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AMCHITKA RADIOBIOLOGICAL PROGRAM PROGRESS REPORT

JANUARY 1977 TO DECEMBER 1977

By

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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 1976, has been given in seven 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 1977.

Results of analyses for samples collected in September 1977, have been added to the tables in Nelson and Seymour (1977) that summarize the results of analyses of samples collected from 1970 to 1977, and include analyses for: (1) gamma-emitting radionuclides in air filters, 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 suvery instruments was added to the Laboratory's program in 1974, and the results of the four 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 September 1977, as reported in this and the seven previous progress reports, that there were no radionuclides of Milrow or Cannikin origin in the water, plants, or animals of Amchitka Island.

TABLE OF CONTENTS

FIGURES

TABLE OF CONTENTS (CONTINUED)

TABLES

TABLE OF CONTENTS (CONTINUED)

TABLES

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 seventh progress reports reiterated the above conclusion and extended the account of the program through August 1976. Major conclusions of the seventh report, as stated by Nelson and Seymour (1977) are as follows:

a. "Naturally occurring ^{7}Be and ^{40}K were the most abundant radionuclides present in most sample types."

b. "Trace quantities of fission products, induced radionuclides and plutonium have been detected in amounts that would be expected from world fallout at that latitude."

c. "No unexpected radionuclides or radionuclide ratios have been detected."

d. "Tritium values in seawater and freshwater are not significantly different than the values that would be expected at island stations at the same latitude in the northern hemisphere."

e. "Some of the ponds and mud pits in the vicinity of the Long Shot Surface Ground Zero remain contaminated with ^{3}H. The drainage from the mud pits is also contaminated. The concentration is less than the amount of ^{3}H in the rainfall at Vienna, Austria, in 1963, and about twice as great as the amount in rainwater samples from 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 70 months after the Cannikin detonation of November 6, 1971, indicates that no radionuclides from the Cannikin or Milrow events have escaped to the surface environment."

In this, the eight progress report, the format is the same as for the seventh progress report except that new data from the analyses of the samples collected in September 1977, were added to the appropriate tables of the previous report. Figure 1 of this progress 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 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. 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 the distillate, as discussed in Held et al. (1973); free and bound ^{3}H in water samples from fish, ptarmigan, and aquatic plant samples was determined by azeotropic distillation and liquid scintillation counting. A discussion of the procedure for processing biological samples for analysis of ^{3}H in bound water was given in Nelson and Seymour (1975a and 1976).

Freshwater samples (34 liters or more) for analyses of radionuclides other than ^{3}H were collected from eight different sites.The water was evaporated and the residue counted for gamma-emitting radionuclides.

