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AMCHITKA BIOENVIRONMENTAL PROGRAM

BIOENVIRONMENTAL SAFETY STUDIES, AMCHITKA ISLAND, ALASKA

SPRING, 1974 TASK FORCE REPORT

Compiled

by

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PREFACE

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

ABBREVIATIONS USED IN THE TEXT

ADF&G	Alaska Department of Fish and Game
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
D-day	November 6, 1971, the day Cannikin was detonated
FRI	University of Washington, Fisheries Research Institute, Seattle, Washington
FWS	United States Department of the Interior, Fish and Wildlife Service
LRE	University of Washington, College of Fisheries, Laboratory of Radiation Ecology, Seattle, Washington
NMFS	National Marine Fisheries Service, NOAA, U.S. Department of Commerce
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 Geological Survey
UT	University of Tennessee, Knoxville, Tennessee

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ABSTRACT

Since 1968, BCL and its subcontractors and consultants, and other contractors of AEC-NVOO have conducted bioenvironmental research designed to predict the effects of nuclear testing activities, recommend measures for minimizing adverse effects, and measure and evaluate the effects, both shortterm and longterm. This report presents the findings made by a scientific field party that visited Amchitka during the period May 21 through June 1, 1974.

Natural modification of rock falls and turf slides along the Bering Sea Coast are continuing as predicted, following both nuclear tests: Milrow and Cannikin. While estimating the changes that have occurred during the winter, since the last field trip to Amchitka, the estimates of total damage attributable to Cannikin were refined. The estimated volumes of these falls and slides are 30,000 m³ for the Bering Sea Coast and 5,000 m³ for the Pacific Ocean Coast. Natural disturbances, probably a recent earthquake, caused turf displacement and rock falls within about 20 km of Cannikin SZ.

Reproduction of birds appeared to be within the expected normal fluctuations. The numbers of falcons and eagles nesting were about the same as during prior years of this study; the number of young Peregrine Falcons was still depressed, probably due to weather conditions. A new cormorant colony, located at Banjo Point, probably was made possible because of the changes in habitat produced by Cannikin.

Cannikin Lake is undergoing natural biological changes, as expected. Zooplankton was more abundant than during the same season last year, copepods reproduced, and phytoplankton density was low. Dolly Varden captured with gill nets were in good condition.

Invertebrate colonization and algal community development is progressing well in the affected area along the Bering Sea Coast adjacent to Cannikin, except in some uplifted areas where there is no longer tidal wetting.

The subtidal study areas that were affected by Cannikin in the Bering Sea were again checked by Scuba divers. As these areas have now reverted to their pre-Cannikin state, additional Scuba observations are not planned.

The maximum total Island sea otter population count in May, 1974 is within the range of previous whole-Island counts, made under comparable conditions, both before and after Cannikin. The number of animals in Area "A" in the Bering Sea adjacent to Cannikin near the disrupted sea

cliffs is about 1/2 what it was immediately before Cannikin and has not changed detectably since 1972; the predicted return to the pretest level has not occurred.

A radiation survey, using an Eberline G-M detector, revealed that the maximum levels of radiation at 1 meter above the ground is similar to background levels in other areas of the United States. Samples of water and biota were collected for radionuclide analyses, also.

INTRODUCTION

In 1966, soon after it was decided that a series of underground nuclear weapons tests would be conducted at Amchitka Island, Alaska, Battelle was asked to plan and initiate a bioenvironmental research program designed to:

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

Certain ancillary studies, 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 with the AEC's assistance. The bioenvironmental effects of that test, described by Seymour and Nakatani (1967), provided useful information for the current study.

Two nuclear tests conducted during the current series were Milrow, a calibration test 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.

The current bioenvironmental field studies began in 1967, about 2 years prior to Milrow. Most of these studies were continued until 2 years after Cannikin, and all studies in which ecological changes are still evident are continuing: 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 Annual Meeting of AIBS, and numerous presentations have resulted from this research.

Some of the published reports that present the significant information concerning the bioenvironmental studies and the previously studied effects of the nuclear testing activities include: Estes and Smith, 1973; Held, 1971; Held, 1972; Held et al., 1973; Hollingsworth, 1971; Kirkwood, 1969; Kirkwood, 1970; Kirkwood, 1971; Kirkwood and Fuller, 1971; Kirkwood and Fuller, 1972; Merritt, 1970; Merritt, 1973; and Nelson and Seymour, 1974. Several other publications planned include a book that will bring together all of the important results of these studies.

Figure 1 indicates the locations of geographical features mentioned in this report.

