single sample (n = 1) are a single count of the sample ± the two-sigma, propagated, counting error. The radionuclide value shown for more than one sample is the mean ± one standard deviation of two or more single sample counts. Dashes in the table indicate the sample count is not significant and NA indicates the radionuclide was not included in the analyses.

Table 8. Potassium-40 and cesium-137 in halibut collected off Amchitka Island

Location and Date	Tissue	n[b]	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
Aug '75	"	1/1	18 ±1.6	0.06±0.04
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
Aug '75	"	1/8	11 ±1.5	0.05±0.03
Constantine Harbor				
Aug '74	Liver	5/5	7.5 ±2.6	0.06±0.07
Sept '77	"	1/1	---	---
Aug '78	"	1/1	7.7 ±2.7	---
Sept '77	Muscle	1/1	18 ±2.8	0.07±0.06
Aug '78	"	1/1	12 ±1.6	0.08±0.04
Midden Cove				
Aug '75	Muscle	2/2	19 ±1.9	0.05±0.04
Aug '75	Liver	4/4	10 ±1.5	---
Square Bay				
Aug '76	Muscle	1/1	18 ±0.5	0.05±0.03

a. Radionuclide values for a single sample (n = 1) are a single count of the sample ± the two-sigma, propagated, counting error. The radionuclide value shown for more than one sample is the mean ± one standard deviation of two or more single sample counts. Dashes in the table indicate the sample count is not significant.

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

c. Pre-Cannikin

Table 9. Potassium-40 and cesium-137 in greenling collected off Amchitka Island

Location and Date	Tissue	n[b]	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
Aug '75	"	1/4	21 ± 2.5	0.49 ± 0.07
Aug '76	"	1/4	9.8 ± 0.8	---
Sept '77	"	1/6	15 ± 2.7	0.08 ± 0.06
Aug '78	"	1/4	18 ± 2.8	0.07 ± 0.06
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	---
Aug '75	"	1/4	11 ± 2.2	0.06 ± 0.05
Aug '76	"	1/4	10 ± 0.9	0.20 ± 0.06
Sept '77	"	1/6	7.9 ± 3.5	---
Aug '78	"	1/4	17 ± 2.6	---
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	"	1/5	21 ± 1.9	0.05 ± 0.04
Aug '74	"	1/4	15 ± 0.7	---
Aug '75	"	1/8	25 ± 2.7	0.08 ± 0.06
Aug '76	"	1/8	18 ± 0.8	---
Sept '77	"	1/7	15 ± 2.5	---
Aug '78	"	1/4	18 ± 2.8	---
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	---

Table 9 (continued)

Location and Date	Tissue	n[b]	Radionuclides pCi/g, dry[a] ^{40}K	^{137}Cs
Sand Beach Cove				
Aug '74	Viscera	1/4	8.1 ±2.1	---
Aug '75	"	1/8	6.3 ±1.4	0.06 ± 0.04
Aug '76	"	1/8	9.6 ±0.4	---
Sept '77	"	1/7	9.0 ±2.4	---
Aug '78	"	1/4	15 ±4.2	---
Square Bay				
Aug '75	Muscle	1/5	16 ±1.6	---
Aug '76	"	1/6	18 ±0.9	---
Sept '77	"	1/5	16 ±2.8	---
Aug '78	"	1/5	14 ±2.1	0.04 ± 0.04
Aug '75	Viscera	1/5	7.8 ±1.4	0.07 ± 0.04
Aug '76	"	1/6	11 ±0.8	0.10 ± 0.05
Sept '77	"	1/5	9.1 ±2.6	---
Aug '78	"	1/5	10 ±2.4	0.10 ± 0.06
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	"	2/6	15 ±1.8	0.07 ± 0.02
Aug '75	"	1/6	17 ±1.8	0.09 ± 0.04
Aug '76	"	1/8	18 ±0.4	0.07 ± 0.02
Sept '77	"	1/6	13 ±2.7	---
Aug '78	"	1/4	19 ±2.9	0.09 ± 0.06
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
Aug '75	"	1/6	9.5 ±1.2	0.04 ± 0.03
Aug '76	"	1/8	9.6 ±0.4	---
Sept '77	"	1/6	11 ±2.5	0.08 ± 0.06
Aug '78	"	1/4	9 ±2.0	0.09 ± 0.05

a. Radionuclide values for a single sample (n = 1) are a single count of the sample ± the two-sigma, propagated, counting error. The radionuclide values shown for more than one sample is the mean ± one standard deviation of two or more single sample counts. Dashes in the table indicate the sample count is not significant.

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

c. Pre-Cannikin.