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

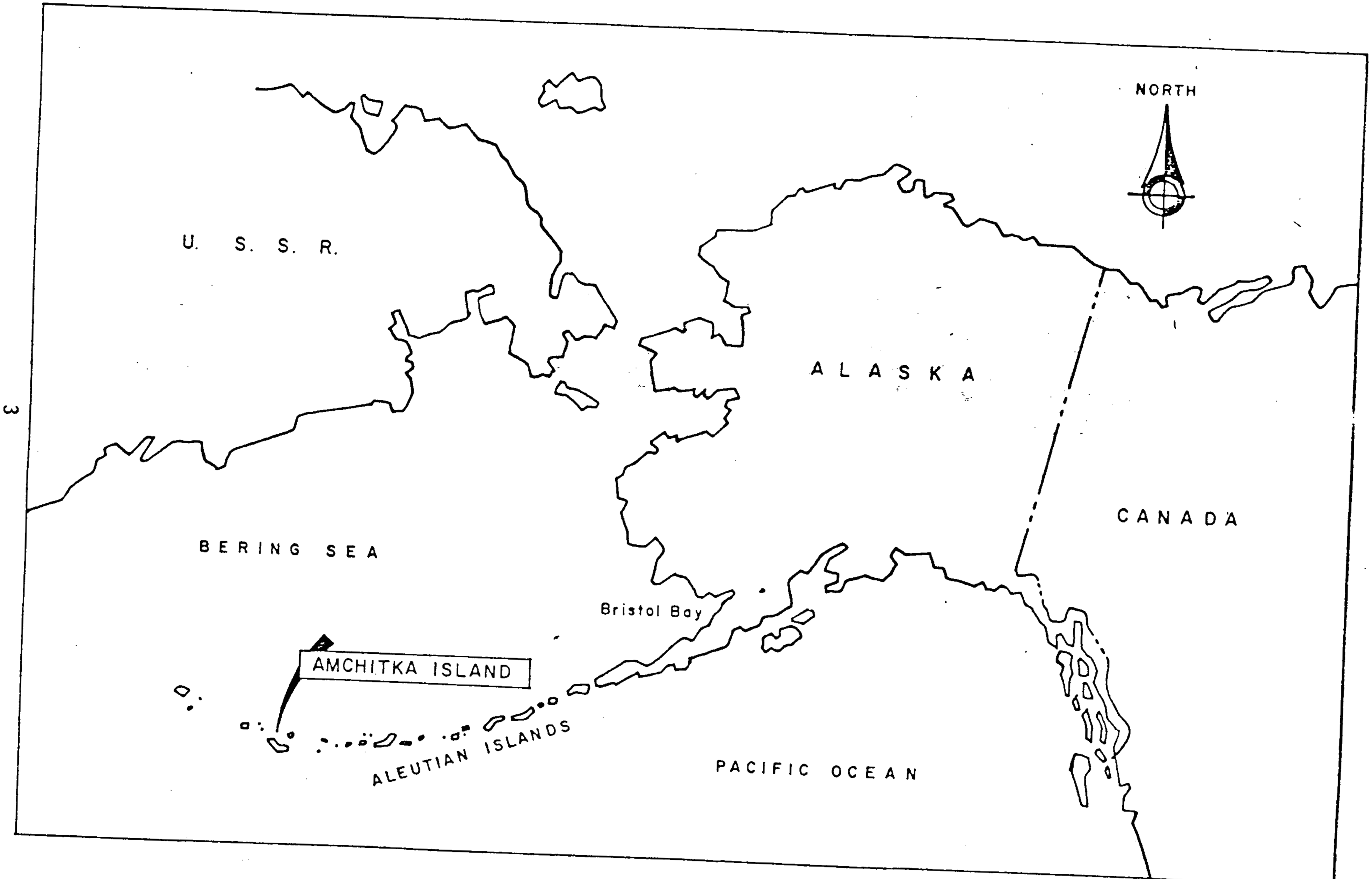

FIGURE 1. Location Map

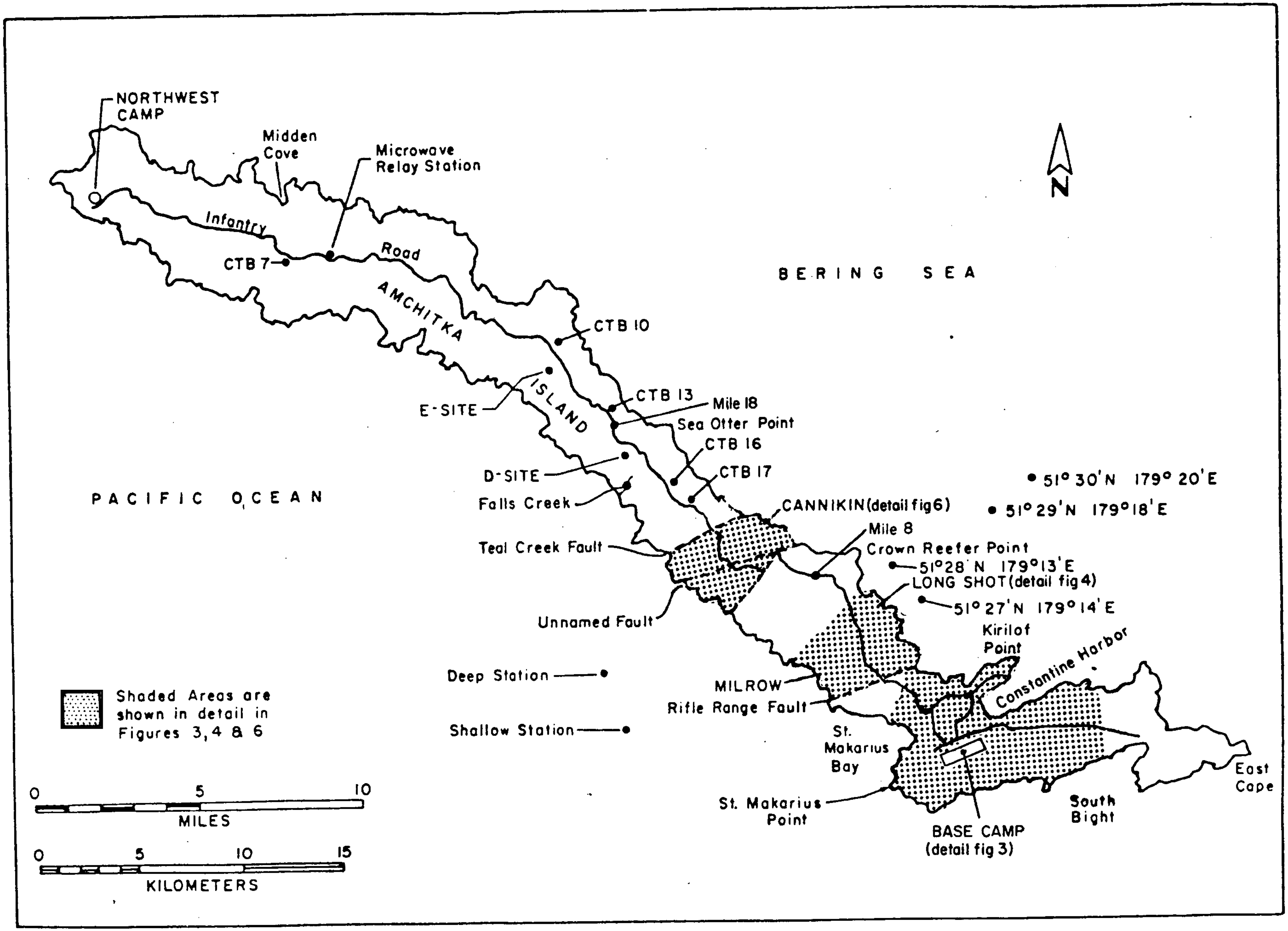

FIGURE 2. Location of Collection Sites on and near Amchitka Island, Alaska

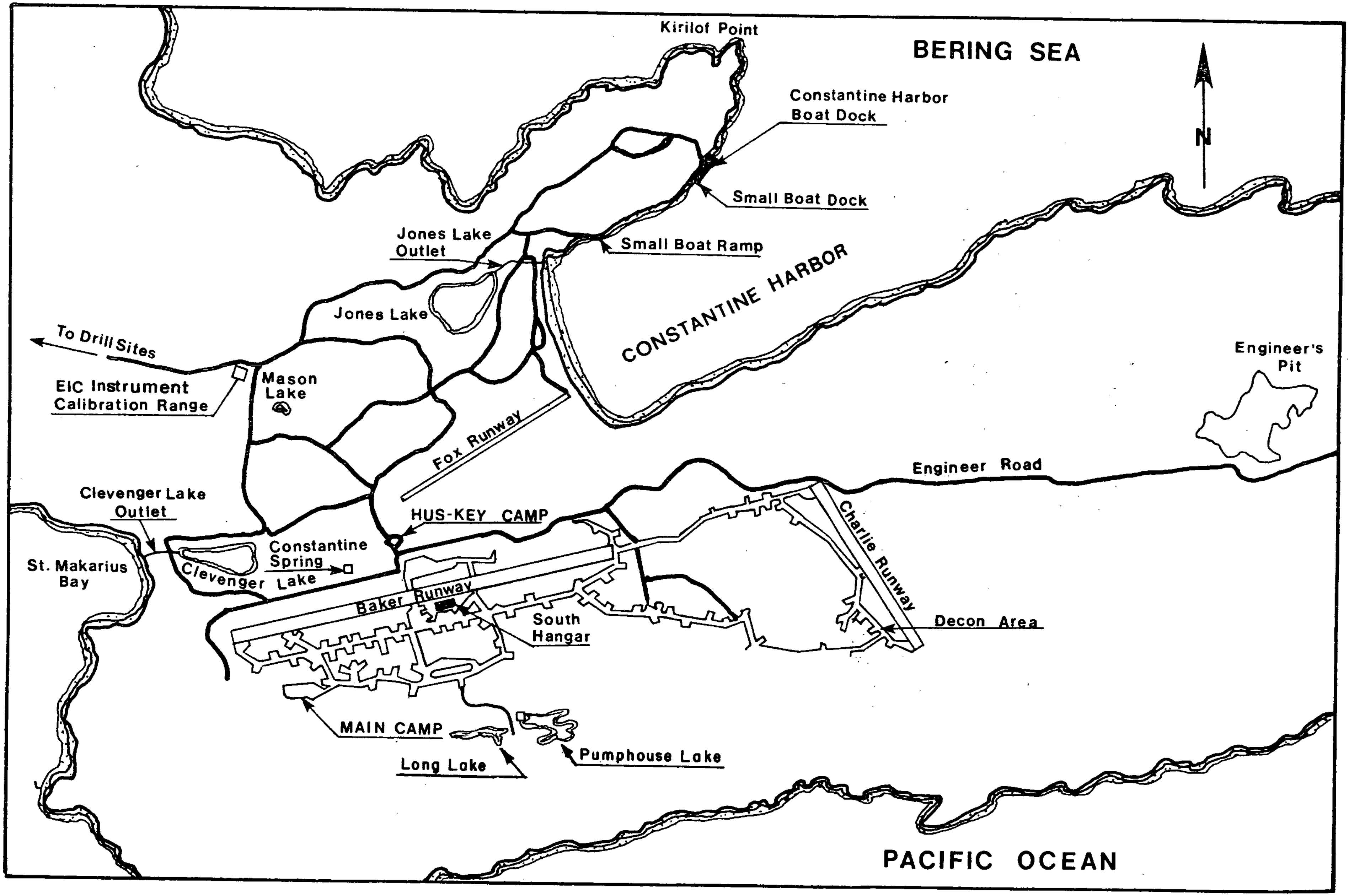

FIGURE 3. Collection Sites and Other Prominent Features in the Amchitka Island Base Camp Area

