BIOENVIRONMENTAL AND HYDROLOGIC STUDIES, AMCHITKA ISLAND, ALASKA

FALL, 1974 TASK FORCE REPORT

Compiled

by

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February, 1975

Prepared for the U.S. Atomic Energy
Commission under Contract No. AT(26-1)-171

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PREFACE

This report summarizes the information submitted by all investigators participating in the Amchitka Program during the Fall, 1974 field trip. Some additional analyses will be completed, especially those involving radionuclides in bioenvironmental samples, and results will be presented in later reports.

ABBREVIATIONS USED IN THE TEXT

AEC	United States Atomic Energy Commission
AEC-NVOO	AEC's Nevada Operations Office, Las Vegas, Nevada
AIBS	American Institute of Biological Sciences
BCL	Battelle's Columbus Laboratories
BYU	Brigham Young University, Provo, Utah
DOD	United States Department of Defense
DRI	University of Nevada, Desert Research Institute
FRI	University of Washington, Fisheries Research Institute, Seattle, Washington
FWS	United States Department of the Interior, Fish and Wildlife Service
II	Isotopes Inc., Palo Alto Laboratories
LRE	University of Washington, College of Fisheries, Laboratory of Radiation Ecology, Seattle, Washington
OSU	The Ohio State University, Columbus, Ohio
SZ	The point on the land directly above the nuclear explosive-emplacement hole
USGS	U.S. Department of the Interior, U.S. Geological Survey
UT	University of Tennessee, Knoxville, Tennessee
UA	University of Alaska, Agricultural Experiment Station, Palmer, Alaska
USU	Utah State University, Logan, Utah
UTM	Universal Transverse Mercator
WW II	World War II

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BIOENVIRONMENTAL AND HYDROLOGIC STUDIES,
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ABSTRACT

Bioenvironmental and hydrologic studies at Amchitka, Alaska have been sponsored by AEC-NVOO since 1967 when the Island was selected as the site for a series of underground nuclear weapons tests. At first these studies involved collecting data needed to predict the effects of nuclear testing activities and to recommend measures for minimizing adverse effects. After the final test on November 6, 1971, the studies were confined to measuring and evaluating these effects. This report presents the findings of a scientific field party visiting Amchitka during the period August 26 through September 4, 1974.

The landscape that was modified by the Milrow and Cannikin nuclear tests is continuing to undergo natural changes, as predicted. The exposed organic substrates have shown considerable vegetative establishment within 5 years and they are expected to achieve complete vegetative closure within 25 years. In contrast, the mineral substrates stripped of vegetation show little change, as predicted. They will probably require centuries to recover, if the present climatic conditions prevail.

Approximately 74 hectares of disturbed area were fertilized and reseeded with chewings fescue, Boreal creeping red fescue, Bering hairgrass, and ryegrass in 1973. The reseeded areas had developed excellent stands of plants in 1974, their second year of growth.

The hydrologic study involved measurements of water levels and stream flows at numerous locations. The water chemistry and stream flow data will be published in reports of the USGS 474 series and "Water Resources Data for Alaska" reports, respectively.

Cannikin Lake continued to undergo natural changes, as expected. Exceptionally large Dolly Varden were collected in Cannikin Lake, probably due to good growth rates of fish that were transplanted from other lakes.

The spawning run of pink salmon in the 20 streams surveyed was smaller than expected. Reasons for the smaller runs might include previous construction activities in one area, siltation in a few areas, harvesting, predation by eagles, commercial fishing, and weather conditions.

Recolonization of uplifted intertidal bench by algal and invertebrate communities continues to advance. The parts uplifted into the supralittoral fringe region, estimated to involve more than 57 hectares, are recolonizing more slowly than other intertidal zones. This is caused by the instability of the new supralittoral environment which is undergoing erosion, receiving sediment, and experiencing limited tidal immersion.

The radioactivity survey, using an Eberline survey meter (Model E-510) and 2 probes, revealed that maximum levels of radioactivity at Amchitka remain comparable to background levels in other areas of the United States.

INTRODUCTION

In 1967, soon after it was decided that a series of underground nuclear weapons tests would be conducted at Amchitka, Alaska, Battelle's Columbus Laboratories (BCL) was asked by the U.S. Atomic Energy Commission (AEC) to plan and initiate a bioenvironmental research program designed to:

- Predict the ecological consequences of AEC-NV00's activities at Amchitka, including the nuclear tests.
- Predict and evaluate the potential hazards to man via marine food chains if there should be an inadvertent release of radioactivity.
- Recommend measures for minimizing the adverse ecological effects.
- Monitor the long-term ecological effects of AEC-NV00's activities, including the nuclear tests.

Other investigations, e.g., geologic and hydrologic studies conducted by the USGS and other prime contractors of AEC, have provided a large amount of information that was necessary to accomplish the objectives listed above. Also, a previous underground nuclear test, Project Long Shot, was conducted in October, 1965, by the U.S. Department of Defense (DOD) with the AEC's assistance. Some bioenvironmental effects of that test, described by Seymour and Nakatani (1967), provided useful information for the current study.

Two nuclear tests were conducted during the current series of tests. They were Milrow, a calibration device detonated about 1,220 m (4,000 ft) underground on October 2, 1969, and Cannikin, a device detonated about 1,790 m (5,875 ft) underground on November 6, 1971. The yield of Milrow was about 1 megaton; the yield of Cannikin was a little less than 5 megatons. Figure 1 indicates their sites as well as other locations referred to in this report.

Most of the current bioenvironmental field studies were initiated in 1967, about 2 years prior to the first nuclear test of the series. Most of these studies were continued until at least 2 years after the final nuclear detonation, and studies in which the most interesting ecological changes are still evident are continuing at this time - most with the same principal investigators. About 100 investigators have participated in the research programs and more than 100 publications, a 2-day symposium at the 1970 Annual Meeting of AIBS, and numerous presentations have resulted from this research.

Earlier the scope and magnitude of the bioenvironmental and hydrologic studies were considerably larger. With the conclusion of the nuclear test program at Amchitka, the studies have been gradually phased down and are now limited to intermittent follow-up studies on subjects of particular interest. See Appendix B for further information about publications from these studies.

All of the published reports that present the significant information concerning the bioenvironmental studies and the previously studied effects of the nuclear testing activities are listed either in Kirkwood and Fuller (1972) or in Appendix B of this report.

A task force of scientists visited Amchitka from May 21 through June 1, 1974. The results of their studies and observations were compiled and reported in Kirkwood (1974).

FIGURE 1. MAP OF AMCHITKA ISLAND, ALASKA, SHOWING LOCATIONS REFERRED TO IN THIS REPORT

This report summarizes the information obtained during the second field study by a force of scientists during 1974; extending from August 24 through September 4, about 3 years after Cannikin was detonated. This fall field study had the following objectives:

1. Bioenvironmental Effects and Hydrologic Studies

To detect, document, and evaluate long-term bioenvironmental effects caused by AEC activities on Amchitka. These studies included:

- a. Effects on vegetation; recovery of streams and ponds from mud spills; salmon-spawning success; biological colonization and development in the new Cannikin Lake; and recovery of intertidal habitats (BCL and subcontractors)
- b. Revegetation and reseeding studies (UA)
- c. Hydrological measurements (USGS).

2. Radiological Monitoring

To obtain and interpret data on the kinds and amounts of radionuclides in the bioenvironment and hydrologic system and to differentiate radioactivities which may be of Amchitka-nuclear-test origin from those originating from worldwide fallout or from natural sources. Radionuclide analyses are being performed on samples of water, vegetation, fish, birds, rats, and invertebrates. Specimens were collected from marine, freshwater, and terrestrial habitats. The work included:

- a. Biological portion of the program (LRE)
- b. Hydrological portion of the program (USGS).

FALL 1974 FIELD STUDIES

Background

Fifteen researchers were involved in various research studies during the fall field investigations; the AEC Project Manager, Raymond A. Brechbill, and his support staff of 14 persons provided logistic support. The organization employing each investigator, the name of each investigator, and the area of responsibility of each investigator are given in Appendix A.

Plant Ecology

History of the Study

The plant ecology study has been under way since June, 1967. C. C. Amundsen succeeded E.E.C. Clebsch as principal investigator in January of 1969. Both investigators are in the Department of Botany and the Graduate Program in Ecology at the University of Tennessee, Knoxville, Tennessee (UT). During this study a plant community distribution map for the entire Island was prepared, plant community shifts resulting from substrate movement and drainage changes were documented, annual plant productivity and disturbed area recovery rates were studied, and the immediate effects of two underground nuclear tests on the landscape were measured.

Both Milrow and Cannikin produced visible changes across several terrestrial plant communities, but the Cannikin changes were more numerous and larger than changes associated with Milrow (Everett and Amundsen, 1975).

The late-summer investigation of ecological changes occurring in the terrestrial plant communities was conducted from August 26 to September 4, 1974. This trip, at the climax of the growing season on Amchitka, followed a spring field investigation, May 21 to May 31, 1974.

Objectives of the Fall, 1974 Research

To accomplish the purpose of the late-summer field investigation, a number of objectives were outlined. These objectives were:

1. Reexamination and/or remeasurement of
 - a. Plots where data on the nature of vegetation recovery had been collected
 - b. Transects established a few days after the Cannikin tests to assess changes in the vegetation caused by immediately visible test effects
 - c. Grids and movement line transects established to monitor natural as well as shock-induced movement of the substrate which might affect plant community stability
 - d. Specifically identified shock-related disturbances to
 - Turf mounds
 - Lakes
 - Other terrain (generally considered normal maritime tundra)
2. Continuing systematic reconnaissance in the vicinity of the nuclear test locales to detect previously unreported changes which might be related to the nuclear tests
3. Further studies to allow prediction of the rates of vegetative recovery on disturbed areas.

Observations

- 1.a. Recovery plots. Plots which were stripped of living shoots and roots in 1968 continue to indicate that natural reestablishment of vegetation proceeds more quickly on organic substrates than on mineral soils, and is also enhanced as drainage improves (flooded plots show no sign of recovery yet).
- b. Cannikin transects. There were ten line intercept transects established during the week following the Cannikin test. Transect 4 was inundated by the present Cannikin Lake. The other nine were reexamined. They show:
 - (1) An area locally flooded for a few days while a culvert which collapsed was restored; this tundra meadow community has recovered and is now stable.
 - (2) Another locally flooded area disturbed by a very temporary blockage of drainage; this tundra meadow community is now recovered and stable.

- (3) Vegetation cover around a small lake, which had been flooded during a seiche at the time of the Cannikin shock, now shows no evidence of the occurrence.
 - (4) Inundated meadow; now the bottom of Cannikin Lake.
 - (5) An area which suffered a flow of mixed mud and oil and exhibited a great deal of plant necrosis continues to recover slowly, although evidence of the damage is still apparent. Plant genera reappearing first are *Juncus* and *Platanthera*.
 - (6) An area where shredded paper was spilled was sampled to determine whether the paper (acting as a mulch) had any effect. There has been no effect.
 - (7) A small lake in which the previous water level was lowered by shock induced changes in the outlet area; a vascular plant community on the old water edge, predominantly *Eriophorum*, has not been affected even though the water has not returned to the previous shoreline (a matter of a few inches drop in level).
 - (8) A culvert collapse at this site caused a flooded meadow. The meadow was drained 11 months later, when the culvert was repaired. This meadow community (Crowberry-Grass-Sedge) is slowly reestablishing with *Carex* species and *Festuca rubra* prominent among the new, scattered vascular plants. Complete recovery is expected within several (10-20) years.
 - (9) A small area of rather scattered vegetation was severely affected by a fuel-oil spill. The oil stain is still very apparent and there has been no vascular plant reestablishment.
 - (10) An area in which the shock "fluffed" the tundra and sheared the roots of the crowberry still shows slight evidence of the phenomenon, but any evidence will be undetectable in a few more years.
- c. Grids and movement line transects. Four multipoint grids and two long (150m+) staked transect lines continue to show minor changes as the result of ordinary movements of the substrate downslope. Only on one (Grid 4 in White Alice Creek watershed) was there any significant shock-induced change. A small collapse-related scarp which cleft to mineral soil shows reestablishment of vascular plants only on small organic soil blocks which have fallen into the fracture.
- d. Specific shock-related disturbances.
- (1) Turf mounds. Two large (10-m diameter) turf mounds were split and peat blocks were ejected by the Milrow shock. On the newly exposed organic substrates at these sites, *Deschampsia*, *Agrostis*, and other vegetation now has fully reestablished. On newly exposed mineral substrates, plants are few. The Cannikin shock caused similar eruptions. The pattern of recovery is similar, although the 25-month interval between the two tests is reflected in the less complete recovery on the organic substrates of the Cannikin disturbances.
 - (2) Lakes. Several lakes underwent varying degrees of drainage change (completely drained to slight changes in shorelines) as

a result of the collapse of the terrain around the respective test sites. The establishment of graminoid vegetation is apparent on these newly exposed lake bottoms, at least on the organic if not the mineral soil. However, it will be decades before the newly establishing vegetative cover is complete because of the low rates of vascular plant establishment that have been observed over larger areas that have been examined on Amchitka.