Table 10. Potassium-40 and cesium-137 in muscle of dolly varden collected at Amchitka Island

Collection Date	Collection Location	n[b]	Radionuclides pCi/g, dry[a] ^{40}K	^{137}Cs
1971[c]	Jones Lake	1/1	15 ± 0.8	0.35 ± 0.05
1972	DK-45 Lake	3/8	16 ± 1.0	5.7 ± 3.9
1973	Jones L., Bridge Cr., Silver Salmon L. Outlet	3/7	16 ± 0.6	0.18 ± 0.09
1974	Jones L., Cannikin L., Duck Cove	6/28	15 ± 1.7	0.28 ± 0.08
1975	Jones L., Cannikin L., Bridge Cr., Duck Cove, Clevenger Cr.	5/19	12 ± 4.4	0.17 ± 0.12
Aug '76	Jones L., Cannikin L., Duck Cove	3/17	15 ± 0.58	0.17 ± 0.06
Sept '77	Jones L., Duck Cove, Clevenger L. Outlet	3/6	14 ± 2.1	0.27 ± 0.17
Aug '78	Jones Lake Outlet	1/3	13 ± 2.5	0.16 ± 0.07
"	Cannikin Lake	1/5	13 ± 2.5	0.21 ± 0.07
"	Duck Cove	1/3	15 ± 1.8	0.51 ± 0.04
"	Clevenger Creek	1/4	14 ± 1.8	0.04 ± 0.04

[a]Radionuclide values for a single sample (n=1) are a single count of the sample ± the two-sigma, propagated counting error. The radionuclide values shown for more than one sample is the mean ± one standard deviation of two or more single sample counts.

[b]Number of samples/total number of fish in all samples.

[c]Pre-Cannikin.

Table 11. Potassium-40 and cesium-137 in Rock Ptarmigan collected at Amchitka Island

Collection Date	Collection Location	Tissue	Number of Birds	Radionuclides pCi/g, dry[a] ^{40}K	Radionuclides pCi/g, dry[a] ^{137}Cs
1970-71[b]	South Bight	Liver	1	---	---
Aug '74	Cannikin Area	Viscera	1	13 ± 1.2	1.6 ± 0.8
1970-71[b]	South Bight	Muscle	4	11 ± 0.5	1.0 ± 0.6
1971-72	Cannikin Area	"	3	11 ± 1.6	0.70 ± 0.04
1973	Cannikin Area[c]	"	5	11 ± 0.8	0.43 ± 0.25
May '74	Cannikin Area	"	2	11 ± 1.2	0.42 ± 0.05
Aug '74	"	"	4	11 ± 1.5	0.90 ± 0.35
Aug '75	"	"	4	14 ± 2	3.4 ± 0.2
"	Mile 8	"	2	11 ± 2	1.4 ± 0.1
"	Milrow Area	"	2	12 ± 2	1.8 ± 0.6
Aug '76	Cannikin Area	"	4	12 ± 0.5	1.7 ± 0.1
"	Milrow/Long Shot	"	3	10 ± 4.5	<0.3
"	Camp Area	"	1	10 ± 0.6	1.5 ± 0.1
"	Mile 18	"	1	9.4 ± 0.6	0.75 ± 0.04
Sept '77	Cannikin Area	"	4	11 ± 2.5	2.1 ± 0.18
"	Long Shot	"	4	8.8 ± 1.0	0.37 ± 0.08
"	Camp Area	"	5	12 ± 2.5	0.55 ± 0.10
Aug 78	Cannikin Area	"	4	9.1 ± 2.3	0.39 ± 0.08
"	Milrow/Long Shot	"	7	9.6 ± 1.8	0.90 ± 0.08
"	Camp Area	"	4	9.4 ± 1.5	0.30 ± 0.04

[a]Values for radionuclides in samples collected from 1970 through 1973 are given as a mean ± one standard deviation of two or more single sample counts. Values for radionuclides in birds collected from 1974 to 1977 are from a single count of a sample of one or more birds ± a two-sigma, propagated counting error. The dashes in the body of the table indicate the sample counts were not significant.

[b]Pre-Cannikin.

[c]One each from Mason Lake, Cannikin area, and Mile 16; two from Mile 5.

Table 12. Strontium-90 in Bone Samples from Rats and Ptarmigan and in Soil Samples Collected at Amchitka Island