This report summarizes the information obtained during a field study, extending from May 2 through June 1, 1974, about 2-1/2 years after Cannikin was detonated. This field study had the following objectives:

(1) Bioenvironmental Effects Studies

To detect, document and evaluate longterm bioenvironmental effects caused by AEC activities on Amchitka. These studies include:

- (a) Geomorphological measurements; effects on vegetation; recovery of streams and ponds from mud spills; biological colonization and development in the new Lake Cannikin; and recovery of intertidal habitats: BCL and its subcontractors.
- (b) Recovery of sea otters and raptor breeding success: FWS.
- (c) Effects on, and recovery of, subtidal habitats: NMFS.
- (d) 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 LRE carried the biological portion of the program; the USGS performed the hydrological portion.

SPRING 1974 FIELD STUDIES

Background

Twenty researchers were involved in various research studies during the spring field investigations; the AEC Project Manager, Mr. Raymond A. Brechbill, and his support staff of 16 persons and one helicopter provided logistic support. The organization employing each investigator, the name of each investigator, and the area of responsibility of each investigator is given in Appendix A.

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

Geomorphology

History of the Study

Geomorphic studies have been conducted annually by K. R. Everett, OSU, since January, 1968. These studies assessed the geomorphic forms and processes on the Island. Slope movements were measured from strain nets. The major soil types of the Island were described and their physical and chemical characteristics documented. A map depicting the major soils and soil associations was prepared for the entire Island. The shortterm effects of two nuclear tests on the Island's landforms and soils were measured. Four publications have resulted from the above studies.

The last of the AEC nuclear tests, Cannikin detonated in November, 1971, produced the most significant changes in landforms, especially along sea cliffs and headlands. These changes included large volume, individual and aggregate, rock and turf falls. During the first year following Cannikin, the affected cliffs and newly produced debris underwent little modification in form. Observation at the end of the second year following the event revealed considerable modification of the fallen materials. Blocks of rock, newly exposed cliff faces and the uplifted intertidal bench showed significant weathering and erosion and redistribution of the comminuted fragments into the surf and intertidal zone. These and other marked changes in the 1-year span indicate the necessity for relatively closely spaced observations and measurement intervals, not only to define trends but also to improve the precision of damage estimates and the accuracy of trend predictions. Therefore the following objectives were selected for the Spring, 1974 field trip.

Objectives of the Spring, 1974 Research

(1) To estimate the current weathering and erosion of the rock and soil materials that fell from sea cliffs and stacks.

(2) To document additional natural modifications to sea cliffs and headlands disturbed by the Milrow and Cannikin events.

(3) To describe the redistribution of weathered materials along the coasts and on the intertidal platforms.

(4) To evaluate changes produced by bedrock weathering and redistribution of organic soils on inland features, principally fault scarps produced by Cannikin.

(5) To re-evaluate the stability of reclaimed disturbed areas* especially at and around AEC drill site "D".

(6) To re-evaluate cliff fall volumes for Cannikin on the Bering Coast and Milrow on the Pacific Coast.

* Areas that were disturbed by AEC activities and later modified by leveling, terracing, and reseeded

Results

(1) Redistribution of the components of rock falls, newly exposed cliffs, and most turf slides has been slight since Cannikin (Appendix B, Figure B-1). With the exception of a small rock fall of 3-4m³ near Banjo Point, the principal changes have occurred on the cliffs northwest of Sand Beach Cove. Here blocks of turf and dune sand have become detached from near the cliff top and are sliding down the cliff face. On these same cliffs rapid physical disintegration of exposed volcanic ash beds has resulted in the detachment of blocks of more resistant bedrock. Both processes will continue for several years.

(2) Cannikin-exposed cliff faces and -derived rock falls are continuing to weather. Areas and fragments composed of abundant coarse and medium clasts and a coarse matrix weather rapidly to cobble and sand-size debris. Approximately 2.5 cm of material has been removed in some places. This material is redistributed on and within the rock fall and in many cases into the surf zone.

(3) Continued addition of weathering products from exposed cliff faces and turf or rock falls and turf slides has produced a nearly complete blanket of "fines" in some areas. Turf islands which have fallen or slipped onto the fine debris appear to be acting as nuclei from which plants, especially Elymus and to some extent Senecio, are colonizing outward (Appendix B, Figure B-2). The fine debris added to the rock falls is so highly permeable that sheet and rill wash are ineffective in its removal. These erosive processes are, however, removing and redistributing weathering products on the bedrock cliffs northwest of Sand Beach Cove and will contribute to their general instability for some time (Appendix B, Figure B-3).

(4) Wave erosion has significantly reduced many of the bulb-shaped sand and turf slides and redistributed their materials into the surf and intertidal zones and beyond (Appendix B, Figure B-4). Channelized run-off from chutes above many of these features has also contributed to their removal (Appendix B, Figure B-5).

(5) Mechanical and chemical weathering appears to have reduced the elevated intertidal platform near Sand Beach Cove by 1 to 2.5 cm, depending upon bedrock lithology.