- (3) Other terrain. Changes to the maritime tundra include fractures, scarps, and landslides. A Milrow-related landslide shows vigorous establishment of vascular vegetation on the exposed organic substrate. There is evidence of similar establishment on organic substrates exposed by Cannikin-induced landslides, but it is less apparent. Along scarps and fractures the establishment of vascular vegetation follows the established pattern; proceeding well on organic substrates, but difficult to see on mineral substrates.
2. Continuing systematic reconnaissance has revealed no previously undetected changes of any consequence which can be linked to the Milrow and Cannikin tests. A minor subsidence, probably associated with Cannikin, was discovered in Ultra Creek basin during the Spring trip. With the full seasonal development of the vegetation, the subsidence could be relocated during the late Summer only because it was flagged. No other new shock-related phenomenon was found.
3. Organic substrates exposed by military activities on Amchitka during WW II show nearly completed establishment of vegetation in almost all circumstances. Organic soils disturbed in connection with the Long Shot test (October, 1965) are well along in developing a complete vegetative cover. Some of the Milrow disturbances show similar trends toward complete cover. It can be said, therefore, that organic substrates show considerable vegetative establishment in 5 years, approach vegetative closure in 9 years, and usually achieve it sometime before 25 years.

In contrast, mineral substrates stripped of vegetation and exposed during WW II and since, show very spotty vegetative cover and, with rare exceptions, do not approach closure. It will likely be centuries (assuming that present climate prevails) before these surfaces are completely vegetated.

Assessments

The following assessments can be made as a result of the two 1974 field trips to Amchitka:

- The transects, grids, plots, and study areas previously selected are adequate for a long-term monitoring of the effects of the Milrow and Cannikin tests on the terrestrial vegetation.
- The kinds of changes to the landscape which have occurred and continue to occur, are well within the range of predictions made prior to the nuclear tests.
- Monitoring of changes should be continued, but two trips a year are not necessary to accomplish such investigations.

- Overall, measurable changes in terrestrial plant biomass productivity (a useful parameter for understanding ecosystem functions in tundra) within a 2-km radius of either Cannikin or Milrow SZ can be predicted at less than 1 percent (loss). This potential loss is of no consequence in terms of the terrestrial landscape of the entire Island. Details are discussed in Everett and Amundsen (1975).

Revegetation and Reseeding

History of the Study

Revegetation research involving trial plantings of disturbed areas on Amchitka was commenced in 1971 by W. W. Mitchell, University of Alaska, Agricultural Experiment Station (UA). This constituted the first known effort to establish a plant cover under maritime tundra conditions in the Aleutian Islands. Seed stocks from Amchitka plant populations were proposed for the undertaking, but a preliminary survey conducted in September, 1970 determined that this was infeasible. Thus, with permission of the U. S. Fish and Wildlife Service (FWS), introduced seeds were selected for a trial at a number of locations in the Island. Here, W. W. Mitchell describes all of the revegetation and re-seeding research performed at Amchitka since 1971, including observations made during 1974.

Methods

The sites chosen for testing represented a variety of situations that could be encountered in the reseeded effort: organic surface soils, gravel, and subsoil. The more organic soils are acidic and the gravelly and subsoil sites are alkaline. The plantings were at low to medium-high altitudes. At the higher altitudes, considerable bare ground is maintained by severe winds and frost action. The lower altitudes, though still subject to high winds, are densely covered with a low growing vegetation.

Included in the trials were seeds of domesticated (commercial) varieties and seeds collected from native plants from mainland Alaska. Twenty-four perennials were tested in row plantings at four sites with six different fertilizer treatments applied across the rows. Among the entries performing the most satisfactorily were red fescue (*Festuca rubra*), timothy (*Phleum pratense*), meadow foxtail (*Alopecurus pratensis*), and Bering hairgrass (*Deschampsia beringensis*). Large differences were evident in the effects of fertilizer treatments on the more organic, acidic soils in the year of establishment. Those treatments with the highest ratio of phosphorus/nitrogen were the most beneficial. Edaphic differences significantly affected the performance of certain of the grasses. Some failed on the more organic soils while growing more or less adequately on the gravelly and subsoil sites.

Grasses recommended for use in reseeding disturbed areas on the Island included highlight chewings fescue (*Festuca rubra* var. *commutata*), Boreal creeping red fescue and Bering hairgrass, all perennials, and annual ryegrass (*Lolium multiflorum*). Highlight chewings fescue is a tufted form of red fescue and Boreal is a creeping (rhizomatous) form of the same species. Only a limited amount of seed of Bering hairgrass collected from native populations on the Alaska mainland was available for inclusion in the mixture. The perennials recommended for use were conspecific with plants indigenous to Amchitka.

A fertilizer treatment of 90/70/66 lb/acre N/P/K was recommended for application at the time of seeding.

Recommendations were necessarily made in the second year of growth (1972) to permit preparations for the reseeded project to be conducted in 1973. However, evaluations of the trial plots and of the reseeded efforts in both 1973 and 1974 were continued. Altogether, about 74 hectares were fertilized and reseeded.

Results

The recommended grasses continued to be among the superior performers in the trial plots. These grasses generally attained leaf heights of from 25 to 40 cm with 50 percent to 90 percent coverage along the row in 1974. First year growth (1973) on the reseeded disturbances was short, generally not exceeding 6 to 10 cm by the perennials. Annual ryegrass grew taller. However, good stands were obtained in almost all areas reseeded, including coarse gravelly sites in gravel pits. The individual plants in the stands appeared healthy near the end of the first growing season.

The plants, achieving much more vigorous growth in their second season, produced culms that often grew from 50 to 65 cm high. Leaf heights ranged from about 10 to 30 cm. Ground coverage in most areas was 70 to 90 percent. On small areas that had been skipped in the fertilizing process the plants generally produced less than 8 cm in leaf height and 20 percent coverage. Culm production was greatly reduced.

A fungal growth, believed to be a species of slime mold, was observed on the new plantings during the 1974 evaluation. It was not detected on any of the native vegetation stands adjacent to the plantings.

In summary, revegetation trials commenced on Amchitka in 1971 culminated in the successful seeding of selected disturbed areas in 1973. Two commercial varieties of red fescue - highlight chewings fescue and Boreal creeping fescue - and the native Bering hairgrass were seeded as perennials in a mix with annual ryegrass. The perennials were conspecific with taxa occurring on the Island.

The recommended grasses continued as superior performers in the trial plots through four seasons of growth. The reseeded areas developed excellent stands of vigorously growing plants in their second season of growth (1974).

Hydrology

History of the Study

Hydrologic investigations have been conducted annually since July, 1965. Participants in the study at various times were the U. S. Geological Survey (USGS), Isotopes, Inc. (II), and the Desert Research Institute of the University of Nevada (DRI). W. C. Ballance (USGS) was the hydrologist in charge of the Fall, 1974 hydrology study.

The studies prior to 1974 were designed to generally define Island hydrology and to precisely define the hydrology of specific site locations. This enabled Dr. Paul Fenske, DRI, to prepare predictions of radionuclide migration in groundwater for the Milrow and Cannikin events. These predictions indicated that the tests could be conducted safely from a hydrologic standpoint.

Milrow produced hydrologic changes that were related to chimney infill, such as the change in stream flow of Clevenger Creek. Most hydrological conditions returning to normal within 1 year indicates that groundwater levels had returned to pretest conditions and the Milrow chimney had filled. Cannikin produced much more severe and longer lasting effects, especially in the drainage area surrounding Cannikin SZ, where a 31-foot-deep lake was formed and stream flow in White Alice Creek was drastically reduced during the filling of Cannikin Lake (see Gonzalez et al, 1974). Surfacewater and groundwater records as of August, 1974 indicate that hydrologic conditions have almost (at least 90 percent) returned to pre-Cannikin levels.

Objectives of the Fall, 1974 Research

The primary objective of the current field study was: To collect data on groundwater and surfacewater so that comparisons between these data and previously acquired data would provide evaluation of the long-term hydrologic effects of Cannikin.

Results

Twelve groundwater and surfacewater recorders were left in operation in August, 1973. Only one recorder failure had occurred prior to their removal during the current field trip. Waterlevel measurements were made during August, 1974 in drillholes, located near Site C, Site D, Site E, Long Shot, White Alice Creek near Site C, and in the vicinity of the Main Camp; stream-flow measurements were made at all gauging sites located on Bridge Creek, White Alice Creek, Clevenger Creek, Limpet Creek, Falls Creek, and Constantine Spring.

All stream-flow data collected during 1974 will be published during 1975 by the USGS in "Water Resources Data for Alaska". All water chemistry data will be published in a USGS 474 series report.

The continuous recording equipment was removed from the streams and drillholes during this field trip.

Limnology

History of the Study

Limnology investigations on Amchitka have been conducted since August, 1967, when they were initiated by D. D. Koob of OSU. T. J. Birch succeeded Koob as principal investigator in July, 1970 and was followed by the current principal investigator, R. Burkett, in January, 1973. Initial investigations were designed to classify and describe the lakes of Amchitka, but recent research has been directed toward detecting and measuring the effects of AEC activities, including nuclear testing and drilling-mud spills. Eight reports on these studies have been published.

Milrow produced several noticeable changes, partly draining two lakes and reducing zooplankton abundance in one lake about 3.5 km from SZ. As predicted, the larger Cannikin nuclear explosion produced more severe effects such as completely draining four lakes and partially draining two; forming a new impoundment, Cannikin Lake, in the subsidence crater; and breaching a sump wall by drilling mud (at D-site) which flowed into Falls Creek. Most of these effects will be noticeable for a long time period.

Objectives of the Fall, 1974 Research

The specific objectives of the Spring and Fall, 1974, field missions were:

1. To continue the assessment of the environmental effects of AEC operations, including nuclear testing, site preparation, and rollup activities, on selected lakes and streams
2. To continue the characterization studies for Cannikin Lake.

Observations and Comments

Data acquired during the Spring and Fall, 1974, sampling missions are presented in Tables 1 through 3; results of primary productivity determinations are reported within the text. Locations of study sites are shown in Figure 2. Water levels were low in all of the lakes, ponds, and streams observed during the Spring field work, but had resumed typical levels by fall. Physical, chemical, and biological data obtained from study stations in lakes and streams indicate that no substantive or unusual fluctuations in these parameters have occurred since the Fall, 1973 expedition.

FIGURE 2. MILROW AND CANNIKIN STUDY LAKES AND STREAMS

TABLE 1. CHEMICAL PARAMETERS OF AMCHITKA LAKES AND STREAMS, SPRING AND FALL, 1974

Station (a)	Date	pH	Alkalinity, mg/l CaCO ₃	Total Hardness, mg/l	Chloride, mg/l	Specific Conductance, ² micromhos/cm
1a	5-24	8.12	26.0	29.0	48.0	275
	8-27	7.20	30.0	19.0	32.3	200
28	5-25	6.43	20.0	23.0	38.8	218
	8-27	6.60	22.0	27.0	30.3	190
31b	5-22	6.30	16.5	25.0	46.8	205
	8-27	6.70	21.0	20.0	26.0	160
43b	5-22	5.80	1.0	11.0	30.3	118
	8-27	6.82	1.0	10.0	25.8	118
43c	5-22	6.20	14.5	22.0	35.5	160
	8-30	6.45	18.0	21.0	29.3	155
43d	5-22	5.68	1.0	11.0	31.8	122
	8-30	5.62	0.5	8.0	25.0	110
44a	5-25	6.23	15.5	24.0	33.0	180
	8-30	6.38	15.0	20.0	23.0	132
50a	5-22	6.02	15.0	23.0	35.0	188
	8-30	6.75	18.5	23.0	28.0	158
51	5-22	6.35	11.0	18.0	34.8	190
	8-30	6.40	8.5	16.0	28.8	150
Cannikin	5-26	7.50	61.8	29.0	97.3	538
	8-29	7.56	62.0	25.0	91.0	520
14-Mile Lake	5-22	6.98	08.5	45.0	38.8	300
	8-30	7.37	61.5	35.0	39.0	300
Falls Cr.	5-25	6.28	26.5	30.0	36.8	218
	8-28	6.32	26.0	33.0	31.3	195
Clevenger Cr.	5-25	7.02	48.5	23.0	52.0	320
	8-27	7.20	86.0	26.0	45.0	340
Bridge Cr.	5-25	6.31	18.0	23.0	36.0	205
	8-28	7.72	23.5	24.0	23.5	150

(a) See Figure 2 for location on Amchitka.

TABLE 2. ZOOPLANKTON POPULATION CONCENTRATIONS OF AMCHITKA LAKES, SPRING AND FALL, 1974

(Organisms/Liter)

Lake (a)	Date	Rotifers	Rotifer Eggs	Cladocerans	Copepods	Nauplii	Total
1a	5-24	922	228	-	-	-	1150
	8-27	346	8	68	-	3	425
28	5-25	428	138	-	-	10	576
	8-27	138	8	10	3	3	162
31b	5-22	21	10	-	-	8	39
	8-27	8	-	-	5	5	18
43b	5-22	8	-	8	18	5	39
	8-27	26	10	5	13	3	57
43c	5-22	122	58	-	5	28	213
	8-30	137	-	13	13	5	168
43d	5-22	3	3	8	10	10	34
	8-30	132	15	80	10	5	242
44a	5-25	29	5	3	13	5	55
	8-30	31	-	13	15	75	134
50a	5-22	59	23	-	15	10	107
	8-30	21	-	8	8	3	40
51	5-22	8	5	-	-	3	16
	8-30	-	3	-	3	18	24
Cannikin	5-26	371	140	3	28	250	792
	8-29	1106	73	385	30	30	1624

(a) See Figure 2 for location on Amchitka.