Collection Date	n[a]	Collection Location	Sample Type	pCi ^{90}Sr/g, dry[b]
1971[c]	2	Sand Beach Cove	Rat, bone	1.6 ± 1.3
1971	2	"	"	5.8 ± 5.9
1973	1	"	"	1.9 ± 2.0
1975	1	"	"	0.5 ± 0.2
1976	1	"	"	<1.3
1977	1	"	"	<0.78
1978	1	"	"	0.63 ± 0.04
1973	1	Other Sites[d]	Rat, bone	1.8 ± 0.4
1974	2	"	"	1.6 ± 1.1
1975	2	"	"	1.4 ± 0.3
1976	5	"	"	<1.3
1977	3	"	"	<0.80
1978	3	"	"	2.1 ± 5.2
1971	1	Cannikin Area	Ptarmigan, bone	31 ± 3.6
1975	1	"	"	13 ± 1.0
1976	1	"	"	14 ± 2.6
1977	1	"	"	17 ± 1.4
1978	1	"	"	13 ± 1.0
1971[c]	1	Milrow/Long Shot	Ptarmigan, bone	27 ± 3.2
1973	1	"	"	11 ± 0.8
1975	1	"	"	14 ± 1.4
1976	1	"	"	19 ± 2.4
1977	1	"	"	16 ± 1.2
1978	1	"	"	9.6 ± 0.6
1971	2	Other Sites[e]	Ptarmigan, bone	27 ± 12
1973	1	"	"	14 ± 0.8
1974	1	"	"	16 ± 9.2
1975	1	"	"	19 ± 2.8
1976	2	"	"	26 ± 0.4
1977	1	"	"	15 ± 1.4
1978	1	Camp Area	"	10 ± 0.8
1975	1	Main Camp	Soil	0.03 ± 0.02
1976	3	"	"	<0.03
1977	1	"	"	<0.14
1978	1	"	"	0.06 ± 0.10
1975	1	Cannikin Area	Soil	<0.16
1976	3	"	"	<0.04
1977	3	"	"	<0.14
1978	3	"	"	0.21 ± 0.26

a. Each bone sample obtained from 2 to 4 individuals.
b. Radionuclide values for single samples (n = 1) are a mean of a repeated count of the sample ± two sigma, propagated, counting error. The radionuclide values for more than one sample is the mean ± one standard deviation of those individual sample values. Since 1976 a correction was made for reagent contaminants and, in 1977, an additional correction for residual sample contaminants. The maximum net effect of these corrections on sample values, in terms of pCi per gram of sample, is about 0.5 for rat samples (3 g.) 0.3 for ptarmigan (5 g) and 0.03 for soils (50 g).
c. Pre-Cannikin.
d. Main dump, Duck Cove, Constantine Harbor, Camp Area, Bridge Creek and Clevenger Creek (mouth).
e. Main camp, mile post 8, Silver Salmon Lake, mile 18.

Table 13. Some gamma-emitting radionuclides in sand and soil collected at Amchitka Island

Location and Date	Sample Type	n	Radionuclides pCi/g, dry[a]						
			^{40}K	^{137}Cs	^{141}Ce	^{144}Ce	^{226}Ra	^{228}Th	^{238}U
Main Camp									
Aug '75	Soil	1	8.0±1.2	---	0.20±0.13	0.14±0.13	0.18±0.04	0.14±0.05	---
Aug '76	"	3	11 ±1.0	0.82±0.60	0.27±0.24	---	0.26±0.06	0.11±0.04	0.17±0.30
Sept '77	"	1	15 ±2.2	0.24±0.07	---	0.29±0.21	0.29±0.07	0.27±0.08	0.85±0.69
Aug '78	"	1	21 ±1.6	0.38±0.05	---	0.22±0.13	0.39±0.04	---	0.67±0.42
Cannikin Area									
Aug '75	Soil	1	11 ±1.3	0.32±0.05	0.22±0.15	0.97±0.18	0.11±0.05	0.08±0.04	---
Aug '76	"	3	10 ±2.5	0.34±0.21	---	0.09±0.12	0.21±0.03	0.11±0.02	0.64±0.18
Sept '77	"	5	8.8±3.0	0.21±0.15	---	0.42±0.02	0.20±0.05	0.19±0.08	---
Aug '78	"	3	9.0±3.8	0.47±0.08	---	0.60±0.15	0.16±0.05	---	---
Constantine Harbor									
Aug '75	Sand	1	13 ±1.2	0.07±0.03	---	---	0.18±0.04	0.09±0.04	0.44±0.36
Aug '76	"	1	16 ±1.6	0.22±0.04	---	---	0.28±0.05	0.11±0.05	0.88±0.47
Sept '77	"	1	15 ±2.1	0.05±0.04	---	---	0.19±0.06	0.09±0.07	---
Aug '78	"	1	15 ±2.2	---	---	---	0.20±0.05	---	---
Sand Beach Cove									
Aug '75	Sand	1	9.8±1.1	0.06±0.03	---	0.2 ±0.1	0.22±0.04	0.11±0.03	0.48±0.20
Aug '76	"	1	8.6±1.1	---	---	---	0.28±0.04	0.13±0.04	0.64±0.33
Sept '77	"	1	4.7±1.1	---	---	---	0.08±0.05	0.07±0.04	---
Aug '78	"	1	7.8±1.8	---	---	---	0.28±0.06	---	0.71±0.62

[a]Radionuclide values for a single sample (n=1) are a single count of the sample ± the two-sigma, propagated counting error. The radionuclide value shown for more than one sample is the mean ± one standard deviation of two or more single sample counts. Dashes in the table indicate the sample count is not significant.