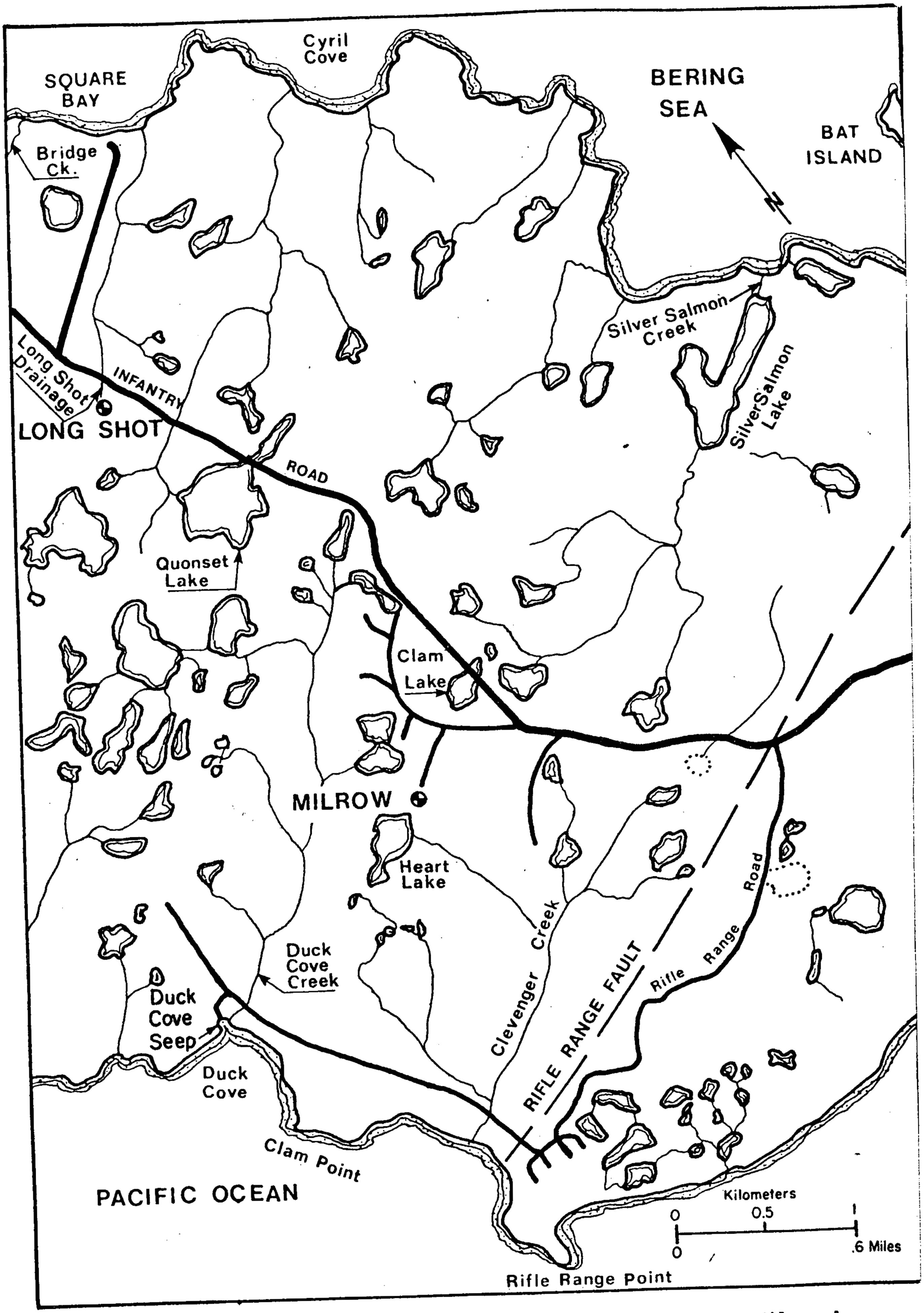

FIGURE 4. Collection Sites and Other Prominent Features in the Milrow Area.

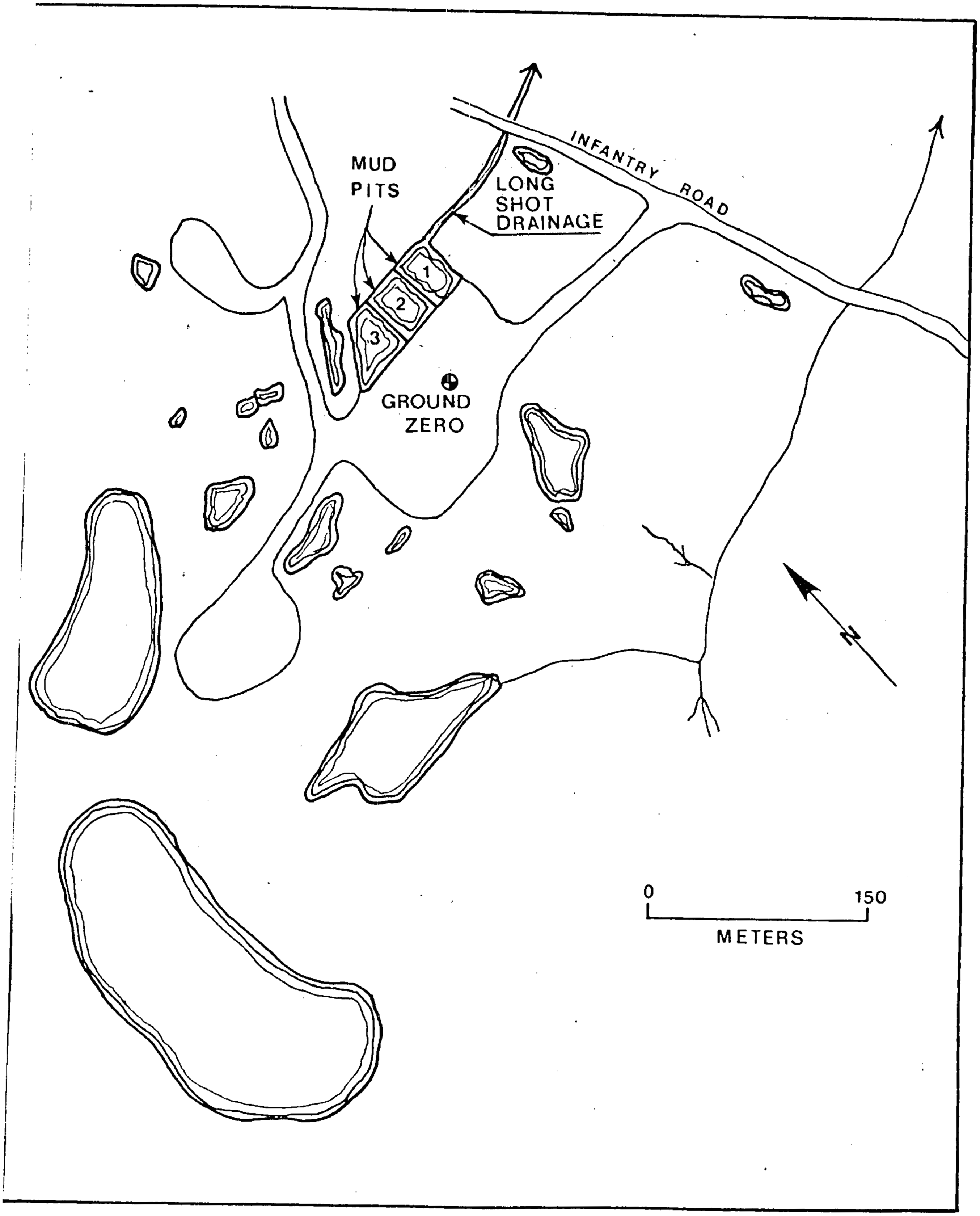

FIGURE 5. Collection Sites and Other Prominent Features in the Long Shot Ground Zero Vicinity.

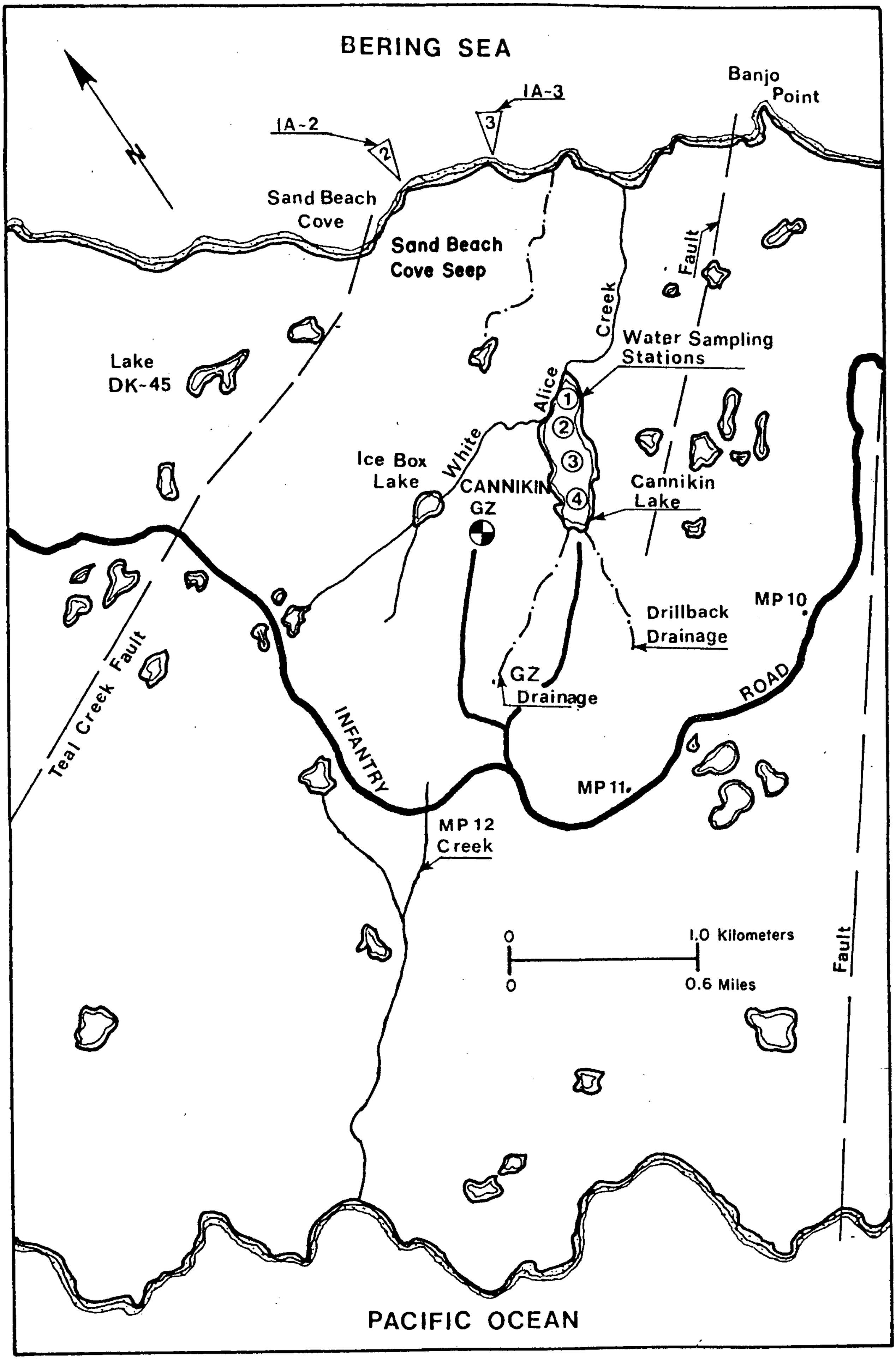

FIGURE 6. Collection Sites and Other Prominent Features in the Cannikin Area

^{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 in single samples collected before 1975 are one-sigma counting errors, while errors for the 1975, 1976, and 1977 values for ^{90}Sr analyses 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 " "
By alpha detection	
$^{239,240}Pu$	0.02 " "