TABLE 3. ROTIFER POPULATIONS OF AMCHITKA LAKES, SPRING AND FALL, 1974

(Organisms/Liter)

Lake (a)	Date	<i>Keratella cochlearis</i>	<i>Keratella quadrata</i>	<i>Polysphara</i>	<i>Asplanchna</i>	<i>Synchaeta</i>	<i>Filinia</i>	Other Species	Percent of Total Zooplankton
1a	5-24	3	490	10	3	45	368	3	80
	8-27	5	53	-	-	-	288	-	81
28	5-25	50	325	50	3	-	-	-	75
	8-27	5	15	118	-	-	-	-	85
31b	5-22	-	8	-	3	-	10	-	54
	8-27	3	-	-	-	5	-	-	44
43b	5-22	8	-	-	-	-	-	-	20
	8-27	3	18	5	-	-	-	-	46
43c	5-22	23	-	55	3	18	10	13	57
	8-30	18	-	3	108	3	5	-	82
43d	5-22	3	-	-	-	-	-	-	9
	8-30	13	3	-	23	85	-	8	55
44a	5-22	-	15	-	-	8	-	3	53
	8-30	-	5	3	20	-	3	-	23
50a	5-22	-	3	43	10	-	3	-	55
	8-30	3	3	-	3	10	-	-	53
51	5-22	-	-	-	-	-	3	5	50
	8-30	-	-	-	-	-	-	-	0
Cannikin	5-26	18	145	208	-	-	-	-	47
	8-29	608	-	-	-	-	498	-	68

(a) See Figure 2 for location on Amchitka.

The conditions of Emerald Lake (Lake 51) and 14-Mile Lake remain unchanged. Emerald Lake has not recovered from the impairment induced by drill-mud input, 14-Mile Lake is a sterile, water-mud sump. Oil was released from bottom sediment upon walking in Lake 50a. Input of oil to this lake was undetected previous to the Spring, 1974, field trip (Kirkwood, 1974). Actually, the ground area adjacent to Lake 50a was the former site of a drill-mud pumping station and oil was spilled in conjunction with its operation.* The amount of oil which drained into this lake appears to have been small, and resultant impacts were slight and only short-term. Water clarity in Lake 50a is not impaired, and floral and faunal components common to Amchitka's lakes and ponds are present.

* C. E. Abegglen. U.S. Fish and Wildlife Service, personal communication.

Lake la continues to receive an inflow of nutrient-enriched water from the sewage ponds, although the inflow has been considerably reduced with evacuation of the Island. Nevertheless, this lake is expected to remain very productive, relatively, for some time. Primary productivity was measured on water samples from Lake la to determine whether the nutrient supply in the lake is decreasing. The carbon fixation rate by phytoplankton during Spring and Fall, 1974 was 3.40 and 5.20 $\text{mgC m}^{-3} \text{ hr}^{-1}$, respectively. The primary productivity rate during Spring, 1972 in Lake la was 119.7 $\text{mgC m}^{-3} \text{ hr}^{-1}$. The difference between the productivity in 1972 and that in 1974 may be due, at least in part, to a reduction in the nutrient input to the lake. Zooplankton abundance remains much greater in Lake la than in other lakes. Moreover, growth and production of periphyton is greater in Lake la than in most other lakes on Amchitka.

Cannikin Lake during Spring, 1974, was approximately 50 cm lower than earlier levels but had attained normal level by autumn. Input of humates to the lake from solubilization of the inundated peat mat has imparted a brown color to the water. However, even with the addition of humates and humic acids, the pH has remained stable. Thermal stratification has not been observed in Cannikin Lake, although some departure from isothermal conditions might exist on especially calm, sunny days - albeit rare weather for Amchitka Island.

Phytoplankton primary productivity in Cannikin Lake tends to be low during spring and higher during fall. The average of four determinations of carbon fixation rate during both Spring and Fall, 1974, was 0.80 and 1.14 $\text{mgC m}^{-3} \text{ hr}^{-1}$, respectively. Results of productivity experiments conducted during 1973 support this Spring-Fall trend: 0.28 and 8.88 $\text{mgC m}^{-3} \text{ hr}^{-1}$ in Spring and Fall, respectively (Burkett, 1974). Within-season variation between 1973 and 1974 data is probably due to differences in weather conditions at the times of sampling.

Zooplankton abundance in Cannikin Lake follows the trend exhibited by phytoplankton. Rotifers, especially *Keratella cochlearis* and *K. quadrata*, are more abundant during fall than they are in spring. The same applies for Cladocera. Few cladocerans were present prior to Fall, 1974, when 385 per liter were recorded. Plankton community development in Cannikin Lake appears to be progressing in a manner similar to what Hobbie (1973) has suggested for Arctic waters. Hobbie states that primary productivity in Arctic waters affects plankton community composition such that as a lake progresses from extremely oligotrophic conditions toward the eutrophic end of the spectrum, more food (energy) becomes available, allowing greater niche diversity. The scheme suggests that the order of increasing diversity is: phytoplankton, rotifers, copepods, and cladocerans. When Cannikin Lake was first sampled during Spring, 1973, primary productivity was very low and zooplankters were rare. Subsequent sampling during late Summer, 1973 revealed that primary productivity had increased about 20-fold, rotifers were very abundant, copepods were numerous, and a few cladocerans were present (Burkett, 1974). Recent field work indicates that cladocerans are now numerous in Cannikin Lake. Moreover, periphyton, mostly the filamentous alga, *Mougeotia* is now abundant along the shoreline along with a variety of diatoms. The facultative aquatic vascular plant, *Equisetum arvense*, was also found growing near the shoreline. Neither periphyton on natural substrates nor aquatic macrophytes had been observed previously in Cannikin Lake.

Drill-mud wastes, leaking from the sumps at D-site and flowing into Falls Creek, are imparting a cloudy appearance to the water. The release is of greater magnitude now than in the Fall, 1973 although physicochemical characteristics of the water in Falls Creek do not reflect this. The dikes at D-site are in very poor condition and they are very likely to breach and subject Falls Creek to another major drill-mud spill.

Clevenger Creek is in good condition. Aquatic macrophytes are abundant there and fish were observed. The road across the lower reach of Clevenger Creek is eroding badly around the culvert. This is releasing sediment and carbonates to that stream portion below the road. Road collapse might eventually result in channel disruption at this location.

Freshwater Fishes and Invertebrates

History of the Study

Freshwater ecology investigations have been conducted annually under the direction of principal investigators, J. M. Neuhold and W. T. Helm of USU, since 1967. During these investigations, all salmon spawning streams (21) and numerous lake systems have been studied. Ten publications have resulted from this study.

Objectives of the Fall, 1974 Research

Ten days were spent on Amchitka in Fall, 1974 to:

1. Enumerate adult pink salmon in streams previously used as spawning sites on Amchitka
2. Enumerate populations of Dolly Varden and benthic macroinvertebrates in Clevenger Creek and integrate these data into recovery trends of the aquatic community since mud spills in 1969
3. Survey the distribution and condition of Dolly Varden in Cannikin Lake and White Alice Creek
4. Aid and supplement collection of aquatic fauna for radiological analyses by LRE.

The following report is an account of these activities, results of the work, and an integration of this information with that collected in past years.

Salmon Spawning Surveys

Methods. Twenty Amchitka streams were visited over a 10-day period to evaluate spawning of adult pink salmon, *Oncorhynchus gorbuscha*, on the Island. This marked the fifth consecutive year that these streams were surveyed. The surveys of 1970, 1971, and 1972 were conducted with helicopter support, but no helicopter was available in 1973 or 1974 and access to all of these streams was by walking or "snow trac".

Although walking to each stream could not possibly yield as thorough a survey (in terms of frequency of visits) as with a helicopter, the 1974 survey was conducted at a time when records showed peak numbers of spawners--August 20 to 31.

Since adult pink salmon on Amchitka have rarely been found more than about 500 m upstream from any stream outlet, survey efforts were concentrated in the lowermost areas of each stream. Two men conducted most of the surveys. In streams with dense vegetation and numerous overhanging banks, one man waded in the stream, poking into undercut areas and deep pools, while the second counted the startled fish. In more open streams, both men walked on the stream banks and counted. Attempts to distinguish fishes' sex proved futile.

Samples of pink salmon were taken with long-handled landing nets or a 20-foot seine. Each fish collected was measured (total and postorbital length), weighed, and its stage of maturity noted as ripe or spent (males) and gravid or spawned-out (females). Some gravid females were sacrificed to determine egg carriage, and spawned-out females were examined to determine egg retention. Samples of gravid females were restricted because only a few adults could be sacrificed in any one stream without drastically reducing the egg stock.

The final estimate of adults in each stream was determined from the actual number of fish counted plus a number of individuals believed to have been missed on the count. Efficiency of the survey varied with each stream depending upon the extent of overhanging banks, streamside vegetation, water level, and density of fish.

Results. Number of Spawners. A total of 263 spawning pink salmon was estimated for the 20 streams surveyed on Amchitka during 1974 (Table 4 and Figure 3). Insignificant numbers may have ascended other streams not visited, but past surveys show that of 30 accessible streams, these 20 received the highest use as spawning sites.

TABLE 4. ESTIMATES OF ADULT PINK SALMON IN AMCHITKA STREAMS

Stream	Estimates by Year ^(a)				
	1970	1971	1972	1973	1974
Roller Coaster	10	0	10	0	10 ^(b)
Clevenger Creek	12	0	12	0	13
Duck Cove	6	0	0	0	0
Silver Salmon	30	0	0	0	0 ^(c)
Clevenger Lake	25	0	0	0	0 ^(c)
Bridge Creek	15	0	0	0	4
Ultra	12	0	2	-	0
BR	10	0	0	-	0 ^(d)
Teal Creek	6	0	10	-	2 ^(d)
Limpet Creek	6	0	15	-	10
356-115	6	0	0	-	0
Chapel Cove	50	0	15	0	5
270-205	5	0	7	0	- ^(e)
Midden Cove	300	80	600	4	175 ^(e)
Burr House - south	20	0	0	-	5
Burr House - north	30	5	12	-	5
Fumarole Cove	35	15	35	1	20
White House	6	0	5	-	0
Top Side	60	0	20	0	10
224-165	5	0	0	-	2
Signal Cove	25	0	0	-	2
Totals	674	100	743	5	263

(a) Zero indicates the stream was visited but no salmon encountered. Dash indicates that the stream was not visited.

(b) Counts by Ray Brechbill and Ian Mercier.

(c) One pink salmon caught intertidally by angler, Clyde Fancher.

(d) Final count by James Kirkwood on August 30.

(e) Final count by Ray Brechbill and Clyde Fancher on September 5

As in past years, Midden Cove Stream supported the greatest number of spawners. Except for Roller Coaster Stream, the major runs were primarily into the streams of the highlands of the Island: Limpet Creek, Chapel Cove Stream, Burr House Cove Stream, Fumarole Cove Stream, and Top Side Stream.

Distribution of Spawners. Nearly all streams surveyed were approached afoot, intercepted upstream, and surveyed from the point where they were intercepted to their outlets. This often constituted over 500 m of stream and in all streams but Midden Cove Stream, the adult pink salmon were encountered in the lowermost 100 m of stream, near the outlet. Adults in Midden Cove Stream were seen up to about 700 m from the stream outlet.* In 1970, when the number of adults returning to this stream was greater, they were encountered up to 1,800 m upstream from the outlet.

No evidence of intertidal spawning was noted this year in any stream deltas, although small schools of fish were seen off Clevenger Lake outlet and Midden Cove Stream.

* Telephone communication with Ray Brechbill, USAEC, NVOO, September 18, 1974.

FIGURE 3. LOCATIONS OF SALMON STREAMS AND OTHER STUDY SITES NEAR THE MILROW AND CANNIKIN TEST SITES

Redd Sites. The preference for spawning sites in 1974 was similar to that recorded in 1970 and 1972 (Helm and Valdez, 1973); redds were located at the downstream end of pools where the percolation of water through the gravel was apparently greatest.

Water Temperatures. Water temperatures in streams in late August, 1974 varied from 7 to 9 degrees C. The higher temperatures were recorded in streams draining toward the Pacific Ocean; this phenomenon was perhaps a function of a predominant wind or rainfall direction during the survey, but no difference was noted in spawning activity. A similar range in water temperature was recorded in past years during spawning.

Lengths and Weights. A total of 26 adult pink salmon was measured and weighed in the field in 1974. Only the 23 in prespawning condition were used to determine mean lengths and weights shown in Table 5. Although the mean length of males was greater than that of females, mean weight of the females was higher (in neither case was the difference significant at $\sigma = 0.05$).

Since sample sizes of adult pink salmon, used for measurements of length and weight, are small, little significant interpretation can be offered to explain annual variation in mean sizes. The adults samples in 1974 were the longest (535 mm) and the heaviest (1,357 g) of any samples in the 5 years surveyed.

It appears that males tend to be larger than females on the even years (1970, 1972, 1974) and smaller on the odd year (1971). Maximum differences of only 33 mm in

TABLE 5. AVERAGE LENGTHS AND WEIGHTS OF ADULT PINK SALMON
(BEFORE SPAWNING) FROM AMCHITKA STREAMS

	Sample Size					Mean Total Length, mm					Mean Body Weight, g				
	1970	1971	1972	1973	1974	1970	1971	1972	1973	1974	1970	1971	1972	1973	1974
Males	12	48	35	0	11	528	511	529	-	542	1446	1273	1420	--	1267
Females	10	37	29	1	12	484	515	510	532	528	1147	1345	1304	1513	1465
All Fish	22	85	64	1	23	502	513	520	532	535	1312	1304	1325	1513	1357

total length (502 in 1970 and 535 in 1974) and 53 g in body weight (1,304 in 1971 and 1,357 in 1974) was noted for the 5 years of salmon survey on Amchitka.