Table 14. Some gamma-emitting radionuclides in freshwater samples collected at Amchitka Island[a]

Location and Date	Liters; Range	Fraction	n	Radionuclides pCi/liter[b] ^{7}Be	^{95}Zr	^{95}Nb	^{137}Cs	^{144}Ce
Jones Lake								
1971[c]	83-477	Particulate	4	---	0.05 ± 0.04	0.11 ± 0.08	0.02 ± 0.04	NA
"	"	Soluble	4	---	0.01 ± 0.01	0.02 ± 0.02	0.02 ± 0.02	NA
1971-72	53-619	Particulate	5	0.2 ± 0.3	0.008± 0.011	0.02 ± 0.02	0.004± 0.009	NA
"	"	Soluble	5	1.3 ± 2.9	0.07 0.15	0.16 ± 0.33	0.05 ± 0.10	NA
1973	152-193	Particulate	2	---	---	---	0.042± 0.015	NA
"	"	Soluble	2	---	---	---	---	NA
May '74	53	Particulate	1	---	0.084± 0.062	0.19 ± 0.06	0.039± 0.029	0.44 ± 0.14
"	"	Soluble	1	---	---	---	---	---
Aug '74	413	Particulate	1	---	---	---	---	---
"	"	Soluble	1	---	---	---	---	---
Aug '75	56	Entire	1	1.1 ± 0.3	---	0.05 ± 0.03	0.12 ± 0.03	---
Aug '76	50	Entire	1	1.9 ± 0.5	---	---	0.08 ± 0.04	---
Sept '77	50	Entire	1	1.6 ± 0.6	0.29 ± 0.09	0.42 ± 0.09	0.13 ± 0.04	0.44 ± 0.17
Aug '78	50	Entire	1	---	---	---	0.11 ± 0.05	0.23 ± 0.22
Heart Lake								
Aug '75	52	Entire	1	2.3 ± 0.4	0.09 ± 0.05	0.15 ± 0.04	0.25 ± 0.04	0.24 ± 0.11
Aug '76	48	Entire	1	1.9 ± 0.5	---	---	0.13 ± 0.05	---
Sept '77	50	Entire	1	---	---	---	---	0.90 ± 0.30
Aug '78	50	Entire	1	1.8 ± 1.3	---	---	0.10 ± 0.04	---
Cannikin Lake								
1972	9-10	Particulate	2	---	0.17 ± 0.23	0.34 ± 0.48	---	NA
1973	72-95	Particulate	2	---	---	---	0.04 ± 0.057	NA
"	"	Soluble	2	---	---	---	0.08 ± 0.11	NA
May '74	314	Particulate	1	---	0.20 ± 0.04	0.25 ± 0.03	0.019± 0.013	0.41 ± 0.07
"	"	Soluble	1	---	---	---	---	---
Aug '74	99	Particulate	1	---	---	---	---	---
"	"	Soluble	1	---	---	---	---	---
Aug '75	53	Entire	1	---	---	---	0.21 ± 0.04	---
Aug '76	50	Entire	1	---	---	---	0.10 ± 0.04	0.24 ± 0.15
Sept '77	50	Entire	1	0.93± 0.78	---	0.46 ± 0.13	0.10 ± 0.06	0.35 ± 0.25
Aug '78	50	Entire	1	---	---	---	0.05 ± 0.03	---

Table 14 (continued)

Location and Date	Liters; Range	Fraction	n	Radionuclides pCi/liter[b] ^{7}Be	^{95}Zr	^{95}Nb	^{137}Cs	^{144}Ce
Long Shot Mud Pit No. 1								
1970-71[c]	62-950	Particulate	6	4.0 ± 4.7	0.4 ±0.6	0.9 ±1.2	0.02 ± 0.03	NA
"	"	Soluble	6	11 ±18	0.002±0.003	0.006±0.009	0.08 ± 0.18	NA
1971-72	29-108	Particulate	5	1.2 ± 1.3	0.25 ±0.29	0.48 ±0.55	0.03 ± 0.07	NA
"	"	Soluble	5	0.44± 0.98	---	---	---	NA
1973	32-38	Particulate	2	2.0 ± 1.0	---	---	0.04 ± 0.06	NA
"	"	Soluble	2	---	---	---	---	NA
May '74	48	Particulate	1	4.0 ± 0.7	1.3 ±0.1	2.7 ±0.2	0.034± 0.028	4.9 ± 0.3
"	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	---	---
Aug '75	50	Entire	1	1.2 ± 0.3	---	---	0.08 ± 0.03	---
Aug '76	52	Entire	1	1.3 ± 0.4	---	---	0.05 ± 0.03	---
Sept '77	50	Entire	1	1.7 ± 0.8	0.44 ±0.14	0.91 ±0.19	0.14 ± 0.06	0.31± 0.24
Aug '78	50	Entire	1	1.3 ± 1.2	---	---	0.12 ± .05	---
Constantine Springs								
Sept '77	50	Entire	1	---	---	---	---	---
Aug '78	50	Entire	1	0.75± 0.62	---	---	0.05 ± 0.03	---
Long Lake								
Sept '77	50	Entire	1	1.1 ± 0.7	0.55 ±0.15	0.61 ±0.14	0.11 ± 0.06	0.41± 0.24
Aug '78	50	Entire	1	---	---	---	0.10 ± 0.05	0.30± 0.20
Sand Beach Cove Seepage								
Sept '77	34	Entire	1	1.1 ± 1.0	0.30 ±0.29	0.33 ±0.14	---	---
Rain Water								
Sept '77	50	Entire	1	28 ± 1.5	4.9 ±0.2	9.4 ±0.3	0.40 ± 0.06	2.8 ± 0.3
Aug '78	50	Entire	1	3.3 ± 2.2	0.24 ±0.23	0.28 ±0.12	0.41 ± 0.06	3.7 ± 0.26