In addition to the radiometric analyses made on the biological and environmental samples, environmental radiation surveys of selected areas on Amchitka Island were made in August 1974, 1975, 1976, and September 1977 with an Eberline survey meter, Model E-510, and a pancake probe with a <2 mg/cm^2 window.

3. RESULTS AND DISCUSSION

Since the completion of the 1976 Amchitka radiobiological progress report the book, "The Environment of Amchitka Island," has been published (Merritt and Fuller, ed. 1977). Chapter 24, "Radionuclides in Air, Water and Biota," (Seymour and Nelson, 1977) is a summary of the radiobiological studies at Amchitka from 1965 to 1975 including the studies reported in the 1970-71 to 1975 annual progress reports. Prior to 1970 there was a radiobiological project for the Long Shot Program in 1965 and for the Milrow Program in 1969 but the effort expended for these two projects was much less than for the Cannikin radiobiological project which began with a pre-event study in 1970. Other chapters of the book provide additional information about the Amchitka environment based upon extensive studies by many investigators.

The samples collected in September 1977 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 1977 schedule of sample collections and analyses were as follows:

1. A water sample was collected from Long Lake for the first time and was used for both ^{3}H and gamma spectrum analyses.

2. Water samples from Constantine Springs and Sand Beach Cove seep and of rainwater from the Main Camp area were collected for gamma spectrum and ^{3}H analyses, whereas only samples for ^{3}H analysis were collected in previous years.

3. The sampling program which has been limited to one collection a year in recent years was supplemented by collections of <u>Fontinalis</u> and water from Bridge and Clevenger creeks and of rainwater from the Main Camp area in the spring and summer of 1977 by staff members of the U. S. Fish and Wildlife Service.*

Most of the samples were analyzed by gamma spectrometry for both natural and fission product radionuclides. In addition, selected samples were analyzed for tritium, strontium-90, and plutonium-239, 240. The results of radiological analyses are presented in Tables 3 to 18.

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*The assistance of James Coffey, Glen Elison, John Martin (refuge manager) and Robert Schulmeister (biologist) of the Aleutian Canada goose restoration program is gratefully acknowledged.

The results of gamma spectrum analysis for three types of biological samples collected in freshwater are given in Tables 3 to 5. 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. Inspection of the tables reveals that the values for the natural radionuclides 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.

To further investigate the "year of collection" effect, the values for the amount of zirconium-95 (^{95}Zr) plus niobium-95 (^{95}Nb) in Fontinalis from Amchitka were compared with the amount of ^{95}Zr plus ^{95}Nb in freshwater moss and algae samples from the Columbia River and with the schedule of atmospheric detonation of nuclear devices of 20 kiloton or greater fission yield in China. These data 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). 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. 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 source of information about the Chinese nuclear detonations was Telegadas (1977). Inspection of Figure 7 provides evidence for the following comments: (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

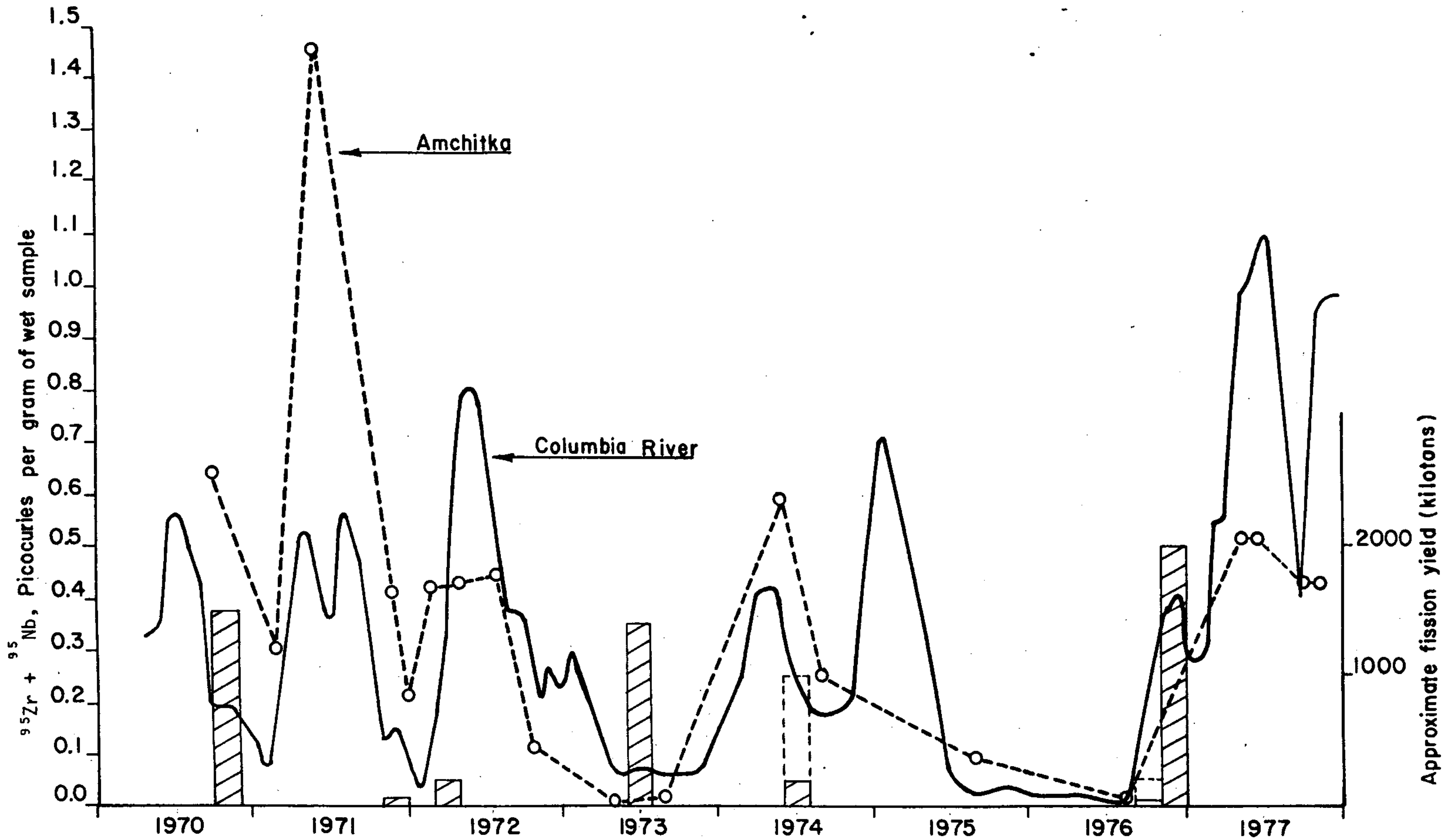

Figure 7. Zirconium-95 plus niobium-95 in freshwater vegetation from Amchitka Island and from the Columbia River and the fission yield of Chinese atmospheric nuclear detonations, 1970 to 1977. The Amchitka samples were the moss, Fontinalis. The Columbia River sample were the moss Calliergonella cuspidata the algae Cladophora sp. or a combination of the two species collected at Goebel, Oregon in 1970-71 and at Rainier, Oregon in 1972-77 (Toombs, 1978). The two 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 nuclear detonations greater than 20 kiloton are shown as bars (Telegadas, 1977).