Egg Count and Retention. Five gravid females were sacrificed for estimates of egg carriage. The low numbers of adults found in any one stream prevented additional sampling for fear of drastically reducing the egg stock. As in past years, the number of eggs in both gonads was estimated volumetrically. A mean of 1,820 eggs was computed for the five females sacrificed in 1974 (Table 6). Total egg counts for these ranged from 1,591 to 2,163.

TABLE 6. EGG COUNTS AND POSTSPAWNING RETENTION FOR ADULT
PINK SALMON FROM AMCHITKA STREAMS

Year	Sample Size	Egg Count		Sample Size	Egg Retention	
		Mean	Range		Mean	Range
1970	10	3,333	1,875-4,000	12	25	0-186
1971	5	2,000	1,750-2,157	6	13	4- 29
1972	8	1,699	1,441-1,927	5	16	0- 45
1973	0	--	--	0	--	--
1974	5	1,820	1,591-2,163	1	24	24

As with the data on lengths and weights, the sample size is too small to make realistic inferences or conclusions from these estimates. However, these estimated mean and range figures coincide closely to those of 1971 and 1972. The 1970 mean of 3,333 eggs per female, which is believed to be too high for Amchitka pink salmon, probably resulted from an error in measuring technique. Females were not taken in 1973 for these estimates. It can be certain, however, that the expected egg count of adult pink salmon on Amchitka is less than 2,000 and more nearly about 1,800 eggs per female (mean of the three means).

Only one spawned-out female was examined for egg retention in 1974 (Table 6). This fish still carried 24 eggs after spawning. In past years, retention has varied from 0 to 186 eggs per female with means of 25, 13, and 16. Based on the three means, egg retention of spawned-out pink salmon on Amchitka is expected to be about 20 eggs per female.

Interpretation. Spawning of pink salmon in Amchitka streams is cyclic; the return of adult spawners is greatest in even years. Since pink salmon have a 2-year life cycle, the runs of even years are related, as are those of the odd years.

Trends in Total Returns. With the similar density of returning adults between 1970 and 1972, 674 and 743, respectively, a comparable return was expected in 1974. However, only 263 adults were estimated in the 20 streams surveyed.

If the related returns, 1970 to 1972 and 1972 to 1974, are examined for each stream, the lower return of adults becomes apparent. Of the ten streams with major runs (15 or more fish) in 1970, the runs into only two (Midden Cove Stream and Fumarole Cove Stream) either increased or remained the same in 1972. The runs into the other eight streams decreased by at least 60 percent in each. Survey methods these two years were nearly identical; at least two men visited each stream at nearly identical frequencies with the aid of a helicopter from the time that the adults first ascended until spawning was completed.

When the returns of 1972 and 1974 were similarly compared, those of all five streams with 15 or more fish showed reductions of 33 percent or more. The run into the major stream, Midden Cove, was down by 71 percent (600 to 175). Survey methods these two years were different - a helicopter was used in 1972 but not in 1974 - and could account for some of this variation. However, although the streams were reached by walking in 1974, it was felt that the spawning ground surveys were conducted during the peak of the run into each stream.

Comparing the odd years, 1971 and 1973, in a similar manner, reductions of 93 to 95 percent were noted in runs of the two streams (Midden Cove and Fumarole Cove) with major runs (15 or more fish). Only the 1971 surveys were conducted by helicopter in a manner similar to surveys of 1970 and 1972, while the 1973 surveys were conducted during a 1-week period.

As a whole, runs into all ten major Amchitka streams between 1970 and 1974 were down by 42 to 100 percent. No increase was seen in any major runs of pink salmon between the first and fifth years surveyed.

Man's Influence. Some of this reduction can be directly attributed to man's activities on Amchitka. The outlet of Clevenger Lake, for example, was rechanneled for a boat launch into St. Makarius Bay, while viable eggs were in the stream (Neuhold, Helm, and Valdez, 1971).

A second stream, Clevenger Creek, received mud spills in June, 1969, which may have reduced the run from previous years to 12 fish, but the salmon continue to use the stream since its recovery from the effects of the spills.

Spawning in Clevenger Creek, Silver Salmon Stream, and Bridge Creek was also likely affected by siltation from road construction and maintenance. Silt loads in these streams, however, have not been quantified.

One important factor that was not quantified but which could have had a major impact on the salmon runs in several Amchitka streams, involves the harvesting of the adults by Island occupants. Not only did some Island inhabitants use conventional sport fishing tackle to capture fish near the mouths of several spawning streams but other residents, during the earlier years of the current nuclear testing program, had to be reminded that it was illegal to take spawning salmon by hand and with clubs. The number of fish taken, especially by the latter methods, was not determined; but, since the spawning runs involved only a few fish (generally less than 100 in each stream), the impact could have been severe, virtually eliminating runs to some streams.

Conversely, some of man's activities may have benefited some of the salmon runs. The small gravel deposits associated with roads across Clevenger Creek and Bridge Creek appear to provide desirable spawning areas for both pink salmon and Dolly Varden; the culverts of these roads provide escape cover.

Since the reduction in runs of pink salmon on Amchitka was observed Islandwide, the possible effects of the Milrow and Cannikin detonations should be considered. The Milrow detonation of October, 1969, was the smaller of the two devices (Merritt, 1970), and it had little effect on fish populations even close to SZ. Unfortunately, no thorough surveys of pink salmon were conducted prior to Milrow, but it is assumed that the eggs of the 1969 run (which returned as adults in 1971) were in gravel redds for about 1 month before the test. Field experiments with pink salmon eggs in egg holders during Cannikin indicated that the larger detonation failed to have significant detrimental effects on salmon eggs. During Milrow, fish of the 1968 year class (which returned in 1970 as adults), were about a year old and feeding at sea. The movements of pink salmon from Amchitka while at sea are unknown, but it is unlikely that they were close enough to be affected by the October detonation. Since these salmonids are physostomes (possess a pneumatic duct between the air bladder and the esophagus) it is highly unlikely that moderate pressure pulses produced by the detonation affected them.

Milrow probably had no effect on the salmon runs except for those fish in Clevenger Creek, which were affected by pretest mud spills (Neuhold, Helm, and Valdez, 1971).

Cannikin in November, 1971, occurred when the eggs of that year's run had been in the gravel about 2 months and were nearly hatched (the peak of spawning occurred about September). Incubation of pink salmon eggs on Amchitka requires about 80 days. Holding-pen experiments with eyed pink salmon eggs during Cannikin revealed no ill effects on survival, hatching success, and fry morphology. At the same time, the year old salmon of the 1970 year class were at sea and likely far enough from Amchitka to be unaffected by pressure pulses. Many Dolly Varden, *Salvelinus malma*, were in streams, ponds, and in the intertidal zone during the detonation, but none were found to be affected by pressure pulses.

None of the reduction in returning salmon, except those mentioned previously, can be directly related to activities of either Milrow or Cannikin.

Other Phenomena. The runs of pink salmon into Amchitka streams are small. These are likely a function of stream size (volume flow and stream length), accessibility (as restricted by volume or natural gravel dikes) as well as restricted gravel areas. Intertidal spawning, if it exists at Amchitka, is also highly restricted by few available gravel deltas at stream outlets. Great variations in numbers might be expected with subtle changes in stream flow and outlet configuration. This phenomenon of variable density of fish in related years can also be attributed to the level of success from egg to escapement and subsequent return to the streams. Even low numbers of mortalities in these small runs at any of these stages can result in a large percentage of reduction in a run.

In all years surveyed, particularly those with largest runs, the numerous bald eagles of Amchitka (both mature and immature) have been observed to congregate at stream outlets. Unfortunately, most of the salmon taken by these large raptors were in pre-spawning condition; adults which were ascending streams over shallow outlet deltas. Evidence of at least five adult pink salmon (3 females with eggs) taken by eagles was found at Top Side Stream in 1974. Several birds were so gorged as to be incapable of flight.

A number of pink salmon from Amchitka might also be taken by a high seas salmon fisheries. Depending on the schooling patterns of the fish, this could greatly reduce the run in any or all streams of Amchitka.

An additional consideration is weather patterns. The majority of pink salmon runs of the Alaskan mainland experienced a downward trend in 1971, 1972, and 1973 (Seibel, 1973). One of the principal reasons for this decrease was the unusually low estuarine temperatures during the winters of 1970-71 and 1971-72. The effects of these temperatures were observed at Kodiak Island and may have extended as far west as Amchitka.

Cannikin Lake Studies

A 125-foot-long experimental gill net (5 frames of 1/2, 1, 1-1/2, 2, and 2-1/2 inch square mesh) set for 24 hours in Cannikin Lake yielded 23 Dolly Varden ranging from 164 to 256-mm standard length (S.L.) (average = 208). The net was fished as a midwater set, located about 30 m from the lake's outlet. A similar set a year before yielded only four Dolly Varden between 125 and 138 mm S.L. (average = 133); (2 nets were set, but all four fish were taken in one).

The differences between 1973 and 1974 catches, both in numbers of fish caught and in their lengths, are striking! The apparent annual increase in length was substantially greater than anticipated, on the basis of prior knowledge of Dolly Varden growth rates. Thus, some other factors had to be sought to explain the large standard lengths observed in the 1974 catch. One explanation could be the introduction described below coupled with a substantial growth rate.

A long-time resident with the work forces on Amchitka related that these fish might be from introductions by local fishermen in the summer of 1973.* He reported at least seven such introductions of fish into Cannikin Lake, each consisting of from "five to fifteen Dollys". The source of Dolly Varden in most introductions was either Fox Runway Lake or Jones Lake; waters with large populations of anadromous Dolly Varden. Between 50 and 100 Dolly Varden may have been introduced into Cannikin Lake in this manner.

Cannikin Lake is landlocked and supports remnants of populations which survived the Cannikin detonation. The response of introduced anadromous Dolly Varden in Cannikin Lake is uncertain. These individuals will likely remain in the lake or White Alice Creek and should attain a larger size than the landlocked forms because of genetic differences. However, it is tempting to speculate that these anadromous individuals will attempt to descend to sea. Since Cannikin Lake drains into White Alice Creek, which spills into the Bering Sea over a sea cliff about 10 m high, these fish could be lost from the drainage entirely.

It is difficult to determine if all or some of these 23 fish captured were introduced into the lake. Annual rings on otoliths of these fish failed to reveal any information that could be used to determine their origin (Figure 4).

The contents of the stomachs of the 23 fish revealed an overwhelming abundance of midge larvae and pupae (Figure 5). Only the species *Chironomus riparius* and *C. plumosus* were represented, but an average of 355 larvae of the former were found per fish (range of 11 to 936 per fish). Also encountered were ostracods, snails, and a few miscellaneous beetles, water mites, and even lupine seeds.

The four Dolly Varden captured the previous year had also fed extensively on immature midges, but at a much lower intensity per fish. The predominant organism of the diet of the four fish caught in 1973 was annelids. This demonstrates the progression of the benthic fauna in Cannikin Lake as the flooded tundra decayed and made detritus available to greater densities of incoming immature insects. No samples of the lake bottom were taken, since the decaying tundra kept the jaws of the Ekman dredge sampler from closing.

* Clyde Fancher, Amchitka, Alaska, August, 1974.

FIGURE 4. AGES, AS INDICATED FROM ANNULI OF OTOLITHS, OF 23 DOLLY VARDEN CAPTURED IN CANNIKIN LAKE AUGUST, 1974

FIGURE 5. DIET OF 23 DOLLY VARDEN FROM CANNIKIN LAKE

The introduction of Dolly Varden into Cannikin Lake was an unfortunate incident. The response of landlocked Dolly Varden to an enlarged habitat was an important aspect of the postevent biological studies that was ruined by well-meaning sportsmen. Nevertheless, further credence is given to the belief that the Dolly Varden populations found today in many ponds not accessible to anadromous fish via streams were introduced by past Amchitka residents, very likely members of World War II occupation forces.

White Alice Creek Studies

White Alice Creek received the first toxic spills of drilling mud from the Cannikin emplacement site in July, 1968. Fish and invertebrate populations were decimated and their repopulation was hindered by a continuing series of spills of drilling mud and supernatant fluid (Neuhold, Helm, and Valdez, 1971).

A remnant of the Dolly Varden population and some invertebrates were encountered near the stream outlet in Summer, 1970. It was also known that a remnant of the landlocked Dolly Varden population inhabited the stream branch above the spill points. The latter is believed to be one of the principal sources of repopulation into Cannikin Lake, which now floods a large area of the basin through which White Alice Creek once flowed. Additional fish probably gained access to both the stream and lake from ponds in the watershed drained or tilted by Cannikin (Helm and Valdez, 1973).

Electrofishing in White Alice Creek in August, 1973, yielded 9 Dolly Varden from two 100-m sections of the stream below Cannikin Lake. Similar attempts in August, 1974, in 100-m sections of the stream yielded 8 Dolly Varden and 4 others were seen. The fish captured in 1973 ranged from 96 to 202 mm S.L. (average = 120 mm), while those of 1974 ranged from 111 to 261 mm S.L. (average = 201 mm). This represents an annual gain in length of about 60 percent which is almost twice as large as the largest annual gain presented in prior reports. Mean weights for the two years were 38 g and 162 g, respectively.

As with the Cannikin Lake sample, the average size of the fish in the 1974 samples was greater than during previous years. Again, it is assumed that significant growth of resident fish occurred, but some of the anadromous Dolly Varden introduced into Cannikin Lake undoubtedly found their way into White Alice Creek and contributed to the unexpectedly high apparent growth rate observed between 1973 and 1974.

Clevenger Creek Fish Populations Studies

The density of Dolly Varden in Clevenger Creek was estimated by multiple capture methods of Zippin (1958). These estimates were conducted periodically before and after the decimating mud spills of 1969.