(6) Lack of pre- and post-Cannikin oblique aerial photographic coverage of a segment of sea cliff facing the Pacific Ocean inhibited an accurate estimate of rock and turf fall produced by Cannikin. Refined estimates for minimum rock and turf fall for Cannikin are as follows: Bering Coast, 30,000 m³; Pacific Coast, 5,000 m³. A revised estimate for Milrow is a combined minimum for rock and turf falls of 6,900 m³.

(7) Most reclaimed areas, and in particular the AEC drill sites, appear to be trending toward stabilization, the exceptions are Drill Sites "E" and "F" where some channelized erosion continues on steep slopes, and Drill Site "D". At Drill Site "D", slump and channelized erosion on the outer face of the retaining walls of the mud pits together with severe wave erosion on their inside faces have nearly breached them.

(8) Very small rock and turf displacements along roads on Kirilof Point, as well as on the shore of Jones Lake and at the head of Constantine Harbor, suggest earthquake disturbance between September, 1973, and May, 1974. An apparently recent turf displacement at the head of St. Makarius Bay and a rock fall on the northwest side of

Kirilof Point may also be earthquake related. The most likely earthquake events were those of early November, 1973.

Plant Ecology

History of the Study

The plant-ecology studies have been conducted annually since June, 1967. E.E.C. Clebsch was succeeded as principal investigator in January of 1969 by C.C. Amundsen. Both investigators are in the Department of Botany of U.T. During these studies, a plant community 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 measured and the immediate effects of the two underground nuclear tests on the terrestrial plants were noted. Four publications have resulted from these studies.

The immediately detectable landform changes with potential for effects on plant communities were construction alterations and shock-induced changes. The shock resulted in turf eruptions, scarp formation and slumps along valleys and the nearby coastal areas of the Island, local pond drainage, and inundations of low lying terrain. Nearly all consequential landscape effects due to the shock were within 2,500 m of Cannikin SZ. To continue the assessment of longer term changes, the following objectives were outlined for study during the Spring of 1974.

Objectives of the Spring, 1974 Research

(1) To re-examine existing grids and plots, placed prior to the nuclear tests, to determine any plant community shifts caused by substrate movement or drainage changes since late Summer of 1973.

(2) To detect new or previously undetected disturbances to the vegetation.

(3) To collect other appropriate data to provide for up-to-date assessments and predictions of the continuing consequences of nuclear testing on the terrestrial vegetation.

Results

A comparison of data obtained during May, 1974, with previously acquired data, showed that nine of the line intercept transects showed one of two general trends occurring since Cannikin. In areas where the organic substrate was only lightly disturbed, the previously established plants which were not uprooted continued to grow, and in a few years such areas should support a closed vegetation. In areas where the substrate was destroyed down to mineral soil, by whatever means, the vegetation has died and recovery in these areas will probably take decades. Four other grids and two

line plots showed no change since the late summer examinations of 1973. The one grid that was fractured by a scarp shows no further change except for some plant reestablishment in the scarp zone.

The reconnaissance revealed only one phenomenon not previously discovered. Minor subsidence, as evidenced by the necrotic tissues of inundation-sensitive plants, can now be detected in a few areas in the general vicinity of Cannikin SZ. These affected areas are not large, but their appearance is a delayed reaction to the test shock.

Avifauna Investigations

History of the Study

The avian ecology studies have been conducted annually since August, 1967. F.S.L. Williamson, formerly of the Johns Hopkins University and now Director of the Chesapeake Bay Center, Smithsonian Institution, was principal investigator through March, 1974, at which time Clayton M. White, BYU, who began with the study in 1969, assumed the tasks of principal investigator. In Spring, 1974, White was employed by FWS to perform some of their studies. To date, five publications have come from the studies and Amchitka data constitute a substantial part of two other publications.

The major changes related to Cannikin, other than direct mortality of birds, involved destruction of nesting sites and other side effects caused by human presence (e.g., refuse dump attracting scavenging birds).

Objectives of the Spring, 1974 Research

The objectives of the avifauna study were:

- (1) To determine if the reduced Peregrine Falcon reproductive effort observed in 1973 was test related.
- (2) To determine if closing the refuse dump had had any effect on bird population.
- (3) To determine if nesting sites damaged by Cannikin were occupied in 1974, and if nesting sites that were destroyed were compensated for by the selection of new sites.

Results

Population censuses of raptors, gulls, and ptarmigans were made by helicopter, and raptor nesting sites were examined. Also a general survey of all birds was made to see if any qualitative changes in seasonal distribution and abundance could be detected.

Results show that both Bald Eagle and Glaucous-winged Gull populations were somewhat depressed from pre-Cannikin numbers. The lower population levels were mainly due to fewer immature birds in the population (Table 1). Both immature eagles and gulls previously relied heavily, for food, on the refuse dump. After the Island was evacuated in 1971, the food availability (lack of refuse and feeding by humans) decreased. Eagles are again nesting in the general vicinity of Cannikin-damaged or -destroyed nesting sites. Productivity during 1974 is normal for the nest sites occupied.