^{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. However, in Table 3, the September 1977 values for Fontinalis were two to three times greater from the Cannikin area than for samples from the Milrow or Long Shot areas, although less than for natural radionuclides. This observation raised the question, "were the differences statistically significant?" To answer the question, the mean radioactivity of the seven Fontinalis samples collected from the Cannikin area (Cannikin Lake, Ice Box Lake, MP-12 Creek) was compared with the mean activity of the four samples from the Milrow area (Clevenger Creek, Duck Cove Creek) and the five samples from the Long Shot area (Bridge Creek, Long Shot drainage stream). The radioactivity of each sample was arbitrarily determined to be the sum of the radioactivity for the eight most abundant fission product radionuclides - ^{95}Zr, ^{95}Nb, ^{103}Ru, ^{106}Ru, ^{125}Sb, ^{137}Cs, ^{144}Ce, and ^{155}Eu. The mean values, and one standard deviation,for these Fontinalis samples from the Cannikin, Long Shot, and Milrow areas, in terms of pCi/g of dry sample, were 15.2 ± 9.0, 6.8 ± 3.9 and 4.3 ± 0.8, respectively. To determine the significance of the mean differences, the "t" test was applied and the conclusion was that the differences were not statistically significant. Hence, even though the differences were two or three fold, the differences were not statistically significant because of the magnitude of the error term and the limited number of samples.

Radionuclide values for Ranunculus are given in Table 4, for aufwuchs in Table 5, and for lichens in Table 6. 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 7) had fewer fallout radionuclides present and at lower concentrations in 1977 and all other years than the two freshwater vegetation types, Fontinalis and Ranunculus. The naturally occurring radionuclide, ^{40}K, was present in concentrations that ranged from 22 to 39 pCi/g of dry sample which is 25 times or more greater than the most abundant fission product. Also, ^{144}Ce was detected in the 1977 samples for the first time since 1974.

Maximum radionuclide values for the green sponge, a marine invertebrate, in terms of pCi/g of dry sample, as given in Table 8, were 8.2 for ^{40}K and ranged from 0.41 to 1.2 for the detectable fission products.

Naturally occurring ^{40}K and fission-produced ^{137}Cs were the two radionuclides most commonly detected in fish (Tables 9-11). Of ten samples analyzed in 1977 - halibut, Dolly Varden, or greenling - ^{137}Cs was detectable in five samples and the maximum value was 0.41 pCi/g of dry sample. 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 12) and, as for fish, the ^{40}K values were significantly greater than the ^{137}Cs values. The values for both radionuclides in the 1977 fish samples fell within the range of values for other years.

The samples analyzed for ^{90}Sr were soils and the bones of rats and ptarmigan (Table 13). In samples collected since 1971, the ^{90}Sr values in terms of pCi/g of dry sample ranged from 11 to 27 for ptarmigan bones and from the limits of detection to 5.8 for rat bones. The 1977 values were slightly less than the ^{90}Sr values for these samples in previous years. Soil samples were collected in 1975, 1976, and 1977 but in only one sample was the ^{90}Sr value greater than the limit of detection and this value was 0.03 pCi/g of dry sample. Both surface soil and sand samples (0-2.5 cm) collected in the last three years were analyzed for gamma-emitting radionuclides. The soil samples were collected at the Main Camp and in the Cannikin Area and the sand samples from Constantine Harbor and Sand Beach Cove. The radionuclides in evidence were ^{40}K, ^{137}Cs, ^{141}Ce, ^{144}Ce, ^{226}Ra, ^{228}Th, and ^{238}U. There were no obvious differences in radioactivity related to either year or collection area. The gamma-emitting fallout radionuclides present in these samples were ^{137}Cs, ^{141}Ce, and ^{144}Ce but their concentration in the samples was less than 1 pCi/g of dry sample. 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. The results of analyses of the residue from the evaporation of 34-50 liter samples are presented in Table 15. 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, the values being 0.44 and 0.91 pCi/liter respectively. These two radionuclides also were present in the September 1977 rainwater sample but at concentrations an order of magnitude greater than the values for the Long Shot Mud Pit No. 1 sample. If recent rainfall was the source of ^{95}Zr and ^{95}Nb observed in the 1977 samples, the concentration in Long Shot Mud Pit No. 1 would be expected to be greater than in the lake samples because of greater dilution in the lakes. The ^{95}Zr and ^{95}Nb observed in the 1977 samples must be of relatively recent origin because of the short half lives of ^{95}Zr and ^{95}Nb (65 and 35 days respectively) and, hence the origin is presumed to be world fallout. The other significant observation from inspection of Table 15 is that the radioactivity for samples from the three new sites in 1977 was within the range of values for samples from other locations.

The concentrations of tritium (^3H) in seawater and freshwater samples are recorded in Table 16. From 1970-71 to 1973 the ^3H values for seawater declined from 103 to 71 pCi/liter and since that time, including 1977, the values have been at or below the limit of detection which is about 48 pCi/liter. The ^3H 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 samples other than those from the Long Shot area has declined to values that have ranged from 93 to 110 pCi/liter in the period 1974-1977. For 1977, the average of 34 freshwater samples (other than samples from the Long Shot area) and 11 rainwater samples were 93 and 111 pCi/liter respectively, and because of the relatively large error terms in both values, the difference between the freshwater and rainwater values is not significant.

The water samples collected from the Long Shot Mud Pits for ^3H analysis have always been considered separately from other samples because this area was found to be slightly contaminated with ^3H 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). In the period from 1970-71 to 1977, the average ^3H values for water samples from Long Shot Mud Pits have declined from 11.3×10^3 to 2.5×10^3 pCi per liter. These values are significantly less than the allowable concentration of ^3H in drinking water for the general population which is 10^6 pCi of ^3H per liter. This value is 1/30 the tritium MPC_W (maximum permissible concentration in drinking water) for continuous intake by the occupational worker (ICRP, 1964). A more extensive discussion of this subject is given in Nelson and Seymour (1977) and Seymour and Nelson (1977). Samples of water that flows from the Long Shot Mud Pits to Square Bay also were collected in 1975, 1976 and 1977 for ^3H analysis. In the 1.6 km course of the drainage stream, the ^3H values decreased from values comparable to the Mud Pit values to values near the mouth of the stream that were comparable to ^3H values in freshwater samples from other areas of Amchitka Island. In 1977 the values, in units of pCi per liter, decreased in regular order from 1.5×10^2 near the Mud Pits to 52 at Square Bay and hence the contribution of ^3H from the Long Shot Mud Pits to the ocean was insignificant.

Table 16 also provides some information for evaluation of the effect of the season of the year upon the amount of ^3H in the samples but the information was insufficient for a positive conclusion. In 1977, water samples were collected from Clevenger and Bridge creeks in May, August and September, and a significantly greater amount of ^3H in the May sample from Clevenger Creek is indicated; however, rainwater samples were collected in March, June, July, August, and September and for these samples, no seasonal effect is apparent although peak seasonal values in late spring - early summer would not have been unexpected.

In Table 17, the results of ^3H analyses of free water extracted from biological samples are presented. The collections in 1977 included samples from the marine environment (Fucus and muscle of greenling and Dolly Varden), from freshwater (Fontinalis and Dolly Varden muscle) and from the terrestrial environment (ptarmigan muscle). The 1977 values, generally, were slightly less than the 1976 values but the differences were not great. The greatest concentrations were in the Fontinalis samples and the average value for 1977 other than samples from the Long Shot Area was 120 pCi per liter, a value not greatly different than the average value of 93 pCi per liter for all Amchitka freshwater samples exclusive of the Long Shot Area. The 1976 observation that the values for ^{3}H in Fontinalis from Clevenger and White Alice creeks were about twice as great as ^{3}H values in water samples from the same location, was not verified by the 1977 data. However, as observed in previous years, the values for ^{3}H in Fontinalis from the Long Shot drainage stream were several times greater than in comparable samples from other areas. Also, the ^{3}H values for Fontinalis were related to the ^{3}H values in the water from which the samples were collected. An effort to measure ^{3}H in the bound water of biological samples is continuing but so far reliable results have not been obtained. Completion of a gas counting system may resolve some of the previous problems.

Some 1975, 1976, and 1977 samples - soil, sand, Fucus and greenling muscle - also 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.

A background radiation survey program with a Geiger-Muller detector - window thickness < 2 mg/cm^2 - was initiated in 1974 and the results of the survey for 1977 and the three previous years are presented in Table 19. Observations were made at 14 locations and in no instance was the average value greater than 0.01 mR per hour, although occassionally 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 September 1977 and the background radiation measurements of that date lead to the same conclusion 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 sample.