a. ^{103}Ru, ^{106}Ru, ^{125}Sb, and ^{140}Ba also present in some samples.

b. Radionuclide values for a single sample (n = 1) are a single count of the sample ± the two-sigma, propagated, counting error. The radionuclide value shown for more than one sample is the mean ± one standard deviation of two or more single sample counts. Dashes in the table indicate the sample count is not significant and NA indicates the radionuclide was not included in the analyses.

c. Pre-Cannikin

Table 15. Tritium Concentration in Water Samples Collected at Sites other than Long Shot Drainage, Amchitka Island, 1970-1978.

Collection Date	Collection Location	Number of Samples	Tritium Units[a]	pCi/liter[b]
I Seawater				
1970-71[c]	d	10	32 ± 19	103 ± 61
1972	d	16	28 ± 25	90 ± 81
1973	d	6	22 ± 13	71 ± 42
1974	d	6	<13	<42
1975	d	6	<15	<48
1976	d	6	<15	<50
1977	d	4	<13	<42
Aug '78	Constantine Harbor	1	<9	<29
"	Square Bay	1	<9	<29
"	Sand Beach Cove	1	<9	<29
"	Duck Cove	1	10 ± 10	32 ± 32
"	St. Makarius Bay	1	34 ± 10	110 ± 32
"	Near Mouth of Long Shot Cr.	2	23 ± 7	74 ± 23
"	Near Mouth of Bridge Cr.	1	20 ± 9	65 ± 29
II Freshwater, except Long Shot Area				
1970-71[c]	d	12	92 ± 46	298 ±149
1972	d	18	49 ± 14	158 ± 45
1973	d	46	50 ± 17	162 ± 55
1974	d	44	32 ± 18	103 ± 58
1975	d	29	34 ± 14	110 ± 45
1976	d	33	30 ± 12	97 ± 39
1977	d	44	28 ± 9	90 ± 29
1978	d	45	26 ± 13	84 ± 42
Jan '78	Camp Area Precipitation	2	< 15	<48
Feb '78	"	2	107 ± 62	346 ±200
Apr '78	"	2	47 ± 45	152 ±145
May '78	"	2	<15	<48
Sept '78	"	1	21 ± 10	68 ± 32

Table 15. (continued)

Collection Date	Collection Location	Number of Samples	Tritium Units[a]	pCi/liter[b]
Oct '78	Camp Area Precipitation	2	<9	<29
Nov '78	"	2	10 ± 1	32 ± 3
Dec '78	"	2	14 ± 7	45 ± 23
May '78	Clevenger Creek	2	<8	<26
Nov '78	"	2	10 ± 1	32 ± 3
Aug '78	"	2	25 ±15	81 ± 48
Nov '78	Bridge Creek	2	12 ± 4	39 ± 13
Aug '78	"	2	33 ± 5	107 ± 16
Aug '78	Constantine Spring	1	24 ± 9	78 ± 29
"	Long Lake	1	25 ± 9	81 ± 29
"	Pump House	1	10 ± 9	32 ± 29
"	Jones Lake Outlet	1	11 ± 9	36 ± 29
"	Clevenger Lake Outlet	1	27 ± 9	87 ± 29
"	Duck Cove Creek	1	<9	<29
"	Seep Area from Cliffs at Duck Cove	2	49 ±11	158 ± 36
"	Clam Lake	1	33 ±10	107 ± 32
"	Heart Lake	1	21 ± 9	68 ± 29
"	Quonset Lake	1	22 ±10	71 ± 32
"	Quonset Creek	1	37 ± 9	120 ± 29
"	Ice Box Lake Inlet[e]	3	40 ± 4	129 ± 13
"	Ice Box Lake Outlet	1	12 ± 9	39 ± 29
"	Cannikin Lake Inlet from Ground Zero	1	18 ±10	58 ± 32
"	Cannikin Lake Inlet from Drillback	1	15 ±10	48 ± 32
"	White Alice Inlet to Cannikin Lake	1	73 ±10	236 ± 32
"	Cannikin Lake Surface and Bottom	9	30 ±25	97 ± 81
"	Cannikin Lake Outlet	3	15 ± 4	48 ± 13

Table 15. (continued)

Collection Date	Collection Location	Number of Samples	Tritium Units[a]	pCi/liter[b]
Aug '78	MP-12 Creek	1	12 ± 9	39 ± 29
"	DK-45 Lake	1	31 ± 9	100 ± 29
"	Sand Beach Cove Seep	2	42 ±13	136 ± 42

a. Radionuclide values for single samples (n = 1) are a mean of a repeated count of the sample ± a one-sigma, propagated, counting error. The radionuclide value shown for more than one sample is the mean ± one standard deviation of those individual sample values.

b. One TU equals 3.23 pCi/liter.

c. Pre-Cannikin.

d. Mean of all collection sites.

e. A small lake formed in the north fork of White Alice Creek after surface subsidence occurred at the Cannikin site.