TABLE 1. BALD EAGLE POPULATION: 1974 DATA AND AVERAGES FOR THE 1969 - 1972 PERIOD

	1974	Average 1969 - 1972
Total Adult		
May 22	156	218
May 26	147	
Total Immature		
May 22	20	65
May 26	27	
Percent Immature		
May 22	11	23
May 26	16	
Nests Examined	82 ^(a)	-
Nests Occupied	54	65
Nests with Young	43	-
Number of Young	74	-

(a) All territories formerly known to have been used.

The number of Peregrine Falcons nesting during 1974 about equaled the average number nesting during the 5 years of adequate nesting studies. The number of young produced in 1974 was slightly above the number produced in 1973 but below the average for the past 5 years. Hatching was about two weeks behind normal in 1974, and clutch size was lower than normal with 4 of the 15 eyries occupied in 1974 (average 1968-1972 was 18) containing only one young bird. The poorer productivity in 1973 and 1974 is believed to be related to weather vagaries.

A new cormorant colony was found on Banjo Point in 1974 at a location where no colonies had existed previously. It is believed that the Cannikin-induced alterations of cliff structures at Banjo Point produced features, such as ledges, needed for nest placement by the birds.

Five species of birds new to Amchitka, of which three are new in the Aleutians in general, were found during May, 1974. They were: Bristle-thighed Curlew, Numenius tahitiensis, Polynesian Tattler, Heteroscelus brevipes, Mongolian Plover, Charadrius mongolus, Dusky Thrush, Turdus naumanni, and Skylark, Aluda arvensis. This brings the total number of species of birds recorded at Amchitka to 131.

The Rock Ptarmigan population was larger than estimated during the previous 6 years.

Hydrology

History of the Study

Hydrological studies have been conducted annually since July, 1967. These studies, conducted by the USGS, were under the control of Mr. W. C. Ballance during the current field trip.

The studies prior to 1974 were designed to determine if it would be safe from a hydrologic standpoint to conduct the planned underground nuclear tests, and to describe the general hydrology of Amchitka Island. Numerous reports have been published by the USGS as a result of these studies.

Milrow produced a few changes that were generally temporary in nature, such as the change in stream flow of Clevenger Creek, but within 1 year, most hydrological conditions had returned to normal. Cannikin produced much more severe and longer lasting effects, especially in the areas near Cannikin SZ, where a 26-foot (8-m) deep lake was formed and stream flow in the lower reaches of White Alice Creek ceased entirely while Cannikin Lake filled.

Objectives of the Spring, 1974 Research

The primary objective of the current field studies was to collect data on groundwater and surfacewater so that comparisons of these data and previously acquired data would provide evaluation of the longterm effects of Cannikin.

Results

Twelve groundwater and surfacewater recorders were left in operation in August, 1973. Of these, only one recorder failure had occurred upon inspection of the sites in May, 1974. Water level was measured in boreholes located near Site C, Site D, Site E, Long Shot, White Alice Creek at Site C, and the Main Camp; stream flows were measured at all gauging sites located on Bridge Creek, White Alice Creek, and Clevenger Creek; and maintenance and servicing were performed at all observation sites for continued operation. Shelters, recorders, and controls appear to be in satisfactory condition.

Cannikin Lake showed abnormally high water marks of varying height around its perimeter, probably caused by wind and ice.

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

LimnologyHistory of the Study

Limnology studies have been ongoing at Amchitka since August, 1967, when they were initiated by Derry Koob of OSU. Thomas Birch of BCL was principal investigator from July, 1970, to January, 1973, when Robert Burkett of BCL assumed responsibility for the program. The initial studies were designed to classify and describe the lakes of Amchitka, but recent research has been directed toward detecting and measuring the effect of AEC activities, including nuclear testing and drilling-mud spills. Seven reports of these studies have been published.

Milrow produced several noticeable changes, including the partial draining of two lakes. As predicted, the larger Cannikin nuclear explosion produced more severe effects: four lakes were completely drained and two were partially drained; a new lake, Cannikin Lake (Appendix B, Figure B-6), formed in the subsidence crater; and caustic drilling-muds breached the sumps at Site D and flowed into Falls Creek. Most of these effects will be noticeable for a long time.

Objectives of the Spring, 1974 Research

The specific objectives of the Spring, 1974 field trip were

- (1) To continue the assessment of the environmental effects that resulted from AEC operations, including nuclear testing, site preparation, and roll-up activities on selected lakes and streams.
- (2) To continue the assessment of biological development in Cannikin Lake.

Results

Water level was low in all of the lakes, ponds, and streams observed during the Spring Field Trip period. Water temperature was very nearly that of day air temperature and ranged from 6 to 8 C. Physiochemical and biological data obtained from the lake and stream stations indicate that no substantive or unusual fluctuations in these parameters have occurred since Fall, 1973.