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. 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.

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

7. 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.

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 1977 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	4.33	———
	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	9.5	———
	MARINE ALGAE		
Fucus distichus Marine algae	Entire	4.94	1.4
	FRESHWATER VEGETATION		
Cladophora sp. Filamentous algae	Entire	5.1	———
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 on Air Filters at Ground Level at the Amchitka Island Base Camp

Collection Period	n[b]	Mean Volume $10^3 m^3$	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. Radionuclide values for a single sample (n = 1) are a single count for 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 N.A. indicates the radionuclide was not included in the analyses.

b. Number of samples.

Table 3

Some Gamma-Emitting Radionuclides in the Freshwater Moss, <u>Fontinalis</u> 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± .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
Aug '75	1	4.2±2.0	6.3±1.4	---	0.44±0.18	---	0.88±0.47	0.17± .09	0.7±0.1	2.3 ±0.3	0.08± .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± .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	---
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± .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
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± .14	1.1±0.1	3.1 ±0.4	0.10± .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± .11	1.4±0.4	0.9 ±0.6	0.08± .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± .16	1.6±0.3	2.3 ±0.7	0.24± .15
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	1.16± .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	---
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± .09	0.8±0.1	2.4 ±0.26	0.09± .05
Aug '76	1	4.7±2.2	7.0±1.3	---	---	---	---	0.18± .09	1.4±0.1	---	---
Sept '77	1	---	3.6±2.1	---	1.1 ±0.4	---	---	---	1.0±0.2	1.5 ±0.4	---

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
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 ±.01	1.2±0.1	3.2 ±0.2	0.2 ±.08
Aug '76	1	4.7± 1.6	5.3±1.2	---	---	---	---	0.12 ±.09	0.7±0.1	0.26±0.21	0.10±.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	---
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
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±.11
Aug '76	1	8.7± 1.9	5.3±1.5	0.3 ±0.3	---	---	1.6±0.5	0.15 ±.10	0.9±0.1	1.7 ±0.2	0.16±.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	---
Ice Box Lake Inlet											
1973	2	4.1± 0.8	5.7±1.0	---	0.08±0.11	---	0.5±0.0	0.28 ±.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	---
Aug '75	1	---	4.7±1.3	---	0.27±0.16	---	0.7±0.5	0.20 ±.11	1.3±0.1	1.8 ± .3	0.09±.07
Aug '76	3	4.8± 1.8	4.0±0.8	0.15±.26	---	---	0.2±0.4	0.21 ±.08	1.4±0.5	0.75± .13	0.13±.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	---
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	---
Aug '75	1	7.9± 1.9	5.1±1.1	---	0.52±0.16	---	1.8±0.5	0.24 ±.09	2.0±0.1	2.1 ± .3	---
Aug '76	3	3.8± 0.6	3.6±0.3	---	---	0.15± .27	0.3±0.3	0.05 ±.09	1.0±0.4	---	0.06±.05
Sept '77	3	19.5± 0.5	5.3±1.8	3.1±0.2	6.6 ±1.1	0.66± .35	4.0±1.7	0.23± .20	1.0±0.2	9.0 ±0.7	0.37±0.21

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 the Freshwater Plant, <u>Ranunculus</u> 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 ±.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	---
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	---
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	---
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±.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	---
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	---
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	sample lost										

Table 4 (Continued)

Location and Date	n	^{7}Be	^{40}K	^{95}Zr	^{95}Nb	^{103}Ru	^{106}Ru	^{125}Sb	^{137}Cs	^{144}Ce	^{155}Eu
		Radionuclides pCi/g, dry [a]									
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 ±.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 ±.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	---
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 5

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	---	0.09±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
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
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
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
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

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 6

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											
1970-71[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
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
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	---
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	---

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

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

Table 7

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
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	---	---
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
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

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 8

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
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
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 9

Potassium-40 and Cesium-137 in Halibut Collected off Amchitka Island

Location and Date	Tissue	n[b]	Radionuclides pCi/g, dry[a] ^{40}K	Radionuclides pCi/g, dry[a] ^{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	Liver	1/1	---	---
" "	Muscle	1/1	18 ± 2.8	0.07 ± 0.06
Midden Cove				
Aug '75	Muscle	2/2	19 ± 1.9	0.05 ± 0.04
" "	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 10

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
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	---
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	---
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	---
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	---

Table 10 (Continued)

Location and Date	Tissue	n[b]	Radionuclides pCi/g, dry[a] ^{40}K	^{137}Cs
Square Bay				
Aug '75	Muscle	1/5	16 ± 1.6	---
Aug '75	Viscera	1/5	7.8 ± 1.4	0.07 ± 0.04
Aug '76	Muscle	1/6	18 ± 0.9	---
Aug '76	Viscera	1/6	11 ± 0.8	0.10 ± 0.05
Sept '77	Muscle	1/5	16 ± 2.8	---
Sept '77	Viscera	1/5	9.1 ± 2.6	---
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	---
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

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 11

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	d	3/7	16 ± 0.6	0.18 ± 0.09
1974	e	6/28	15 ± 1.7	0.28 ± 0.08
1975	f	5/19	12 ± 4.4	0.17 ± 0.12
Aug '76	Cannikin Lake	1/2	14 ± 0.5	0.19 ± 0.03
"	Jones Lake	1/9	15 ± 0.4	0.22 ± 0.02
"	Duck Cove	1/6	15 ± 1.8	0.10 ± 0.04
Sept '77	Clevenger Lake Outlet	1/2	15 ± 2.6	0.08 ± 0.05
"	Jones Lake	1/3	12 ± 3.1	0.41 ± 0.13
"	Duck Cove	1/1	16 ± 4.9	0.32 ± 0.15

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.

d. Jones Lake, Bridge Creek, Silver Salmon Lake Outlet.

e. Jones Lake, Cannikin Lake, Duck Cove.

f. Jones Lake, Cannikin Lake, Bridge Creek, Duck Cove, Clevenger Creek.

Table 12

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	^{137}Cs
1970-71[b]	South Bight	Liver	1	---	---
Aug '74	C-Site	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	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
Aug '75	C-Site	"	4	14 ± 2	3.4 ± 0.2
Aug '75	Mile 8	"	2	11 ± 2	1.4 ± 0.1
Aug '75	Milrow Area	"	2	12 ± 2	1.8 ± 0.6
Aug '76	C-Site	"	4	12 ± 0.5	1.7 ± 0.1
Aug '76	Milrow/Long Shot	"	3	10 ± 4.5	<0.3
Aug '76	Camp Area	"	1	10 ± 0.6	1.5 ± 0.1
Aug '76	Mile 18	"	1	9.4 ± 0.6	0.75 ± 0.04
Sept '77	C-Site	"	4	11 ± 2.5	2.1 ± 0.18
Sept '77	Long Shot	"	4	8.8 ± 1.0	0.37 ± 0.08
Sept '77	Camp Area	"	5	12 ± 2.5	0.55 ± 0.10

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, C-Site, and Mile 16; two from Mile 5.

Table 13

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 ± 1.0
1975	1	"	"	0.5 ± 0.2
1976	1	"	"	<1.3
1977	1	"	"	< 0.78
1973	1	Other Sites[d]	Rat, bone	1.8 ± 0.2
1974	2	"	"	1.6 ± 1.1
1975	2	"	"	1.4 ± 0.3
1976	5	"	"	<1.3
1977	3	"	"	< 0.80
1971	1	Cannikin Area	Ptarmigan, bone	31 ± 1.8
1975	1	"	"	13 ± 1.0
1976	1	"	"	14 ± 2.6
1977	1	"	"	17 ± 1.4
1971[c]	1	Milrow/Long Shot	Ptarmigan, bone	27 ± 1.6
1973	1	"	"	11 ± 0.4
1975	1	"	"	14 ± 1.4
1976	1	"	"	19 ± 2.4
1977	1	"	"	16 ± 1.2
1971	2	Other Sites[e]	Ptarmigan, bone	27 ±12
1973	1	"	"	14 ± 0.4
1974	1	"	"	16 ± 4.6
1975	1	"	"	19 ± 2.8
1976	2	"	"	26 ± 0.4
1977	1	"	"	15 ± 1.4
1975	1	Main Camp	Soil	0.03 ± 0.02
1976	3	"	"	<0.03
1977	1	"	"	<0.14
1975	1	Cannikin Area	Soil	<0.16
1976	3	"	"	<0.04
1977	3	"	"	<0.14

a. Each bone sample obtained from 2 to 4 individuals.

b. Radionuclide values for single samples (n = 1), collected before 1975, are a mean of a repeated count of the sample ± a one-sigma, propagated, counting error. Errors for 1975, 1976, and 1977 values are two-sigma counting errors. The radionuclide value for more than one sample is the mean ± one standard deviation of those individual sample values. In 1976 and 1977 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 g of sample, is about 0.5 for rat samples (3g), 0.3 for ptarmigan (5g) and 0.03 for soils (50g).