The density of this population, since the abatement of these spills, has increased. This most recent estimate (1,464 fish for the 1,850 m of stream) shows a substantial increase of Dolly Varden in Clevenger Creek (Figure 6) compared to all post-spill estimates--and even compared to the prespill maximum of 1,136 juvenile fish.

FIGURE 6. DENSITY OF JUVENILE DOLLY VARDEN IN CLEVANGER CREEK BEFORE AND AFTER MUD SPILLS

FIGURE 7. LENGTH-FREQUENCY HISTOGRAM FOR 339 DOLLY VARDEN FROM CLEVANGER CREEK, AUGUST 24 - 27, 1974

All of the Dolly Varden captured during this visit were immature fish, and an abundance of Age Groups I, II, and III fish was noted (Figure 7). The Age Group 0 fish were not frequently encountered. The relative strengths of the 1971 year class (Age Group III), 1972 year class (Age Group II), and the 1973 year class (Age Group I) are evident, the second and third appearing to be the strongest. The low numbers of Age Group 0 fish can be attributed to low recruitment to the brood stock as a result of the 1969 mud spills. Much of the brood stock, being ocean residents at the time of these spills, for the most part, escaped their effects, but the immature fish, soon to be recruited as brood stock, were decimated. Subsequent to the spills, the only brood stock available was the rapidly diminishing population of fish which matured before 1969. At best, these fish returned to spawn for 4 years. The next strong recruitment to the brood stock will occur Spring of 1975 when these Age Group III fish mature. Many are thought to have descended to sea before the August, 1974 surveys were made.

The abundance of the Age Group III fish will boost the population of young Dolly Varden in Clevenger Creek for the following years. However, when it comes time for the now Age Group 0 and I fish to mature, their numbers will be low, resulting in a second decline in egg production. (The first resulted directly from the mud spills.) This should be partly counterbalanced by egg deposition from older, larger, and more fecund brood fish.

The population of Dolly Varden in Clevenger Creek is expected to fluctuate considerably for a number of years because of this brood stock recruitment phenomenon and

fluctuating food supply (specifically invertebrate populations). Except for these fluctuations in density, this fish population has practically recovered from the effects of the mud spills.

The population of pink salmon in Clevenger Creek is discussed in a previous section of this report.

Clevenger Creek Invertebrate Population Studies

Dynamic changes in the standing crop of benthic macroinvertebrates were seen in the August collection, when compared with previous postspill samples (Table 7). Estimated density of seven types of invertebrates encountered was 3,593 individuals per m². Three types - limnophilid caddisflies, sphaerid clams, and isopods - were not found, but three smaller leptocerid caddisflies - *Hyallala*, amphipods, and simuliids - were evident. Although the diversity of species remained similar, the different organisms found in later sampling may indicate subtle ecological changes after abatement of mud spills.

The estimated density of mayflies in August, 1974 is higher than any previous post-spill estimates, and is comparable to that before the spills. This species is a key indicator organism because of its stringent requirements for clean flowing water and high oxygen concentration.

Individuals of the species *Chironomus riparius*, becoming very numerous after abatement of the mud spills, appeared to occupy niches vacated by other species. Recovery of all invertebrate populations in Clevenger Creek, together with increased predation by increasing numbers of Dolly Varden, appear to have moderated the high density of this species.

Like the population of Dolly Varden, the benthic macroinvertebrates in Clevenger Creek were affected by the prior mud spills. Ecological relationships that were involved included: inter- and intraspecific competition, predation, and habitat modification. The harmonious reestablishment of these and other relationships will mark total recovery of the aquatic community in Clevenger Creek.

Intertidal Marine Ecology

History of the Study

The intertidal algal and invertebrate communities of Amchitka have been under investigation since 1967 as a part of the marine ecology research program conducted by the Fisheries Research Institute (FRI), University of Washington. R. L. Burgner and R. Nakatani have been the principal investigators throughout the investigation.

The Cannikin detonation uplifted the intertidal benches in a localized area on the Bering Sea coast adjacent to SZ a maximum of 1.1 meters. The original algal and associated invertebrate communities have disappeared and are being replaced by others adapted to the new and still shifting environmental conditions on the bench topography (Kirkwood and Fuller, 1972; Merritt, 1973; Lebednik, 1973; and Nakatani and Burgner, 1974).

Recovery of the affected region has been studied with periodic, systematic sampling of specific study site plots established in the uplifted region before and after Cannikin. Monitoring of some control areas in the intertidal uplifted area resulting from the Milrow test, and of experimental recolonization areas, provides a base for comparison of the biological recovery of the uplifted intertidal bench.

Comparing the results of previous surveys with the results obtained during the low-tide series from May 21 to 28, 1974 (30 months post-Cannikin) shows that the colonizing algal and invertebrate communities in many uplifted areas are stabilizing, but that formation

TABLE 7. DENSITIES OF MACROINVERTEBRATES IN CLEVINGER CREEK BEFORE AND AFTER MUD SPILLS

Time and Event	Organism ^(a) , per m ²										Totals
	1	2	3	4	5	6	7	8	9	10	
1968											
Jan.-First Spill											
July	4,687	68	102	3	986	16	432	0	0	0	6,295
1969											
May-June-Major Spill											
June 29	0	0	0	0	0	0	0	0	0	0	0
July 29	13	14	0	0	0	0	0	0	0	0	27
Aug. 26	0	0	0	0	0	0	0	0	0	0	0
Sept. 15	54	0	0	0	0	0	0	0	0	0	54
Oct. 2--Milrow											
Oct. 3	44	0	0	0	118	0	0	0	0	0	162
Dec. 18	4	1	0	0	82	0	0	0	0	0	87
1970											
April 10	58	1	0	0	132	0	0	0	0	0	181
June 17	1,120	1	51	0	8	0	0	0	0	0	1,180
July 23	898	1	63	1	106	26	2	0	0	0	1,096
Aug. 21	1,395	2	12	0	99	0	0	0	0	0	1,507
Sept. 29	1,426	6	1	0	105	16	1	0	0	0	1,554
Nov. 19	590	4	0	0	86	12	0	0	0	0	693
1971											
Jan. 28	96	1	0	0	54	0	0	0	0	0	151
March 20	136	0	29	0	25	0	0	0	0	0	190
June 10	349	1	38	0	81	0	64	0	0	0	533
July 31	4,523	3	43	1	1,214	0	691	0	0	0	6,475
Aug. 19	5,203	17	63	0	986	0	589	0	0	0	6,858
Sept. 9	5,386	19	0	0	669	0	510	0	0	0	6,584
Oct. 23	2,653	1	0	52	122	4	11	0	0	0	2,843
Nov. 6--Cannikin											
Dec. 12	892	1	0	0	282	16	70	0	0	0	1,261
1974											
Aug. 28	3,214	27	145	0	91	0	0	110	3	3	3,593

(a) Codes for organisms:

1 = <i>Chironomus riparius</i>	6 = Sphaeridae
2 = <i>Chironomus</i> sp. and <i>Hydrobaenus</i> sp.	7 = <i>Gnorimosphaeroma lutea</i>
3 = <i>Pseudocloeon</i> sp.	8 = Leptocaridae
4 = Limnophilidae	9 = <i>Hyalbola</i> sp.
5 = Oligochaeta	10 = Simuliidae

of permanent communities is inhibited in other bench areas where the bench is unstable. It is estimated that in some areas the bench surface was eroded by as much as 1 to 2.5 cm in about 2 years' time.

The current surveys were conducted during the August 27-30, 1974 low-tide series. The results presented below reflect the combined observations and trends of both the Spring and Summer, 1974 trips.

Objectives of the Fall, 1974 Research

The objectives of investigations on August 27-30 were to continue quantitative assessment of the recovery of biotic communities on and adjacent to the uplifted intertidal benches in the area of Cannikin SZ on the Bering Sea coast. The assessment involved counts and photographic estimates of algae and invertebrate abundances, estimates of bench surface erosion, and documentation of successional stages attained by experimentally manipulated recolonization study sites in areas unaffected by Cannikin.

Methods

Sampling Procedures. One-quarter meter square quadrats on the Bering Sea intertidal bench in the vicinity of Cannikin SZ (designated areas IA-2 and IA-3) that were established in 1970 and immediately preceding Cannikin in 1971 have been sampled bi-monthly since the Cannikin test through August, 1972 and at least at yearly intervals thereafter (Nakatani and Burgner, 1974).

Direct counts of individual invertebrates and estimates of algal cover by species were made *in situ* during the low tidal period. The study plots were photographed to provide documentation and transparencies for later measurement of actual algal cover and indications of erosion.

Other studies included observations and documentation of the (1) invertebrate populations on Cannikin-uplifted intertidal benches at Banjo Point, (2) status of algal recolonization on experimentally manipulated intertidal areas at Duck Cove, Rifle Range Point, and St. Makarius Bay, (3) estimation of total area of bench between and including Banjo Point and IA-2 which was uplifted above the intertidal zone by Cannikin, and (4) establishment of permanent bench markers to measure rate of erosion.

In August, 1974 only half of the existing eulittoral (formerly sublittoral fringe) plots and none of the sublittoral fringe (formerly subtidal) plots were sampled for invertebrates because the low tides were not low enough to permit sampling [see Lebednik, Weinmann, and Norris (1971), and O'Clair and Chew (1971) for definition of littoral zones characterizing Amchitka's rock benches]. Algal cover documentation of the IA-2 and IA-3 bench plots was completed except for the sublittoral fringe plots. Sampling of the recolonization plots of St. Makarius Bay was also only partially completed due to the unfavorable tidal state.

Results

Estimation of the Uplifted Bering Sea Bench. By superimposing 94 plane geometric figures between Banjo Point and Sand Beach Cove on the bench configuration, it was estimated conservatively while in the field that the total area of intertidal bench uplifted above the intertidal zone by Cannikin was 57.6 hectares. This estimate included neither unreachable islets nor uplifted bench area to the east of Banjo Point or west of Sand Beach Cove, but did include the total bench between these points where the uplift was estimated to range between 45 cm and 1.1 meters.

Invertebrate Communities. The survey of IA-2 plots (Figures 8 and 9) showed significant changes in composition of invertebrate populations between August, 1973 and May to August, 1974 (Table 8). The number of species (species richness) has increased

FIGURE 8. IA-2 BENCH PLOTS 1-10 AND 26-30, SUPERIMPOSED ON 25m UTM (U.S. ARMY) GRID, INDICATING BENCH MARGINS

FIGURE 9. IA-2 BENCH PLOTS 11-25 AND 32-36, SUPERIMPOSED ON 25m UTM GRID (U.S. ARMY) INDICATING BENCH MARGINS

Lower portion of each figure is shoreward region of bench. Solid squares represent sublittoral fringe, open squares eulittoral, and solid circles supralittoral zone study plots sampled on the post-Cannikin bench.

from a mean of 27 species in August, 1973 to 31 species per plot in May, 1974 on originally subtidal plots now in the sublittoral fringe zone. This increase is a response, in part, to the increased siltation observed on the uplifted bench. Since pretest species richness averaged 20 to 23 species per plot, the growth of established species populations is expected to decline to a lower level on the unstable benches. Succession of colonizing species toward stabilization on Amchitka's recently uplifted benches seem to agree with other recolonizing situations investigated in Island biogeography studies (Simberloff and Wilson, 1969, 1970).

Eulittoral plots, formerly in the sublittoral fringe region, show a leveling off in species richness to a mean of 13 species per plot, an increase from 8 species per plot found in April, 1973. These areas are also inundated by silt to depths of 0.5 to 2.0 cm in many areas and siltation (a Cannikin-induced phenomenon) may be a natural controlling factor effecting species richness in these bench invertebrate communities.

Plots presently characterizing supralittoral fringe regions (originally the upper eulittoral regions) show little change from the earlier mean of zero to one species per plot to two to three species per plot and they are expected to maintain the same level of species richness or decrease to the former level. Seasonally occurring supralittoral insects and the artificially created habitat of drift kelp captured by the plot markers allowed an unnatural increase in species richness.

Communities located in plots at IA-3 (Figure 10) are comparable in richness and composition to those in IA-2 (Table 9). All formerly upper eulittoral plots are now located in the supralittoral fringe region except for one formerly sublittoral plot which now is upper eulittoral. This has a well-established invertebrate and algal community, 3 years after the Cannikin uplift. Species richness on that plot has increased from six to ten species since August, 1973. Other eulittoral bench areas with less tidal exposure might experience long recolonization periods before reaching stability. Well-established invertebrate populations and algae communities on the Banjo Point bench indicate later stages of colonization than those noted at IA-2 and IA-3. This is presumed to be related to the lesser uplift at Banjo Point compared with that at IA-2 and IA-3 benches.