The status of Lake 51 (Emerald Lake) and 14-Mile Lake* remains unchanged. Emerald Lake has not recovered from the reduction in biota precipitated by drill-mud input; 14-Mile Lake is a sterile, water-mud sump. Oil was released from bottom sediment upon wading in Lake 50a. Input of oil to this lake is of recent origin, since none was observed while sampling the lake during the Fall, 1973. Also, oil was observed along the roadbank and shoreline adjacent to Lake 50a. Since the Island was unoccupied

* Shown in Figure 2.

by people between the sampling periods in Fall, 1973 and Spring, 1974, the source of the pollutant is not known. Impacts to Lake 50a appear to not have been severe; water clarity is still very good and plankton populations were present.

Lake 1a* continues to receive an inflow of nutrient-enriched water from the sewage ponds, although the amount of inflow has been considerably reduced by departure of people from the Island. Nevertheless, this lake is expected to remain relatively very productive for some time. Primary productivity measurements were conducted on water samples from Lake 1a in order to ascertain whether or not the nutrient supply in the lake is decreasing. The carbon fixation rate by phytoplankton during this period was $3.40 \text{ mgC m}^{-3} \text{ hr}^{-1}$. The rate determined from Lake 1a water samples during Spring, 1972 was $119.7 \text{ mgC m}^{-3} \text{ hr}^{-1}$. This difference may be due, at least in part, to a reduction in the nutrient input to the lake. Zooplankton abundance was much greater in Lake 1a than in other lakes. Moreover, growth and production of periphyton was markedly evident in Spring, 1974, and not in most other lakes.

FIGURE 2. CANNIKIN INTENSIVE-STUDY LAKES, LIMNOLOGICAL STUDIES

Zooplankters were relatively abundant in Cannikin Lake, unlike the springtime condition a year ago. The large copepods, so numerous in Fall, 1973, were very sparse, but the abundance of nauplii indicates an established, reproducing population. Apparently, only a few adult copepods overwinter. This is not unusual. Phytoplankters were not plentiful and primary productivity is expected to be low in the spring and high in the fall. The average of four separate determinations of carbon-fixation rate during this spring period was $0.80 \text{ mgC m}^{-3} \text{ hr}^{-1}$. Periphyton, mostly filamentous alga

* Shown in Figure 2.

Mougeotia and a variety of diatoms, is abundant along the shoreline. The aquatic plant Equisetum arvense was found growing near the shoreline, also. Neither periphyton nor aquatic macrophytes have been observed previously in Cannikin Lake.

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

Clevenger Creek is in good condition after mud spills in 1968 and 1969. 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 around the culvert may eventually result in channel disruption at this location.

Freshwater Fishes and Invertebrates

History of the Study

Freshwater ecology studies have been conducted annually under the direction of principal investigators, John Neuhold and William Helm of USU, since 1967. During these studies, all salmon spawning streams (21) and numerous lake systems have been studied. Ten publications have resulted from these studies.

Objectives of the Spring, 1974 Research

Objectives of the spring trip were limited to

- (1) Collecting fish for radiochemical analysis.
- (2) Verifying that Dolly Varden were still in Cannikin Lake.

Results

Work during the Spring of 1974 was performed by BCL. As expected, fry nets fished in streams (including Burr House Stream) did not capture salmon fry, since pink salmon fry had completed their seaward migration.

Gill nets were fished in Cannikin Lake for 24 hours and four Dolly Varden were captured. Lengths of these fish ranged from 19 to 26 cm, and weights from 72 to 195 grams. A scale-sample and the stomach were taken from each fish for possible future analyses to determine age and feeding habits. It should be noted that the residence time of these fish in Cannikin Lake is undeterminable. The fish carcasses were used by LRE for radiometric analysis. Sticklebacks may inhabit the Lake also, but none have been observed or captured to date.

Investigators from FRI, LRE, and FWS collected 52 Dolly Varden from Jones Lake for radiometric and pesticide analyses. The pertinent data from these fish (measurements, weights, etc.) were forwarded to the investigators at USU.

Future Plans

A Fall, 1974 field study is planned for the purpose of determining salmon spawning success and also to continue the assessment of the effects of AEC operations, particularly the effects of Milrow and Cannikin on the freshwater vertebrate and invertebrate populations of Amchitka.

Intertidal Marine Ecology

History of the Study

Intertidal marine ecology studies have been part of the larger marine ecology research program conducted by the FRI since 1967. The same principal investigators, R. L. Burgner and R. Nakatani, have been involved since its inception. Sixteen publications have resulted from these studies.