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 14

Some Gamma-Emitting Radionuclides in Sand and Soil Collected at Amchitka Island

Sample Type	Collection Location	n	Radionuclides pCi/g, dry[a] ^{40}K	^{137}Cs	^{141}Ce	^{144}Ce	^{226}Ra	^{228}Th	^{238}U
I. August 1975									
Soil	Main Camp	1	8.0±1.2	---	0.20±0.13	0.14±0.13	0.18±0.04	0.14±0.05	---
Soil	Cannikin Area	1	11 ±1.3	0.32 ± 0.05	0.22±0.15	0.97±0.18	0.11±0.05	0.08±0.04	---
Sand	Constantine Harbor	1	13 ±1.2	0.07 ± 0.03	---	---	0.18±0.04	0.09±0.04	0.44±0.36
Sand	Sand Beach Cove	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
II. August 1976									
Soil	Main Camp	3	11 ±1.0	0.82 ± 0.60	0.27±0.24	---	0.26±0.06	0.11±0.04	0.17±0.30
Soil	Cannikin Area	3	10 ±2.5	0.34 ± 0.21	---	0.09±0.12	0.21±0.03	0.11±0.02	0.64±0.18
Sand	Constantine Harbor	1	16 ±1.6	0.22 ± 0.04	---	---	0.28±0.05	0.11±0.05	0.88±0.47
Sand	Sand Beach Cove	1	8.6±1.1	---	---	---	0.28±0.04	0.13±0.04	0.64±0.33
III. September 1977									
Soil	Main Camp	1	15 ±2.2	0.24± 0.07	---	0.29± 0.21	0.29±0.07	0.27±0.08	0.85±0.69
Soil	Cannikin Area	5	8.8 ±3.0	0.21± 0.15	---	0.42± 0.02	0.20±0.05	0.19±0.08	---
Sand	Constantine Harbor	1	15 ±2.1	0.05± 0.04	---	---	0.19±0.06	0.09±0.07	---
Sand	Sand Beach Cove	1	4.7 ±1.1	---	---	---	0.08±0.05	0.07±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 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 15

Some Gamma-Emitting Radionuclides in Freshwater Samples Collected on 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
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
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

Table 15 (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
Constantine Springs								
Sept '77	50	Entire	1	---	---	---	---	---
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
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

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 16

Tritium Concentration in Water Samples Collected at Amchitka Island, 1970-1977

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
September 1977	Constantine Harbor	1	<13	<42
"	Square Bay	1	<15	<49
"	Sand Beach Cove	1	<13	<49
"	Duck Cove	1	13 ± 11	42 ± 36
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
March 1977	Main Camp (rainfall)	2	34 ± 5	110 ± 16
June "	"	2	<24	<78
July "	"	2	34 ± 1	110 ± 3
August "	"	2	46 ± 28	149 ± 90
Sept. "	"	3	34 ± 2	110 ± 6
May "	Clevenger Creek	1	17 ± 11	407 ± 61
August "	"	1	33 ± 11	107 ± 36
Sept. "	"	1	23 ± 11	74 ± 36
May "	Bridge Creek	1	32 ± 21	103 ± 68
August "	"	1	18 ± 11	58 ± 36
Sept. "	"	1	41 ± 11	132 ± 36
September 1977	Constantine Spring	1	19 ± 12	61 ± 39
"	Long Lake	1	<16	<52
"	Jones Lake Outlet	1	13 ± 11	42 ± 36
"	Clevenger Lake Outlet	1	21 ± 12	68 ± 39

Table 16 (Continued)

Collection Date	Collection Location	Number of Samples	Tritium Units[a]	pCi/liter[b]
II. Freshwater (cont.)				
September 1977	Heart Lake	1	15 ± 12	48 ± 39
"	Clam Lake	1	39 ± 11	126 ± 36
"	Duck Cove Creek (Mouth)	1	28 ± 11	90 ± 36
"	Seep-Duck Cove	1	20 ± 11	65 ± 36
"	Quonset Creek (at road)	1	31 ± 11	100 ± 36
"	Mile Post 12 Creek	1	29 ± 11	94 ± 36
"	Cannikin Lake Inlet from Ground Zero	1	14 ± 11	45 ± 36
"	Cannikin Lake Inlet from Drillback	1	42 ± 12	136 ± 39
"	Cannikin Lake White Alice Inlet	1	20 ± 11	65 ± 36
"	Cannikin Lake Station #1 Surface	1	<15	<48
"	Cannikin Lake Station #1 Bottom	1	<15	<48
"	Cannikin Lake Station #2 Surface	1	46 ± 12	149 ± 39
"	Cannikin Lake Station #2 Bottom	1	28 ± 12	90 ± 39
"	Cannikin Lake Station #3 Surface	1	36 ± 12	116 ± 39
"	Cannikin Lake Station #3 Bottom	1	31 ± 12	100 ± 39
"	Cannikin Lake Station #4 Surface	1	18 ± 12	58 ± 39
"	Cannikin Lake Station #4 Bottom	1	20 ± 12	65 ± 39
"	Cannikin Lake Outlet	2	29 ± 18	94 ± 58
"	Ice Box Lake Inlet[e]	1	23 ± 11	74 ± 36
"	Ice Box Lake Outlet[e]	1	<14	<45
"	DK-45 Lake	1	27 ± 11	87 ± 36
"	Seep-Sand Beach Cove	2	32 ± 8	103 ± 26
III. Long Shot Mud Pits				
1970-1971[c]	Mud Pit #3	3	3500 ±460	11300±1500
1974	"	1	2900 ±460	9400± 160
1975	"	1	867 ± 19	2800± 61

Table 16 (Continued)

Collection Date	Collection Location	Number of Samples	Tritium Units[a]	pCi/liter[b]
III. Long Shot Mud Pits (Cont.)				
1976	Mud Pit #3	1	1150 ± 23	3710 ± 74
1977	"	1	915 ± 23	2956 ± 74
1976	Mud Pit #2	1	1140 ± 23	3680 ± 74
1977	"	1	731 ± 20	2361 ± 65
1970-71[c]	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
1975	"	1	122 ± 11	395 ± 36
1976	"	2	716 ± 12	2310 ± 39
1977	"	2	681 ± 27	2200 ± 87
IV. Long Shot Mud Pit Drainage				
August 1975	3 meters below Mud Pit #1	1	872 ± 19	2820 ± 61
"	Infantry Road	1	666 ± 16	2150 ± 52
"	100 meters below road	1	424 ± 15	1370 ± 48
"	500 meters below road	1	82 ± 13	264 ± 42
"	200 meters above Sq. Bay	1	121 ± 13	390 ± 47
"	Mouth of creek	1	107 ± 13	347 ± 42
August 1976	3 meters below Mud Pit #1	1	739 ± 18	2390 ± 58
"	Infantry Road	1	342 ± 14	1100 ± 45
"	100 meters below road	1	278 ± 14	898 ± 45
"	200 meters below road[f]	1	252 ± 13	814 ± 42
"	400 meters below road[f]	1	103 ± 12	333 ± 39
"	500 meters below road	1	53 ± 11	171 ± 36
"	200 meters above Sq. Bay	1	48 ± 11	155 ± 36
"	20 meters above Sq. Bay	1	27 ± 11	87 ± 36
September 1977	Infantry Road	1	454 ± 16	1466 ± 52
"	100 meters below road	1	148 ± 13	478 ± 42
"	200 meters below road	1	84 ± 12	271 ± 39
"	400 meters below road[f]	1	57 ± 12	184 ± 39

Table 16 (Continued)

Collection Date	Collection Location	Number of Samples	Tritium Units[a]	pCi/liter[b]
IV. Long Shot Mud Pit Drainage (Cont.)				
September 1977	200 meters above Sq. Bay	1	41 ± 12	132 ± 39
	20 meters above Sq. Bay	1	16 ± 12	52 ± 39