TABLE 8. STATUS OF ALGAL RECOLONIZATION OF IA-2 BENCH PLOTS, MAY-AUGUST, 1974

Plot	Date Established	Uplift Displacement, cm	Dominant Algae Community (a)		Dominant Invertebrate Assemblage (a)		Status
			Former	Present	Former	Present	
<u>Changed From Subtidal to Sublittoral Fringe Zone</u>							
28	February 1972	+94 9	<i>Laminaria yezoensis</i>	<i>Laminaria longipes</i>	<i>Strongylocentrotus</i> , <i>Aomaea</i> sp <i>Margarites</i> , <i>Musculus</i> , <i>Ascidacea</i> sp	<i>Strongylocentrotus</i> , <i>Margarites</i> , <i>Actiniidae</i> , <i>Musculus</i> , <i>Mitrella</i> , <i>Cucumaria</i> , <i>Parallorches</i> (May 1974) (b)	Canopy algae and invertebrate communities stabilizing, understory becoming established
32	December 1971	+97 2	<i>Laminaria yezoensis</i>	<i>Alaria crispa</i>	<i>Actiniidae</i> , <i>Aomaea</i> sp , <i>Strongylocentrotus</i> , <i>Musculus</i> , <i>Ascidacea</i> (February 1972)	<i>Balcis</i> , <i>Styela</i> , <i>Musculus</i> , <i>Aomaea</i> sp., <i>Mitrella</i> , <i>Margarites</i> , <i>Ascidacea</i> , <i>Leptasterias</i> , <i>Actinaria</i> (May 1974) (b)	Ditto
35	February 1972	+78 9	<i>Alaria</i> f. <i>stulosa</i> <i>Laminaria groenlandica</i>	<i>Laminaria longipes</i>	<i>Actiniidae</i> , <i>Strongylocentrotus</i> , <i>Hiatella</i> , <i>Parallorches</i> , <i>Ascidacea</i>	<i>Hiatella</i> , <i>Mitrella</i> , <i>Actiniidae</i> , <i>Margarites</i> , <i>Leptasterias</i> , <i>Henricia sanguinolenta</i> , <i>Strongylocentrotus</i> (May 1974) (b)	"
36	February 1972	+78 9	<i>Alaria</i> f. <i>stulosa</i> - <i>Laminaria groenlandica</i>	<i>Alaria crispa</i>	<i>Strongylocentrotus</i> , <i>Actiniidae</i> , <i>Parallorches</i> , <i>Hiatella</i> , <i>Ascidacea</i>	<i>Margarites</i> , <i>Strongylocentrotus</i> , <i>Mitrella</i> , <i>Ophiopholis</i> , <i>Parallorches</i> , <i>Aomaea</i> sp , <i>Leptasterias</i> , <i>Henricia sanguinolenta</i> (May 1974)	"
<u>Changed From Sublittoral Fringe to Eulittoral (Upper) Zone</u>							
29	February 1972	+97 6	New surface (upper vertical)	<i>Halosaccorhynchus rhodomenia</i> var. <i>rata</i>	<i>Littorina aleutica</i> , <i>Littorina atkana</i>	<i>Littorina</i> spp , <i>Acarina</i> , <i>Gammaridea</i> , <i>Collisella strigatella</i> , <i>Collisella pelta</i> , <i>Liparochelone</i> , <i>Balanus glandula</i> , <i>Idotea</i>	Interactive successional period for invertebrate and algae communities
30	February 1972	+97 6	New surface (lower vertical)	<i>Halosaccorhynchus rhodomenia</i> var. <i>rata</i>	<i>Gammaridea</i> , <i>Littorina aleutica</i> , <i>Littorina atkana</i>	<i>Littorina</i> spp , <i>Halosaccorhynchus strigatella</i> , <i>Collisella pelta</i> , <i>Acarina</i> , <i>Liparochelone</i> , <i>Gammaridea</i> , <i>Idotea</i> (May 1974) (b)	Ditto
31	February 1972	+97 6	New surface (horizontal)	<i>Halosaccorhynchus rhodomenia</i> var. <i>rata</i>	<i>Littorina aleutica</i> , <i>Balanus glandula</i> (May 1974) (b)	<i>Littorina aleutica</i> , <i>Balanus glandula</i> (May 1974) (b)	

TABLE 8. (Continued)

Plot	Date Established	Uplift Displacement, cm	Dominant Algae Community(a)		Dominant Invertebrate Assemblage(a)		Status
			Former	Present	Former	Present	
<u>Changed From Sublittoral Fringe (Back Bench) to Eulittoral (Lower) Zone</u>							
33	February 1972	+78.9	<i>Laminaria longipes</i>	<i>Fucus distichus</i> <i>porphyra</i> spp.	<i>Halichondria</i> , Actiniidae, <i>Musculus</i> , <i>Margarites</i> , <i>Hiatella</i> , <i>Strongylocentrotus</i>	<i>Idotea</i> , <i>Mytilus</i> , <i>Cingula</i> spp., <i>Margarites</i> , <i>Halocoma</i> , <i>Turtonia</i> , <i>Paralorchestes</i> , Ascidacea, <i>Littorina</i> spp., <i>Exosphaeroma</i>	Interactive successional period for invertebrate and algae communities (Heavily silted)
<u>Changed From Sublittoral Fringe (Midbench) to Eulittoral (Upper) Zone</u>							
34	February 1972	+78.9	<i>Thalassiophyllum clathrus</i>	<i>Alaria craspada</i> , <i>Fucus distichus</i>	Actiniidae, <i>Hiatella</i> , <i>Strongylocentrotus</i> , <i>Bonellioopsis</i>	<i>Paralorchestes</i> , <i>Acmaea</i> sp., <i>Turtonia</i> , <i>Idotea</i> , <i>Strongylocentrotus</i> , <i>Halocoma</i> , <i>Mytilus</i> , Ascidacea	Interactive successional periods for invertebrate and algae communities
<u>Changed From Sublittoral Fringe (Midbench) to Supralittoral Fringe Zone</u>							
12	August 1970	+93.0	<i>Laminaria longipes</i>	(<i>Fucus distichus</i>)	<i>Halichondria</i> , Actiniidae, <i>Henricia</i> , <i>Lepidochitona</i> , <i>Musculus</i> , <i>Notoacmea</i> scutum, <i>Mitrella</i> , <i>Alvania</i> , <i>Styela</i>	<i>Littorina</i> spp., Diptera, Acarina, Collembola	No recolonization by other than ephemeral algae and invertebrate species; instable substrate
17	August 1970	+84.1	<i>Laminaria longipes</i>	(<i>Porphyra</i> spp.)	Actiniidae, <i>Lepidochitona</i> , <i>Notoacmea</i> , <i>Buccinum</i> , <i>Mitrella</i> , <i>Leptasterias</i> , <i>Strongylocentrotus</i>	Diptera, Acarina, Collembola, <i>Littorina aleutica</i> , Gammaridea	Ditto
25	August 1970	+87.8	<i>Laminaria longipes</i>	--	<i>Halichondria</i> , Actiniidae, <i>Lepidochitona</i> , <i>Notoacmea</i> , <i>Mitrella</i> , <i>Leptasterias</i>	Diptera, Acarina Collembola, <i>Littorina sitkana</i>	No recolonization by other than ephemeral algae and invertebrate species; instable substrate (Highly eroded)
27	December 1971	+94.9	<i>Laminaria longipes</i>	(<i>Halosaccion glandiforme</i>)	<i>Lepidochitona</i> , <i>Leptasterias</i> , <i>Cucumaria</i> , <i>Littorina aleutica</i> , <i>Hiatella</i> (February 1972)	Diptera, Acarina, Collembola, <i>Balanus glandula</i> , Gammaridea	No recolonization by other than ephemeral algae and invertebrate species; instable substrate
<u>Changed From Eulittoral to Supralittoral Fringe Zone</u>							
1	August 1970	+110.0	<i>Ulva</i> (sand)	--	<i>Littorina sitkana</i> , <i>Halocoma</i> , <i>Idotea</i> , <i>Exosphaeroma</i>	Acarina	Ditto
2	August 1970	+100.7	<i>Fucus distichus</i>	--	<i>Littorina</i> spp., <i>Halocoma</i> , <i>Thais</i> , <i>Siphonaria</i> , <i>Idotea</i> , <i>Exosphaeroma</i>	No animals	"
3	August 1970	+99.6	<i>Littorina</i> (sand)	--	<i>Littorina sitkana</i>	Acarina	"

TABLE 8. (Continued)

Plot	Date Established	Uplift Displacement, cm	Dominant Algae Community (a)		Dominant Invertebrate Assemblage (a)		Status
			Former	Present	Former	Present	
Changed From Eulittoral to Supralittoral Fringe Zone (Continued)							
4	August 1970	+97.8	<i>Alaria crispata</i> - <i>Fucus distichus</i> - <i>Halosaccion glandiforme</i>	<i>Cladophora</i> sp.	<i>Littorina</i> spp., <i>Halocanchoa</i> , <i>Thais</i> , <i>Siphonaria</i> , <i>Idotea</i> , <i>Exosphaeroma</i>	No animals	No recolonization by other than ephemeral algae and invertebrate species; instable substrate (Highly eroded)
5	August 1970	+94.9	<i>Halosaccion glandiforme</i> - <i>Fucus distichus</i>	(<i>Porphyra</i> spp.)	<i>Balanus glandula</i> , <i>Mytilus</i> , <i>Collisella strigatella</i> , <i>Littorina</i> spp.	Diptera	Ditto
6	August 1970	--	<i>Fucus distichus</i> - <i>Porphyra</i> spp.	Buried	<i>Collisella digitalis</i> , <i>Littorina</i> spp., <i>Halocanchoa</i> , <i>Siphonaria</i> , <i>Idotea</i>	Buried	"
7	August 1970	--	<i>Hedophyllum sessile</i>	Buried	<i>Halichondria</i> , <i>Actinidae</i> , <i>Buccinum</i> , <i>Mitrella</i> , <i>Cerithiopsis</i> , <i>Leptasterias</i>	Buried	"
8	August 1970	--	<i>Laminaria longipes</i>	Buried	<i>Halichondria</i> , <i>Actinidae</i> , <i>Margarites</i> , <i>Lepidochitona</i> , <i>Balcis</i> , <i>Leptasterias</i>	Buried	"
9	August 1970	+97.9	<i>Corallina pilulifera</i> - <i>Corallina juncovirens</i>	(<i>Halosaccion glandiforme</i>)	<i>Cucumaria</i> , <i>Littorina</i> spp., <i>Thais</i> , <i>Idotea</i> , <i>Exosphaeroma</i>	Diptera, Acarina Gammaridea	"
10	August 1970	+97.6	<i>Halosaccion glandiforme</i>	--	<i>Littorina</i> spp., Gammaridea	Gammaridea	"
11	August 1970	+97.1	<i>Halosaccion glandiforme</i>	--	<i>Balanus glandula</i> , <i>Mytilus</i> , <i>Collisella strigatella</i> , <i>Littorina</i> spp., <i>Siphonaria</i>	No animals	"
13	August 1970	+93.3	<i>Alaria crispata</i>	--	<i>Collisella pelta</i> , <i>Schizoplax</i> , <i>Lepidochitona</i> , <i>Buccinum</i> , <i>Littorina</i> spp., <i>Halocanchoa</i> , <i>Thais</i> , <i>Cucumaria</i> , <i>Henricia sanguinolenta</i>	Diptera	"
14	August 1970	+92.8	<i>Fucus distichus</i> - <i>Alaria crispata</i> - <i>Halosaccion glandiforme</i>	--	<i>Collisella strigatella</i> , <i>Littorina</i> spp., <i>Halocanchoa</i> , <i>Thais</i> , <i>Siphonaria</i> , <i>Idotea</i> , <i>Exosphaeroma</i>	No animals	"

TABLE 8. (Continued)

Plot	Established	Uplift Displacement, cm	Dominant Algae Community (a)		Dominant Invertebrate Assemblage (a)		Status
			Former	Present	Former	Present	
Changed From Eulittoral to Supralittoral Fringe Zone (Continued)							
15	August 1970	+90 6	<i>Iradaea cornu- copiae-Fucus distichus</i>	(<i>Halosaccion glandiforme</i>)	<i>Mytilus</i> , <i>Collisella strigatella</i> , <i>Littorina</i> spp., <i>Siphonaria</i>	Diptera	No recolonization by other than ephemeral algae and inverte- brate species, instable substrate (Highly eroded)
18	August 1970	+86 9	<i>Oclonthalia floccosa</i>	(<i>Halosaccion glandiforme</i>)	<i>Littorina</i> spp., <i>Halococoncha</i> , <i>Thais</i> , <i>Ido^ea</i> , <i>Exosphaeroma</i>	No animals	Ditto
19	August 1970	+89 6	<i>Halosaccion glandiforme</i>	(<i>Halosaccion glandiforme</i>)	<i>Littorina</i> spp., <i>Balanus glandula</i>	<i>Littorina atkana</i> , <i>Oligochaeta</i> sp , <i>Ligia</i>	"
20	August 1970	+90 4	<i>Alaria crispa- Halosaccion</i>	(<i>Porphyra</i> spp)	Actiniidae, <i>Balanus carosus</i> , <i>Lepido- chitina</i> , <i>Mytilus</i> , <i>Collisella pelta</i> , <i>Thais</i> , <i>Littorina</i> spp.	Gammaridea, <i>Ligia</i>	"
21	August 1970	--	<i>Hedophyllum sessile</i>	Buried	<i>Leptasterias</i> , <i>Cucumaria</i>	Buried	"
22	August 1970	+74 7	<i>Halosaccion glandiforme- Alaria crispa- Iradaea cornu-</i>	--	<i>Collisella striga- tella</i> , <i>Littorina spp.</i> , <i>halococoncha</i> , <i>Thais</i> , <i>Idotea</i>	<i>Ligia</i> , <i>Littorina atkana</i>	"
23	August 1970	+78 0	<i>Alaria crispa</i>	--	<i>Halichondria</i> , <i>Lepta- sterias</i> , <i>Collisella strigatella</i> , <i>Halo- concha</i> <i>Lepidochitona</i> , <i>Cucumaria</i>	No animals	"
24	August 1970	+78 9	<i>Corallina vancouverensis</i>	--	<i>Collisella strigatella</i> , <i>Actinaria</i> , <i>Thais</i> , <i>Littorina</i> spp , <i>Turtonia</i> , <i>Cingula</i> , <i>Idotea</i> , <i>Exosphaeroma</i>	<i>Littorina aleutica</i> , Gammaridea	"
26	December 1971	+94.9	<i>Alaria crispa</i>	(<i>Halosaccion glandiforme</i>)	<i>Halichondria</i> , <i>Phascol- soma</i> , <i>Turtonia</i> , <i>Cucu- maria</i> (February 1972)	<i>Littorina</i> spp , <i>Acarina</i> , Gammaridea	"

(a) Species in parentheses denote ephemeral occurrences or very low abundances, dates in parentheses denote the last (most recent) date of the period when the plot was sampled

(b) Plot could not be checked in August, 1974, because of tidal height

FIGURE 10. IA-3 BENCH PLOTS 1-15, SUPERIMPOSED ON 25m UTM (U.S. ARMY) GRID, INDICATING BENCH MARGINS

Lower portion of figure is shoreward region of bench. Solid squares represent sublittoral fringe, open squares eulittoral, and solid circles supralittoral zone study plots sampled on the post-Cannikin bench.