Intertidal and sublittoral algal and invertebrate communities were severely altered as a direct result of the uplift (max + 1m) of the intertidal benches in localized areas on the Bering Sea Coast adjacent to Cannikin SZ during the Cannikin test on November 6, 1971 (Kirkwood and Fuller, 1972, BMI-171, 147). Evaluation of the biological recovery of the affected intertidal region has been pursued by continued systematic observation and sampling of specific study areas established in the uplifted region before and after Cannikin. Additional monitoring of control areas, the intertidal area uplifted as a result of Milrow, and experimental recolonization areas are providing supportive information necessary to assessing the biological recovery of the Cannikin-impacted intertidal region.

The current surveys during the low tide series, May 21 through May 28, 1974, were conducted by Charles Simenstad and Charles O'Clair.

Objectives of the Spring, 1974 Research

The primary objective of FRI's investigations during the spring task force visit to Amchitka was to continue assessment of the recovery of biotic communities on and in the vicinity of the uplifted intertidal benches on the Bering Sea Coast adjacent to Cannikin SZ.

An additional objective (at the request of BCL) was to collect specimens needed to verify identifications of crustacean wood borers, Limnoriidae, previously collected in the Constantine Harbor area at Amchitka. These organisms are found in intertidal and subtidal areas.

Description of Sampling Procedures

Quadrats (0.25 m^2), established on the Bering Sea intertidal bench adjacent to Cannikin SZ (IA-2 and IA-3) (see Figure 1) in 1970 prior to Cannikin and in 1971 immediately preceding Cannikin, were resampled for abundance and species composition of invertebrates and macroalgae. Direct counts of invertebrates and estimates of algal cover were made during the spring low-tide periods during the field trip. Additionally, each plot was photographed to document later measurement of actual algal cover.

Further studies included general observations and photographic documentation of the (1) IA-1 uplift fault near Milrow SZ (see Figure 1), (2) Cannikin-uplifted areas in intertidal benches at Banjo Point, (3) control transects T-1 in St. Makarius Bay and T-2 in Cyril Cove, and (4) experimentally manipulated algal communities in intertidal areas at Duck Cove, Rifle Range Point, and St. Makarius Bay.

In addition to these specific studies, general photographic documentation of the overall IA-1, 2, and 3, Rifle Range, and St. Makarius Bay study areas was made from the air by using both real and infrared color films.

Results

Invertebrates. Two aspects of the effect of uplifting on intertidal invertebrate communities are of interest. The first is the fate of remnant populations which were uplifted above their normal upper limit. Most species thus affected have either migrated to lower levels or were stranded and died prior to the current sampling period. Notable exceptions are (1) adult barnacles, Balanus cariosus and B. glandula, on outer (seaward) surfaces of exposed areas uplifted as much as 1 meter have shown negligible mortality from April, 1972, to the present and (2) similarly, an unidentified, formerly sublittoral limpet uplifted into the sublittoral fringe has maintained remnant populations since February, 1972.

The second aspect of interest is the rate of invertebrate colonization in uplifted areas, mainly by species from elevations higher, both intertidal and above, than the preevent elevations of these areas. Almost without exception, those areas that were uplifted more than 1/2 meter (IA-2 and IA-3) above their former intertidal elevations are being colonized by Diptera, Acarina, and Collembola. Further, populations of these species appear to be seasonally variable, although predictable, from year to year. Former sublittoral areas uplifted into the intertidal zone are showing a continued increase in the number of species. The holdfasts of Laminaria longipes, the dominant macrophyte of the sublittoral fringe in these areas, are trapping sediment, thereby providing habitat for polychaetes and bivalves. However, the attainment of a relatively stable "climax" community is expected to be delayed until the many remaining dead Clathromorphum crusts and Laminaria yezoensis holdfasts are, for the most part, sloughed off.

Several thousand specimens of an isopod marine borer (pile worms) were collected from pilings and timbers in Constantine Harbor and returned to William F. Clapp Laboratories. About 500 of these will be identified by species, sexed, and measured. To date, only Limnoria lignorum has been identified from the Amchitka collections.

Algae. Recovery of algal cover of the Cannikin-uplifted intertidal bench appears to be proceeding as predicted. Die-off of algae on the seaward margin of the uplifted bench along the margins of surge channels was retarded, as a result of the effects of wave splash. These are now stabilizing as algal association typical of their new locations in the tidal zones (i.e., Laminaria longipes has replaced L. yezoensis, and Halosaccion glandiformes has replaced Laminaria longipes). Shoreward, uplifted areas are now above the high-tide level, and receive little wave-splash wetting. As a result, macroalgae populations have not been established. This impact is apparently being further enhanced by continued erosion of the bench surface which is not permitting a stable surface for permanent algal attachment (see Geomorphology Section). New surfaces produced along the lip of the bench during the uplift are proceeding through a succession from the original "pioneer" species to the composite of the "climax" community characteristic to this tidal zone. The most notable example, in this case, is the increased dominance of Rhodomenia palmata in areas that were dominated by Halosaccion glandiforme 9 to 10 months after Cannikin.