Table 16. Tritium concentration in water samples collected at Long Shot Drainage, Amchitka Island, 1970-1978.

Collection Location	Collection Date	Number of Samples	Tritium Units[a]	pCi/liter[b]
Long Shot Mud Pit				
Mud Pit #3[d]	1970-71[c]	3	3500±460	11300±1500
	1974	1	2900±460	9400±160
	1975	1	867±19	2800±61
	1976	1	1150±23	3710±74
	1977	1	915±23	2956±74
	1978[d]	1	704±21	2274±68
Mud Pit #2	1976	1	1140±23	3680±74
	1977	1	731±20	2361±65
	1978	1	623±20	2012±65
Mud Pit #1	1970-71[c]	3	1800±260	5800±840
	1972	4	2050±240	6600±780
	1973	2	1900±420	6100±1400
	1974	2	1300±250	4200±810
	1975	1	122±11	395±36
	1976	2	716±12	2310±39
	1977	2	681±27	2200±87
	1978	1	492±18	1589±58
Long Shot Mud Pit Drainage 3 Meters below Mud Pit #1	1975	1	872±19	2820±61
	1976	1	739±18	2390±58
	1978	1	529±18	1709±58
Infantry Road	1975	1	666±16	2150±52
	1976	1	342±14	1100±45
	1977	1	454±16	1466±52
	1978	1	394±15	1273±48

Table 16. (continued)

Collection Location	Collection Date	Number of Samples	Tritium Units[a]	pCi/liter[b]
600 meters below road	1975	1	424±15	1370±48
	1976	1	278±14	898±45
	1977	1	148±13	478±42
	1978	1	279±13	901±42
200 meters below road[d]	1976	1	252±13	814±42
	1977	1	84±12	271±39
	1978	3	272±90	879±291
400 meters below road[d]	1976	1	103±12	333±39
	1977	1	57±12	184±39
	1978	2	168±18	543±58
500 meters below road	1975	1	82±13	264±42
	1976	1	53±11	171±36
	1978	1	70±10	226±32
200 meters above Square Bay	1975	1	121±13	390±47
	1976	1	48±11	155±36
	1977	1	41±12	132±39
	1978	2	92±17	297±55
20 meters above Square Bay	1975	1	107±13	347±42
	1976	1	27±11	87±36
	1977	1	16±12	52±39
	1978	2	62±5	200±16

a. Radionuclide values for single samples (n=1) are a mean of a repeated count of the sample ± a one-sigma, propagated, counting error. The radionuclide value shown for more than one sample is the mean ± one standard deviation of those individual sample values.

b. One TU equals 3.23 pCi/liter

c. Pre-Cannikin

d. Ranunculus collection site

Table 17. Tritium in free water from biological samples collected at Amchitka Island.

Sample Type, Tissue Collection Location	Collection Date	n[a]	Tritium Units[b]	pCi/liter[b]
Fucus, entire				
Constantine Harbor	Aug '75	2	<35±18	<110± 58
	Aug '76	1	35±11	110± 36
	Sept '77	1	23±10	74± 32
	Aug '78	1	15± 9	48± 29
Square Bay	Aug '75	3	<26±12	<84± 39
	Aug '76	2	25± 3	81± 10
	Sept '77	1	38±11	122± 36
	Aug '78	1	53±19	171± 61
Sand Beach Cove	Aug '75	2	<21± 1	<68± 3
	Aug '76	3	31± 4	100± 13
	Sept '77	1	28±11	90± 36
	Aug '78	1	<9	<29
Duck Cove	Aug '76	3	23± 3	74± 10
	Sept '77	4	<13	<42
	Aug '78	1	<9	<29
Greenling Muscle				
Constantine Harbor	May '74	2	48± 4	155± 13
	Aug '75	1	<14	<45
	Aug '76	1	<21	<68
	Sept '77	2	<13	<42
	Aug '78	1	<9	<29
Square Bay	Aug '75	4	<20± 2	<65± 6
	Aug '76	1	<19	<62
	Sept '77	1	17±10	55± 32
	Aug '78	1	<9	<29
Sand Beach Cove	May '74	3	94±39	304±126
	Aug '75	2	<20± 1	<65± 3
	Aug '76	3	20± 7	65± 23
	Sept '77	1	<12	<39
	Aug '78	1	<10	<32
Duck Cove	Aug '76	1	<46	<150
	Sept '77	1	<13	< 42
	Aug '78	1	16± 9	52± 29