Algae Communities. Former subtidal plots on IA-2 which were permanently displaced into the sublittoral fringe region are stabilizing with the algal species characteristic of the new region (Figure 8 and Table 8). *Alaria crista* or *Laminaria longipes*, respectively, dominates the community depending whether the area uplifted occupies the upper or lower portion of sublittoral fringe region (Figure 8 and Table 8). These plots are beyond early succession and are now reaching the expected stable community. This later successional stage contains fewer species (one to two species) than earlier stages where "fugitive" species of algae (four to eleven species) occupied the plots.

Those plots lifted from the sublittoral fringe into the eulittoral region are stabilizing as communities comprised of relatively few species. The composition of these communities is characteristic of their respective vertical and benchflat position (Weinmann, 1969). New surfaces created along the face of the bench during the violent uplift (Plots 29, 30, 31) have become increasingly dominated by *Halosaccion* and *Rhodymenia*, the latter occupying the higher vertical surface. *Laminaria longipes*, *Thalasssiophyllum* and *Alaria*, and *Laminaria groenlandia* communities, respectively, have developed into *Porphyra-Fucus*, *Alaria-Fucus*, and *Alaria-Laminaria longipes* communities. Benchflat distance will determine the ultimate dominant alga within any one vertical zone. These plots, with decreasing species richness, do not yet possess the relative composition of stabilized communities. This is indicated by fluctuating abundances of ephemeral colonizers such as *Cladophora*, *Porphyra*, and *Rhodymenia*. The continuous siltation and erosion of different parts of this bench surface inhibit the rate of succession on these plots. While wave splash and frequent tidal immersion are apparently limiting erosion of some intertidal locations represented by these plots, in other locations, sedimentation from the adjacent cliff falls continues to prevent complete colonization by late successional ("climax") algae communities.

The plots uplifted from the eulittoral and high sublittoral fringe regions into the supralittoral fringe region have attained little recolonization other than temporal occurrences of diatoms and seasonal settling of pioneer annuals such as *Halosaccion* and *Porphyra*. These regions receive tidal inundation only during extreme high tides and severe storm periods, and thus do not have sufficient tidal submersion to sustain recolonization, even if spore recruitment could occur. In addition, erosion, siltation, and standing fresh-water occurring on the supralittoral bench are also inhibiting algal recolonization. Erosion of the rock matrix material in the volcanic breccia and of other intrusive material was observed to be severe in some bench areas; changes were discernible even between the May and August, 1974 surveys. This often resulted in the disappearance of algae between May and August, normally a period of rapid algal growth.

TABLE 9. STATUS OF ALGAL RECOLONIZATION OF IA-3 BENCH PLOTS, MAY-AUGUST, 1974

Plot	Date Established	Uplift Displacement, cm	Dominant algae community (a)		Dominant Invertebrate Assemblage (a)		Status
			Former	Present	Former	Present	
<u>Changed From Subtidal to Eulittoral (Upper) Zone</u>							
	August 1970	+54 2	<i>Laminaria longipes</i>	<i>Fucus distichus</i>	<i>Grantia</i> sp , <i>Halichondria</i> , <i>Actiniidae</i> , <i>Parallorchestes</i> , <i>Mitrella</i> , <i>Cucumaria</i> , <i>Leptasterias</i> , <i>Styela</i> (Sept 1971)	<i>Littorina</i> spp , <i>Idotea</i> , <i>Exosphaeroma</i> , <i>Turtonia</i> , <i>Gammaridea</i>	Stabilizing algae and invertebrate communities
<u>Changed From Eulittoral (Midbench) to Supralittoral Fringe Zone</u>							
2	August 1970	+52 4	<i>Hedophyllum sessile</i>	--	<i>Halichondria</i> , <i>Actinaria</i> , <i>Parallorchestes</i> , <i>Lepidochitona</i> , <i>Buccinum</i> , <i>Margarites</i> , <i>Mitrella</i> , <i>Cerithiopsis</i> , <i>Leptasterias</i> (Sept 1971)	<i>Littorina</i> spp , <i>Acarina</i> , <i>Ligia</i>	No recolonization by other than ephemeral algae and invertebrate species, instable substrate
7	August 1970	+47 4	<i>Hedophyllum sessile</i>	--	<i>Halichondria</i> , <i>Actinaria</i> , <i>Parallorchestes</i> , <i>Buccinum</i> , <i>Margarites</i> , <i>Mitrella</i> , <i>Leptasterias</i> , <i>Strongylocentrotus</i> , <i>Cucumaria</i>	<i>Littorina</i> spp , <i>Gammaridea</i> , <i>Haloonocha</i> , <i>Turtonia</i>	Ditto
<u>Changed From Eulittoral (Inner Bench Upper) to Supralittoral Fringe Zone</u>							
3	August 1970	+52 4	<i>Halosaccorion glandiforme</i>	--	<i>Littorina</i> spp , <i>Haloonocha</i> , <i>Thais</i> , <i>Exosphaeroma</i> , <i>Idotea</i> (Sept 1971)	<i>Diptera</i> , <i>Littorina sitkana</i>	
4	August 1970	+32 2	<i>Corallina vancouverensis</i> - <i>Clathromorphum</i>	(<i>Enteromorpha</i> sp)	<i>Actinaria</i> , <i>Nereis</i> , <i>Thais</i> , <i>Cucumaria</i> , <i>Cingula aleutica</i> , <i>Idotea</i> , <i>Exosphaeroma</i> (Sept 1971)	<i>Littorina</i> spp , <i>Gammaridea</i>	
5	August 1970	+56 4	<i>Fucus distichus</i>	Buried	<i>Collisella pelta</i> , <i>Littorina</i> spp , <i>Thais</i> , <i>Holoonocha</i> , <i>Siphonaria</i> , <i>Idotea</i> (Sept 1971)	Buried	
13	August 1970	+49 1	<i>Fucus distichus</i>	(<i>Cladophora</i>)	<i>Collisella pelta</i> , <i>Littorina</i> spp , <i>Thais</i> , <i>Haloonocha</i> , <i>Siphonaria</i> , <i>Idotea</i> (Sept 1971)	<i>Ligia</i> , <i>Orchestia</i> , <i>Littorina atkana</i> , <i>Annelida</i>	
14	August 1970	+50 1	<i>Halosaccorion glandiforme</i> <i>Ulva lactuca</i>	(<i>Cladophora</i>)	<i>Littorina</i> spp , <i>Haloonocha</i> , <i>Cingula aleutica</i> , <i>Thais</i> , <i>Idotea</i> (Sept 1971)	<i>Diptera</i> , <i>Littorina atkana</i> , <i>Oligochaeta</i> , <i>Gammaridea</i>	

TABLE 9. (Continued)

Plot	Date Established	Uplift Displacement, cm	Dominant algae community (a)		Dominant Invertebrate Assemblage (a)		Status
			Former	Present	Former	Present	
Changed From Eulittoral (Inner Bench Upper) to Supralittoral Fringe Zone (Continued)							
15	August 1970	+50.8	<i>Fucus distichus</i>	--	<i>Littorina</i> spp., <i>Haloonocha</i> , <i>Cingula aleutica</i> , <i>Thais</i> , <i>Cucumaria</i> , <i>Idotea</i> (Sept. 1971)	<i>Ligia</i> , Gammaridea	No recolonization by other than ephemeral algae and invertebrate species, instable substrate
Changed From Eulittoral (Outer Bench) to Supralittoral Fringe Zone							
6	August 1970	+47.9	<i>Alaria crispa</i> - <i>Corallina</i> <i>vancouverensis</i>	--	<i>Collisella strigatella</i> , <i>C. pelta</i> , <i>Littorina</i> spp., <i>Thais</i> , <i>Actinaria</i> , <i>Cucumaria</i>	<i>Littorina</i> spp., <i>Haloonocha</i>	Ditto
7	August 1970	+47.4	<i>Hedophyllum</i> <i>sessile</i>	--	<i>Halichondria</i> , <i>Actinaria</i> , <i>Parallorhynchus</i> , <i>Buccinum</i> , <i>Margarites</i> , <i>Mitrella</i> , <i>Lep-</i> <i>tasterias</i> , <i>Strongy-</i> <i>locentrotus</i> , <i>Cucumaria</i> , (Sept. 1971)	<i>Littorina</i> spp., Gammaridea, <i>Haloonocha</i> , <i>Turtonia</i>	"
8	August 1970	+47.7	<i>Alaria crispa</i> - <i>Corallina</i> <i>vancouverensis</i>	(<i>Fucus</i>)	<i>Littorina</i> spp., <i>Lepidochitona</i> , <i>Haloonocha</i> , <i>Cucumaria</i> , <i>Cingula aleutica</i> , Gammaridea, <i>Thais</i> , <i>Parallorhynchus</i>	<i>Littorina</i> spp., Gammaridea, <i>Haloonocha</i>	"
9	August 1970	+47.2	<i>Fucus distichus</i> - <i>Alaria crispa</i>	--	<i>Halichondria</i> , <i>Collisella</i> <i>strigatella</i> , <i>Collisella</i> <i>pelta</i> , <i>Littorina</i> spp., <i>Haloonocha</i> , <i>Siphonaria</i> , <i>Idotea</i> , Gammaridea, <i>Thais</i> , <i>Cucumaria</i>	<i>Littorina atkana</i> , <i>Ligia</i>	"
10	August 1970	+47.4	<i>Fucus distichus</i> - <i>Halosaccion</i> <i>glandiforme</i> - <i>Iridaea</i> <i>cornucopiae</i>	--	<i>Collisella strigatella</i> , <i>Littorina</i> spp., <i>Haloonocha</i> , <i>Thais</i> , <i>Idotea</i> , <i>Exosphaeroma</i>	<i>Littorina atkana</i>	"

(a) Species in parentheses denote ephemeral occurrences or very low abundances, dates in parentheses denote the last (most recent) date of the period when that plot was sampled

Plots at IA-3 indicate trends similar to comparable plots at IA-2 (Figure 10 and Table 9). The one upper eulittoral plot is becoming stabilized as a representative *Fucus* community. Only one genus tolerant of low salinity, *Enteromorpha*, persists in the standing water accumulated on the supralittoral shoreward bench.

Summary

The recolonization of uplifted intertidal bench by algal and invertebrate communities is advancing at rates governed by the present bench height, the stability of the bench substrate, and degree of exposure to wave splash and tidal immersion. More than 57 hectares of bench uplifted from subtidal or sublittoral fringe and eulittoral regions, respectively, have passed through a stage of high species richness which characterizes initial colonization and are now phasing into less diverse, but more stable communities. The composition of these communities generally characterize their existing vertical zone and benchflat position. As these communities continue to mature, introduction and replacement of some (fugitive) species by later successional species, more adapted to conditions in the stabilizing community will occur. In this manner, understory algal communities (e.g., *Corallina* and *Clathromorphum*) and associated invertebrates will become established once canopy communities (e.g., *Laminaria* and *Alaria*) have entered a stable successional stage.

Regions displaced into the supralittoral fringe region display limited recolonization due to the unstable, unpredictable character of the supralittoral bench environment, from continued introduction of sediment onto the bench (also seen to alter succession in eulittoral invertebrate communities), relatively rapid erosion of the bench surface (especially in areas uninfluenced by wave splash), and limited tidal immersion. It is estimated that three-fourths of the uplifted intertidal bench includes such supralittoral regions. This situation will not be altered until the upraised bench erodes to a level that allows tidal immersion. It is assumed that at that point the bench surface will begin to stabilize with the reduction in desiccation and freezing-thawing influences. Algal and invertebrate recruitment will then initiate more active recolonization than has been observed through August, 1974.

Radioactivity

The sampling programs conducted by LRE and USGS during the August-September, 1974 trip to Amchitka were identical, with minor exceptions, to the programs conducted during May, 1974, as reported in the Spring, 1974 Task Force Report (BMI-171-157) compiled by Kirkwood (1974). Therefore, the history and objectives of the radioactivity studies as stated in the Spring, 1974 Task Force Report are still relevant, and a synopsis of these topics, in addition to the results of the fall sampling is given below.

History of the Study

Although the underground nuclear detonations were designed to prevent radioactive contamination of the biota and surface environments of Amchitka, radiological surveillance and sampling programs have been conducted on and around Amchitka at intervals since the 1965 DOD underground nuclear test, Long Shot. The USGS on behalf of the AEC, initiated water sampling of wells, streams, and springs on Amchitka in 1965 to establish pre-nuclear explosion background levels of radioactivity. A long-term water-sampling network was initiated in 1967 to detect possible effects of nuclear testing on the Island. This network was expanded in 1971 to cover the drainage area surrounding the final nuclear explosion and to include offshore marine stations.