In areas where growth of large canopy macroalgae (i.e., Laminaria sp., Alaria sp., and Hedophyllum sp.) is evident, the characteristic algal understories have not yet become established. It is assumed that understory algae will not develop here until the canopy growth has become firmly established.

Subtidal Benthic Ecology

History of the Study

Subtidal marine benthic studies, which evolved from a Scuba sampling program, have been conducted annually by NMFS since 1969. The same principal investigator, T. R. Merrell, has directed the program since its inception.

Objectives of the Spring, 1974 Research

The objectives were to observe and document the biological recovery of several subtidal sites in the Bering Sea which were severely perturbed by Cannikin.

Results

The sampling sites were the same ones in the Bering Sea that have been observed periodically since immediately after the Cannikin nuclear test, when it was first found that considerable damage to the sea bottom had occurred. The beginning of the Spring, 1974, trip was plagued by poor weather and mechanical problems with the boats, but eventually, 4 days of observations were made offshore from Cannikin SZ.

Three sites were inspected. Two were rockfalls in 21.5 to 24.6-m (70 ft to 80 ft) water which have been monitored since Cannikin to observe and record biological colonization of freshly exposed surfaces of fractured rocks. The third site was a large

boulder at a depth of about 11 m (35 ft) that was inverted by Cannikin. The previously exposed biological assemblages on the upper surface was shifted to a shaded position beneath the boulder, and the surface upon which the boulder previously rested was exposed.

In general, fresh rock surfaces, observed following Cannikin, are now covered with populations of plants and animals typical of those found on similar adjacent, but undisturbed, rock surfaces. The main difference, now evident between undisturbed and freshly colonized surfaces, is the size of individual organisms or colonies of organisms. Those on the surfaces exposed as a result of Cannikin are generally smaller than those on the undisturbed surfaces, presumably because of the younger age of the former.

At the two rockfalls in deeper water, much of the newly exposed surface is now covered with young coralline algae (Clathromorphum sp.). Many individual plants have expanded into a solid covering. In addition to the corallines, there are many leafy red algae, and on the highest and most exposed surfaces where light is maximum, there is a heavy brown growth of large brown algae (Laminaria sp. and Alaria sp.). Encrusting animals on these newly exposed surfaces include a bryozoan (Membranipora sp.), a hydroid (Aglaophenia sp.), and unidentified sponges. The urchin (Strongylocentrotus sp.) is the principal mobile organism present.

The inverted boulder in shallower water also appears to have achieved relative biological stability on both its present upper and lower surfaces. Almost all the original brown algae cover has now disappeared from the previously exposed surface that now lies in a shaded position beneath the boulder. The only exception was one holdfast and stripe of a large Laminaria sp. that has persisted since Cannikin. (When first seen after the boulder was overturned by Cannikin, this surface had a heavy covering of these large kelps.) Most of the corallines and some of the leafy red algae are continuing to survive in their shaded position. Encrusting sponges are the dominant invertebrates on this surface and may be expanding to the point where they are covering some of the corallines. Apparently, the corallines have been able to survive the reduced light level of the new position, but they may eventually be eliminated by an overgrowth of sponges.

The present upper surface of the inverted boulder now has a dense cover of large brown algae (Laminaria sp. and a few Alaria sp.). Beneath the kelps are red algae, sponges, and bryozoans. This surface, which was virtually barren immediately after Cannikin, has now become colonized to the point of being almost indistinguishable from similar, undisturbed surfaces nearby.

Photographic documentation of the biological recovery of the study sites was continued to provide a visual supplement to verbal descriptions.

Marine Mammals - Sea Otters

History of the Study

Sea otter studies, including aerial and shore-based population surveys, have been conducted since 1967 on Amchitka Island. Aerial surveys are known to produce relatively low population estimates, whereas, shore-based counts provide maximum estimates under ideal conditions of weather, sea state, and population dispersion. These

counts have been made by D. L. Spencer (1969) in 1968; J. G. Stephan (1968, 1969, 1972) in 1969, 1970, 1971; and Estes and Smith (1973) in 1971 and 1972; and by the FWS in 1972 and 1974. Ten publications have resulted from these studies.

The sea otter survey program was started by FWS. Other investigators were from BCL, University of Arizona, and ADF&G. Principals involved have been D. L. Spencer, J. G. Stephan, B. Cater, J. B. Kirkwood, I. Mercier, W. Sowl, C. Abegglen, V. Bird, J. Estes, and K. Schneider.

Objectives of the Spring, 1974 Research

The 1974 sea otter survey program was made possible by the availability of a helicopter. The specific objective was to determine whether any gross changes in the total Amchitka sea otter population, and in the population segment within Area "A", had resulted from Cannikin. Area A is a 10-mile (16 km) segment of Bering Sea coastline adjacent to the Cannikin site where the explosion produced pressure effects in the ocean were the greatest.