Table 17. (continued)

Sample Type, Tissue Collection Location	Collection Date	n[a]	Tritium Units[b]	pCi/liter[b]
Dolly Varden, Muscle				
Ice Box Lake	Oct '72	3	45± 9	145± 29
White Alice Creek	Aug '73	2	162±52	523±168
Bridge Creek	Aug '73	4	64± 3	207± 10
(Intertidal area of creek)	Aug '75	2	16± 2	51± 6
Duck Cove	Aug '76	2	43± 9	140± 29
	Sept '77	1	<11	<36
	Aug '78	1	<9	<29
Jones Lake	May '74	3	68± 54	220± 174
	Aug '75	4	26± 16	85± 52
	Aug '76	1	58± 13	190± 42
	Sept '77	1	38± 11	123± 36
	Aug '78	1	<9	<29
Cannikin Lake	Aug '75	1	39± 12	130± 39
	Aug '76	1	72± 17	230± 55
	Aug '78	1	22± 9	71± 29
Ranunculus, entire				
Duck Cove Creek	Aug '73	2	68± 35	220± 113
White Alice Creek	Aug '73	2	89± 28	228± 90
Bridge Creek	Aug '76	2	<67	<220
	Aug '78	3	25± 4	81± 13
Longshot Mud Pit 3	Aug '78	2	787± 7	2542± 23
Longshot Creek (250 m below Infantry Rd)	Aug '78	1	143± 11	462± 36
Longshot Creek (400 m below Infantry Rd)	Aug '76	1	120± 17	390± 55
	Aug '78	1	72± 10	233± 32
Clevenger Creek	Aug '78	2	31± 1	100± 3

Table 17. (continued)

Sample Type, Tissue Collection Location	Collection Date	n[a]	Tritium Units[b]	pCi/liter[b]
Fontinalis, entire				
Clevenger Creek	Aug '76	4	102± 6	329± 19
	Sept '77	1	27±16	87± 52
	Aug '78	3	38± 6	123± 19
	Nov '78	1	37± 9	120± 29
Ice Box Lk Inlet	Aug '76	3	37±16	120± 52
	Sept '77	2	54± 9	174± 29
	Aug '78	3	32± 1	103± 3
White Alice Creek (Cannikin Lk Drainage)	Aug '75	2	39±28	126± 91
	Aug '76	5	71±15	229± 48
	Sept '77	3	32± 9	103± 29
	Aug '78	3	32± 4	103± 13
Bridge Creek	Feb '78	1	<10	<32
	Aug '78	1	<9	<29
Longshot Creek (200 m upstream from Square Bay)	Aug '75	2	85±14	275± 45
	Sept '77	1	107±12	346± 39
	Aug '78	1	95±10	307± 32
Longshot Creek (25 m upstream from Square Bay)	Aug '76	1	150±15	480± 48
	Sept '77	1	62±11	200± 36
	Aug '78	1	97±11	313± 36
Ptarmigan, Muscle				
Camp Area	Aug '76	2	<21	<68
	Sept '77	1	21±10	68± 32
	Aug '78	1	17± 9	55± 29
Milrow/Longshot	Aug '76	2	40±17	130± 55
	Sept '77	2	35± 5	113± 16
	Aug '78	1	<9	<29
Cannikin Area	Aug '76	1	36±18	120± 58
	Aug '78	1	10±10	32± 32

a. n equals the number of free water samples from a single tissue sample.
b. Radionuclide values for single samples (n = 1) are a mean of a repeated count of the sample ± a one-sigma, propagated, counting error. The radionuclide value shown for more than one sample is the mean ± one standard deviation of these individual sample values.

Table 18. Plutonium - 239,240 in Fucus, Greenling, Sand, and Soil Samples collected at Amchitka Island