Prior to the August, 1974 collection period, the network stations were sampled by the USGS in September, November, and December, 1971; January, April, and October, 1972; August, 1973; and May, 1974. Annual reports on the radiochemical content of these water samples are published in the USGS-474 series available from the Department of Commerce, National Technical Information Service.

Radiological surveillance for the three detonations has been conducted by the following organizations: LRE, II, and USGS for Long Shot (1965); BCL, II, and USGS for Milrow (1969); LRE, II, and USGS for Cannikin (1971). The post-Cannikin surveys, including the August-September, 1974 surveys, were conducted by LRE and USGS. V. Nelson, LRE, and W. Ballance, USGS, were in charge of these studies during 1974. Earlier hydrologic sampling and related studies were under the leadership of Dr. P. R. Fenske at Isotopes, Inc. and the University of Nevada, Desert Research Institute.

In addition to the above, an on-site radiological safety program was performed by the Eberline Instrument Corporation during detonation and drillback operations.

Objectives of the Fall, 1974 Research

The objectives of the LRE program were as follows:

1. To collect and analyze biological and environmental samples from Amchitka and surrounding waters as part of the continuing program for periodic documentation of radionuclides, both naturally occurring and man-made.
2. To conduct a radiation survey of areas surveyed previously, including areas most likely to be contaminated if radionuclides escaped from underground test sites.

The objective of the USGS sampling program was:

1. To determine if man-made radionuclides are present in ground and surface samples from Amchitka.

Results

Laboratory of Radiation Ecology. During the August-September, 1974 field trip, about 75 biological and environmental samples were collected by LRE, with aid from FRI, UT, and FWS. These samples included water, fish, marine and freshwater algae, marine invertebrates, birds, terrestrial and freshwater vegetation, aufwuchs, rats, and an air sample. Areas sampled include Cannikin Lake, Jones Lake, DK-45 Lake, Long Shot Mud Pits, Sand Beach Cove, Duck Cove, Constantine Harbor, five streams in the drainage areas of the Cannikin, Milrow, and Long Shot SZ's, terrestrial sites near the three SZ's, and other miscellaneous locations. Most of these samples are being analyzed for gamma emitting radionuclides, and some also for ^3H , ^{55}Fe , and ^{90}Sr . Results of these analyses will be reported in the LRE "Amchitka Radiobiological Program Progress Report" for the period January to December, 1974.

A radiation survey was performed, using an Eberline survey meter (Model E-510) and two probes. Window thicknesses for the probes were either 30 mg/cm² or less than 7 mg/cm². Measurements were made in two ways: first, in order to compare the May and August, 1974 measurements, readings were taken for both periods with the beta shield closed on the probe with the 30 mg/cm² window; and, second, for greater sensitivity readings were taken with an unshielded probe with a window thickness of less than 7 mg/cm². Thirteen areas between Charlie Runway and E-Site were surveyed; locations and results

of these measurements are given in Table 10. These areas included the Long Shot, Milrow, and Cannikin SZ's and adjacent areas. The Cannikin drillback site and Sand Beach Cove were also surveyed. Maximum values recorded while holding the survey instrument 1 meter above the ground ranged from 0.02 mR/hr to 0.04 mR/hr, using the probe with the 30 mg/cm² window, covered by the beta shield, and from 0.03 to 0.05 mR/hr when using the probe without the beta shield and with the window of less than 7 mg/cm². Average levels at all sites were about 0.01 mR/hr or less. These values are similar to the values generally recorded in other areas of the United States.

USGS. On the basis of 3 years of negative results, AEC-NV00 reduced the number of sampling points to 16 that are located adjacent to the nuclear explosion sites and to the base camp. Water samples collected during August will be analyzed routinely for tritium, gross alpha, and gross beta/gamma content. It is expected that the reduced network will be sampled during each future scientific party visit.

TABLE 10. RADIATION SURVEY OF SELECTED SITES, AUGUST, 1974

Location	Radiation Level ^(a) , mR/hr			
	Maximum		Average	
	<7 mg/cm ²	30 mg/cm ² (b)	<7 mg/cm ²	30 mg/cm ² (b)
Decon Facility (Charlie Runway)	0.05	0.03	0.01	<0.01
Inside "D" Barracks (Main Camp)	0.04	0.03	0.01	<0.01
Husky Camp	0.04	0.03	<0.01	<0.01
Jones Creek Effluence	0.04	0.03	<0.01	<0.01
EIC Calibration Range	0.04	0.03	<0.01	<0.01
Rifle Range Target Area (Near Rifle Range Point)	0.04	0.03	0.01	<0.01
Duck Cove	0.03	0.02	<0.01	<0.01
Milrow SZ	0.04	0.03	0.01	<0.01
Northwest Side of Pad	0.04	0.03	0.01	<0.01
General Area	0.04	0.03	0.01	<0.01
Long Shot SZ	0.05	0.02	0.01	<0.01
Mud Pits	0.05	0.02	0.01	<0.01
Northwest Side of Pad	0.05	0.02	0.01	<0.01
General Area	0.05	0.02	0.01	<0.01
Cannikin SZ	0.04	0.04	0.01	<0.01
Northwest Side of Pad	0.04	0.04	0.01	<0.01
General Area	0.04	0.04	0.01	<0.01
Drillback Pad	0.05	0.03	0.01	<0.01
Sand Beach Cove	0.04	0.03	<0.01	<0.01
D-Site	0.05	0.04	0.01	<0.01
E-Site	0.03	0.03	<0.01	<0.01

(a) Eberline G-M detector, Model 510 was used.

(b) With beta shield closed.

SUMMARY

The most important consequences of the nuclear testing activities at Amchitka are described in numerous reports: for complete listing of the reports see Appendix E of BMI-171-147 (Kirkwood, 1972) and Appendix B of this report, BMI-171-158. The most recent evaluation of these effects, as made during the period August 26 through September 4, 1974, were as follows:

- Meadow areas inundated by the new Cannikin Lake have stabilized as lake bottom.
- Meadow areas that were flooded for relatively short periods (a few days) after the Cannikin detonation have recovered to their prior state.
- Meadow areas that were affected by oils and drilling muds, released by the Cannikin pressure pulses, are recovering slowly.
- Graminoid vegetation is becoming established on the organic substrates of the lake bottoms that were drained by the Cannikin test.
- Exposed mineral substrates show very slow establishment of vegetative cover. Complete vegetative cover for these areas is predicted to require centuries under present climatic conditions.
- Revegetation efforts using fertilizer (90/70/66 lb/acre of N/P/K, respectively) and grass (chewing fescue, Boreal creeping red fescue, Bering hairgrass, and rye grass) appear to be successful during the second year of growth.
- Cannikin Lake continues to undergo biological changes, as predicted.
- Exceptionally large Dolly Varden in Cannikin Lake resulted from introduced individuals coupled with good growth rates in the uncrowded environment.
- Phytoplankton primary productivity in Cannikin Lake continue to follow the trends of being lower during the Spring than during the Fall sampling periods. The productivity of Cannikin Lake is similar to that found in other similar lakes at Amchitka.
- Clevenger Creek has almost completely recovered from the earlier drilling mud spills. Ecological relationships such as predation and competition, are having an effect on invertebrate species, as during years prior to the release of drilling mud.
- The total number of pink salmon spawners in 1974 was estimated at only 263 versus 734 in 1972 and 674 in 1970. The reduced number is not believed to be related to the nuclear tests. Among the possible causes of this decline are: mud spills and siltation in a few spawning streams, predation by eagles, harvesting by Island residents, commercial fishing in the high seas, and weather conditions.
- Dolly Varden were larger than expected in White Alice Creek. This may be due to introductions (individuals introduced into Cannikin Lake can move into White Alice Creek) and a good growth rate, as noted for Cannikin Lake.

- Communities of algae and invertebrates are developing as expected in the intertidal portions of the uplifted bench on the Bering Sea side of Amchitka.
- Recolonization of the post-Cannikin supralittoral fringe region (uplifted by Cannikin from the eulittoral intertidal region) is progressing slowly. This is believed to be due to siltation, erosion, and limited tidal immersion.
- No radioactivity above the background level that could be attributed to nuclear testing at Amchitka was encountered by field radiation detectors.
- Samples of animals (birds, rats, fish, and invertebrates), plants (terrestrial, freshwater, and marine), and water (marine and freshwater) were returned to laboratories of LRE and USGS for radiochemical analyses. Results of these analyses will be reported later.

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APPENDIX A

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ORGANIZATIONS AND INDIVIDUALS PARTICIPATING IN THE FALL, 1974 FIELD STUDIES^(a)

Overall Planning and Coordination

Battelle Columbus Laboratories, W.F. Clapp Laboratories
Dr. J.B. Kirkwood (Project Scientist)
Mr. I.M. Mercier (Scientific Field Coordinator)

Liaison for U.S. Fish and Wildlife Service

U.S. Fish and Wildlife Service
Mr. C.E. Abegglen

Revegetation and Reseeding

University of Alaska
Dr. W.W. Mitchell (Principal Investigator^(b))
Mr. A. Mansfield

Plant Ecology

University of Tennessee
Dr. C.C. Amundsen (Principal Investigator)

Hydrology

U.S. Geological Survey
Mr. W.C. Ballance (Hydrologist in charge)
Mr. L.E. Wollitz

Limnology

Battelle Columbus Laboratories
Dr. R.D. Burkett (Principal Investigator)

Freshwater Vertebrate and Invertebrates

Utah State University
Dr. W.T. Helm^(b)
Mr. R.A. Valdez
Mr. P.E. Mongillo

Intertidal Marine Ecology

University of Washington, Fisheries Research Institute
Mr. C.E. O'Clair
Mr. C.A. Simenstad
Dr. O.A. Mathisen

Radioactivity

University of Washington, Laboratory of Radiation Ecology
Dr. V.A. Nelson
Mr. A. Johnson

U.S. Geological Survey
Mr. W.C. Ballance
Mr. L.E. Wollitz

(a) Drs. E.E.C. Clebsch, University of Tennessee, and I.L. Brisbin, AEC Headquarters, who conducted studies not included in this program, also provided technical assistance on several phases of the work.

(b) Was not a member of the Fall, 1974 task force.

APPENDIX B

APPENDIX B

Amchitka Bioenvironmental Publications Not Listed in
Appendix of BMI-171-147

A Bibliography of Amchitka Bioenvironmental Program related publications issued through May, 1972 was published as Appendix E in BMI-171-147, the Cannikin D+2 Months Report by Kirkwood and Fuller, June, 1972. Publications issued since that time are listed below.

Barr, Nancy 1973. Extension of the known range of the crab, *Cryptolithodes typicus* Brandt, to Amchitka Island (Decapoda, Anomura, Lthodidae). Crustaceana, Vol. 25, part 3.

Barr, Louis, Robert J. Ellis, and John H. Helle. 1973. Fossil tree stumps found *in situ* on submerged ridge at Amchitka Island, Alaska. Fishery Bulletin, Vol. 71, No. 4; pp 1099-1103.

Birch, T.J. 1973. Amchitka Bioenvironmental Program. Limnology on Amchitka Island, Alaska. Annual Progress Report. July 1, 1971 - June 30, 1972. Battelle, Columbus Laboratories, U.S. AEC Report, BMI-171-151. 38 p. and appendixes.

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Estes, J.A. and N.S. Smith. 1973. Amchitka Bioenvironmental Program. Research on the sea otter, Amchitka Island, Alaska. Final Report, October 1, 1970 - December 31, 1972. Arizona Cooperative Wildlife Research Unit, U.S. AEC Report, NVO-520-1. 68 p. and appendixes.

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Helm, W.T. and R.A. Valdez. 1973. Amchitka Bioenvironmental Program. Freshwater Vertebrate and Invertebrate Ecology of Amchitka Island. Annual Progress Report. July 1, 1971 - June 30, 1972. Battelle, Columbus Laboratories, U.S. AEC Report, BMI-171-148. 12 p.

Hollingsworth, R.E. 1971. Environmental Statement-Cannikin. U.S. AEC, June, 1971. 69 p. and comments from Federal and other agencies and AEC's responses.

Isakson, J.S. 1974. Biological Effects of Underground Nuclear Testing on Marine Organisms II. Observed Effects of Amchitka Island, Alaska, Tests on Marine Fauna. In Proceedings of the First Conference on Environmental Effects of Explosives and Explosions (May 30-31, 1973). Naval Ordnance Laboratory NOLTR 73-233. pp 98-106.

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- Nordmeyer, H.T. 1974. Population dynamics and migratory habits of *Salvelinus malma* (Walbaum) on Amchitka Island, Alaska. M.S. Thesis, Utah State University, Logan.
- Rausch, R.L. 1973. Post Mortem Findings in Some Marine Mammals and Birds Following the Cannikin Test on Amchitka Island. U.S. Public Health Service, Arctic Health Research Center, Fairbanks, Alaska. Prepared for U.S. AEC-NVOO. NVO-130. 68 p. and figures.
- Sherrod, S.K. 1974. Biology of bald eagles on Amchitka Island, Alaska. Unpublished M.S. Thesis, Brigham Young University, 70 p.
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- Williamson, F.S.L., C.M. White, and W.B. Emison, 1973. Amchitka Bioenvironmental Program. Studies on the Avifauna on Amchitka Island, Alaska. Final Program and Summary Report, August 14, 1967 - July 30, 1973. Battelle, Columbus Laboratories, U.S. AEC Report, BMI-171-155.
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