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.

f. 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
"	"	Square Bay	Aug '75	3	<26±12	<84± 39
"	"	"	Aug '76	2	25± 3	81± 10
"	"	"	Sept '77	1	38±11	122± 36
"	"	Sand Beach Cove	Aug '75	2	<21± 1	<68± 3
"	"	"	Aug '76	3	31± 4	100± 13
"	"	"	Sept '77	1	28±11	90± 36
"	"	Duck Cove	Aug '76	3	23± 3	74± 10
"	"	"	Sept '77	4	<13	<42
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
"	"	Square Bay	Aug '75	4	<20± 2	<65± 6
"	"	"	Aug '76	1	<19	<62
"	"	"	Sept '77	1	17±10	55± 32
"	"	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
"	"	Duck Cove	Aug '76	1	<46	<150
"	"	"	Sept '77	1	<13	<42
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
"	"	" [c]	Aug '75	2	16± 2	51± 6
"	"	Duck Cove	Aug '76	2	43± 9	140± 29
"	"	"	Sept '77	1	<11	<36
"	"	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
"	"	Cannikin Lake	Aug '75	1	39±12	130± 39
"	"	"	Aug '76	1	72±17	230± 55
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
"	"	Long Shot Creek[d]	Aug '76	1	120±17	390± 55
Fontinalis	Entire	Clevenger Creek #1	Aug '76	2	106±18	340± 58
"	"	"	Sept '77	1	27±16	87± 52
"	"	" #2	Aug '76	2	97±14	310± 45
"	"	White Alice Creek #1	Aug '75	2	39±28	126± 91
"	"	"	Aug '76	1	72±17	230± 55
"	"	"	Sept '77	1	24±10	78± 32

Table 17 (Continued)

Sample Type	Tissue	Collection Location	Collection Date	n[a]	Tritium Units[b]	pCi/liter[b]
Fontinalis	Entire	White Alice Creek #2	Aug '76	2	86±11	280± 36
"	"	" #2	Sept '77	1	30±11	97± 36
"	"	" #3	Aug '76	2	56±48	180±160
"	"	"	Sept '77	1	41±11	132± 36
"	"	Ice Box Lake Inlet #1	Aug '76	1	<21	<68
"	"	"	Sept '77	1	47±12	152± 39
"	"	" #2	Aug '76	1	39±19	130± 61
"	"	" #3	Aug ' 76	1	52±18	170± 58
"	"	"	Sept '77	1	60±11	194± 36
"	"	Long Shot Creek #1[e]	Aug '75	2	85±14	275± 45
"	"	" #1	Sept '77	1	107±12	346± 39
"	"	" #2[f]	Aug '76	1	150±15	480± 48
"	"	" #2	Sept '77	1	62±11	200± 36
Ptarmigan	Muscle	Camp Area	Aug '76	2	<21	<68
"	"	"	Sept '77	1	21±10	68± 32
"	"	Milrow/Long Shot	Aug '76	2	40±17	130± 55
"	"	"	Sept '77	2	35± 5	113± 16
"	"	Cannikin Area	Aug '76	1	36±18	120± 58

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

b. Radionuclide values for singe 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.

c. Intertidal area at the mouth of the creek.

d. 400 meters below Infantry Road.

e. Site #1 is 200 meters upstream from Square Bay.

f. Site #2 is 25 meters upstream from Square Bay.

Table 18

Plutonium-239,240 in *Fucus*, Greenling, Sand, and Soil Samples Collected at Amchitka Island in 1975, 1976, and 1977.

Sample Type	Collection Location	August 1975		August 1976		September 1977	
		pCi/g, dry[a]	dpm/kg, wet	pCi/g, dry[a]	dpm/kg, wet	pCi/g, dry[a]	dpm/kg, wet
Fucus, entire	Sand Beach Cove	0.006 ± 0.002	3.0 ± 1.0	0.003 ± 0.002	1 ± 0.8	0.002 ± 0.002	0.9 ± 0.8
Fucus, entire	Constantine Harbor	0.002 ± 0.002	0.8 ± 0.8	<0.002	<0.8	0.002 ± 0.0006	0.9 ± 0.2
Fucus, entire	Square Bay	na	-	0.003 ± 0.002	1 ± 0.8	0.005 ± 0.002	1.4 ± 0.6
Fucus, entire	Duck Cove	na	-		-	0.002 ± 0.0008	0.8 ± 0.4
Greenling,Muscle	Sand Beach Cove	<0.002	<0.8	<0.002	<0.8	0.001 ± 0.0004	0.001 ± 0.0004
Greenling,Muscle	Constantine Harbor	<0.003	<1.2	<0.002	<0.8	<0.0001	<0.05
Sand,Surface[b]	Sand Beach Cove	0.004 ± 0.002	-	<0.001	-	0.001 ± 0.0006	-
Sand,Surface	Constantine Harbor	<0.002	-	0.003 ± 0.002	-	0.005 ± 0.002	-
Soil,Surface	Cannikin Area #1	0.015 ± 0.004	-	0.008 ± 0.002	-	0.005 ± 0.006	-
Soil,Surface	Cannikin Area #2	na	-	<0.002	-	0.002 ± 0.0008	-
Soil,Surface	Cannikin Area #3	na	-	0.009 ± 0.005	-	0.001 ± 0.0001	-
Soil,Surface	Camp Area #1	0.001 ± 0.001	-	<0.002	-	0.004 ± 0.002	-
Soil,Surface	Camp Area #2	na	-	0.005 ± 0.003	-	na	-
Soil,Surface	Camp Area #3	na	-	0.006 ± 0.004	-	na	-

a. The radionuclide value for these single samples is a single count of the sample ± the two-sigma, propagated, counting error. Samples not analyzed for $^{239,240}Pu$ are indicated by na.

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

Table 19

Background Radiation at Selected Sites on Amchitka Island

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

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

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1970-71	NVO-269-11	Held, E. E.
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
1974	NVO-269-23	Nelson, V. A., and A. H. Seymour
1975	NVO-269-27	Nelson, V. A., and A. H. Seymour
1976	NVO-269-31	Nelson, V. A., and A. H. Seymour

6. TABLE AND MAP INDEX

Collection Site	Figure No. (s)	Table No. (s)
Baker Runway	3	13
Base Camp	2 & 3	2, 13, 19
Bering Sea	1 & 2	9, 11
Bridge Creek	4	3, 4, 11, 16, 17
Cannikin Lake Inlet From Drillback	6	16
Cannikin Lake	6	6, 11, 15, 16, 17
Cannikin Lake Outlet	6	3, 4, 16, 17
Cannikin Lake Inlet From GZ	6	16
Cannikin Lake Inlet From White Alice Inlet	6	5, 16
Cannikin Site	2 & 6	12, 13, 14, 18, 19
Chapel Cove Stream	2	11
Clam Lake	4	6, 13, 16
Clevenger Creek	4	3, 4, 11, 13, 16
Clevenger Lake Outlet	3	4, 16
Constantine Harbor	2 & 3	7, 9, 10, 13, 14, 16, 17, 18
Constantine Harbor	3	16
Constantine Spring	3	15, 16
Crown Reefer Point	2 & 4	7
D-Site	2	19
Decon Area	3	19
Duck Cove	4	7, 8, 10, 11, 13, 17
Duck Cove Creek	4	3, 4, 11, 16
Duck Cove seep	4	16
E-Site	2	19
EIC Calibration Range	3	19
Heart Lake	4	15, 16
Hus-Key Camp	3	19
IA-2	6	None
IA-3	6	"
Ice Box Lake (Lake 05-46)	6	6, 16
Ice Box Lake Inlet	6	3, 16, 17
Infantry Road	2,4-6	None
Jones Lake	3	11, 15, 16, 17, 18
Jones Lake Outlet	3	16, 19
Lake DK-45	6	11
Lake DK-45 Outlet	6	None
Long Lake	3	15, 16
Long Shot	2, 4, 5	5, 15, 16, 19
Long Shot Drainage	4 & 5	3, 4, 16, 17
Main Camp	3	12, 13, 14, 18, 19
Midden Cove	2	9
Mile 8	2	12, 13
Mile 18	2	12, 13
Milrow	2 & 4	12, 19, 13, 17
MP 12 Creek	6	3, 16
Quonset Creek	4	16
Rifle Range Target Area	4	19
Sand Beach Cove	6	7, 8, 10, 13, 14, 16, 17, 19

TABLE AND MAP INDEX (CONTINUED)

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