Sample Type	Collection Location	Collection Date	pCi/g, dry[a]	DPM/kg, wet
Fucus, entire	Sand Beach Cove	Aug. 1975	0.006 ± 0.002	3.0 ± 1.0
		Aug. 1976	0.003 ± 0.002	1 ± 0.8
		Sept. 1977	0.002 ± 0.002	0.9 ± 0.8
		Aug. 1978	0.003 ± 0.0008	1.5 ± 0.4
Fucus, entire	Constantine Harbor	Aug. 1975	0.002 ± 0.002	0.8 ± 0.8
		Aug. 1976	<0.002	<0.8
		Sept. 1977	0.002 ± 0.0006	0.9 ± 0.2
		Aug. 1978	0.003 ± 0.0006	1.4 ± 0.3
Fucus, entire	Square Bay	Aug. 1976	0.003 ± 0.002	1.0 ± 0.8
		Sept. 1977	0.005 ± 0.002	1.4 ± 0.6
		Aug. 1978	0.003 ± 0.001	1.7 ± 0.3
Fucus, entire	Duck Cove	Sept. 1977	0.002 ± 0.0008	0.8 ± 0.4
		Aug. 1978	0.003 ± 0.001	1.6 ± 0.3
Greenling, Muscle	Sand Beach Cove	Aug. 1975	<0.002	<0.8
		Aug. 1976	<0.002	<0.8
		Sept. 1977	0.001 ± 0.0004	0.5 ± 0.2
		Aug. 1978	<0.001	<0.4
Greenling, Muscle	Constantine Harbor	Aug. 1975	<0.003	<1.2
		Aug. 1976	<0.002	<0.8
		Sept. 1977	<0.0001	<0.05
		Aug. 1978	<0.001	<0.4
Sand, Surface[b]	Sand Beach Cove	Aug. 1975	0.004 ± 0.002	---
		Aug. 1976	<0.001	---
		Sept. 1977	0.001 ± 0.0006	---
		Aug. 1978	<0.001	---
Sand, Surface	Constantine Harbor	Aug. 1975	<0.002	---
		Aug. 1976	0.003 ± 0.002	---
		Sept. 1977	0.005 ± 0.002	---
Soil, Surface	Cannikin Area Drillback #1	Aug. 1975	0.015 ± 0.004	---
		Aug. 1976	0.008 ± 0.002	---
		Sept. 1977	0.005 ± 0.006	---
		Aug. 1978	0.003 ± 0.002	---
Soil, Surface	Cannikin Area Drillback #2	Aug. 1976	<0.002	---
		Sept. 1977	0.002 ± 0.0008	---
		Aug. 1978	0.005 ± 0.001	---

Table 18 (continued)

Sample Type	Collection Location	Collection Date	pCi/g, dry[a]	DPM/kg, wet
Soil, Surface	Cannikin Area Drillback #3	Aug. 1976	0.009 ± 0.005	---
		Sept. 1977	0.001 ± 0.0001	---
		Aug. 1978	0.004 ± 0.001	---
Soil, Surface	Camp Area	Aug. 1975	0.001 ± 0.001	---
		Aug. 1976	<0.002	---
		Aug. 1976	0.005 ± 0.003	---
		Aug. 1976	0.006 ± 0.004	---
		Sept. 1977	0.004 ± 0.002	---
		Aug. 1978	0.004 ± 0.001	---

a. The radionuclide value for these single samples is a single count of the sample ± the two sigma, propagated, counting error.

b. Surface samples were the 0 to 2.5 cm layer.

Table 19. Background radiation at selected sites on Amchitka Island.

Location	Radiation Level[a], mR/hr									
	Average Reading					Maximum Reading				
	1974	1975	1976	1977	1978	1974	1975	1976	1977	1978
Decon Facility	0.01	0.01	0.01	0.01	0.02	0.05	0.04	0.03	0.04	0.03
Inside "D" Barracks	0.01	<0.01	0.01	0.01	0.01	0.04	0.04	0.04	0.05	0.03
Husky Camp	<0.01	0.01	0.01	0.01	0.02	0.04	0.05	0.04	0.05	0.05
Jones Creek Effluence	<0.01	<0.01	0.01	0.01	0.01	0.04	0.04	0.03	0.04	0.03
EIC Calibration Range	<0.01	0.01	0.01	0.01	0.02	0.04	0.04	0.05	0.05	0.03
Rifle Range Target Area	0.01	0.01	0.01	0.01	0.02	0.04	0.05	0.04	0.06	0.03
Duck Cove	<0.01	<0.01	0.01	0.01	0.02	0.03	0.04	0.04	0.05	0.03
Milrow SGZ & Vicinity	<0.01	0.01	0.01	0.01	0.01	0.04	0.04	0.06	0.05	0.02
Long Shot SGZ & Vicinity	0.01	0.01	0.01	0.01	0.02	0.05	0.05	0.05	0.04	0.04
Cannikin SGZ & Vicinity	0.01	0.01	0.01	0.01	0.01	0.04	0.04	0.04	0.04	0.04
Cannikin Drillback	0.01	0.01	0.01	0.01	0.01	0.05	0.04	0.05	0.05	0.04
Sand Beach Cove	<0.01	<0.01	0.01	0.01	0.02	0.04	0.04	0.04	0.06	0.03
D-Site	0.01	<0.01	0.01	0.01	0.02	0.05	0.03	0.04	0.05	0.03
E-Site	0.01	<0.01	0.01	0.01	0.02	0.03	0.04	0.04	0.03	0.03

a. Eberline G-M detector, Model E-510; probe window thickness less than 2 mg/cm^2.

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1972	NVO-269-17	Held, E.E.
1972	NVO-269-19	Held, E.E., et. al.
1973	NVO-269-21	Nelson, V.A., and A.H. Seymour
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1975	NVO-269-27	Nelson, V.A., and A.H. Seymour
1976	NVO-269-31	Nelson, V.A., and A.H. Seymour
1977	NVO-269-34	Seymour, A.H., and A.F. Johnson

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