Results

Data from surveys on May 22, 25, 26, and 29, 1974, by FWS and ADF&G are tabulated below.

<u>Date</u>	<u>"A" Aerial Count</u>	<u>"A" Shore Count</u>	<u>Island Count</u>
22 May		Orientation Survey	
25 May	253	354	-
26 May	293	-	1545
29 May	374	510	3226

The May, 1974 surveys, while limited, show the persistence of the initial impact of the Cannikin test on the sea otter population in Area "A". It had previously been assumed that the sea otter density in Area "A" would be at the pretest level by this time, through additions by immigration and reproduction. Instead, it appears that the population level in Area "A" is about 1/2 what it was estimated to be immediately before Cannikin, and has not changed detectably since November, 1972. The maximum total Island population count obtained in May, 1974 is within the range of previous whole-Island counts, made under comparable conditions, both before and after Cannikin (see Estes and Smith, 1973). Therefore, it is concluded that no major sea otter population changes have occurred in the past 2 years at Amchitka Island.

A supplemental study was conducted on the occurrence of plastic garbage at Amchitka (see Appendix C).

Marine Fishes

Marine fisheries studies have been part of the marine ecology research program conducted by FRI since 1967. Results of these studies have been reported in 9 publications.

According to Nakatani and Burgner (1974) (BMI-171-156), detectable effects of nuclear testing on marine fishes could not be demonstrated during the field studies in 1973, so marine fishes were not studied during the Spring, 1974 sampling trip.

Radioactivity

History of the Study

Although the underground nuclear testing was designed to prevent radioactive contamination of the biota and environments of Amchitka, a surveillance and sampling program has been conducted at intervals since 1967. (A more limited program was also conducted for Long Shot in 1965.) The initial work, conducted by BCL, LRE, and USGS, established background levels of radioactivity and the current sampling program, conducted by LRE and USGS, is designed to determine if the radioactivity has been adequately contained from all of the three previous underground nuclear tests. Environmental and biotic samples have been collected frequently since 1967 for radiometric analysis by more than half of the biological investigators who have worked at Amchitka. Investigators from BCL have published five reports on this subject. The organizations involved in the current studies, LRE and USGS, have published four and eight reports, respectively. The principal investigators during the current studies, which began in 1967, have been: Dr. Vogt of BCL; Drs. Held, Nelson, and Seymour of LRE; and Mr. Ballance of USGS. Both Dr. Nelson and Mr. Ballance participated in the Spring, 1974 work.

The current sampling programs are designed to detect any radionuclides that might be escaping from the test sites, even though such leakage is improbable.

Objectives of the Spring, 1974 Research

The objectives of LRE were:

(1) To collect samples and perform radiometric analyses as a part of the periodic documentation of radionuclides, both naturally occurring and man-made, in biological and environmental samples from Amchitka and surrounding waters.

(2) To conduct a radiation survey of areas most likely to be contaminated by man-made radioactivity. These areas include Long Shot, Milrow, and Cannikin SZ's.

The objectives of USGS were:

- (1) To determine if man-made radioactivity is present in the freshwater ecosystem of Amchitka.
- (2) To determine if man-made radioactivity is present in the marine waters near Amchitka.

Results

Laboratory of Radiation Ecology. During the May, 1974 field trip, about 70 biological and environmental samples including water, fish, marine and freshwater algae, marine invertebrates, birds, terrestrial and freshwater vegetation, and periphyton and related organisms, were collected by LRE. Areas sampled included Cannikin Lake, Jones Lake, DK 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 will be analyzed for gamma-emitting radionuclides, some will be analyzed for ^3H , ^{55}Fe , and ^{90}Sr . Results of these analyses will be reported in the LRE progress report, covering the period from January to December, 1974.

A radiation survey, using an Eberline G-M detector (Model E-510), with a window thickness of 30 mg/cm^2 , was also performed. Thirteen areas between Charlie Runway and E-site were surveyed (Table 2). These areas included the Long Shot, Milrow, and Cannikin SZ's and the adjacent area. The Cannikin drill back site and Sand Beach Cove were also surveyed. Maximum levels recorded while holding the survey instrument 1 meter above the ground ranged from 0.02 mR/hr to 0.03 mR/hr. Average levels at all sites were less than 0.01 mR/hr. These levels are similar to or less than background levels in other areas of the United States.

USGS. The USGS collected 104 water samples on Amchitka and offshore. Tritium determinations will be made on all of these samples and gross alpha and gross beta/gamma determinations will be made on 42 of them.

Results of gross alpha, gross beta, and tritium determinations made by the USGS will be compared with previous results for the freshwater on Amchitka and for the seawater off Amchitka, near the nuclear test sites, to determine any changes in radiochemical content. The results of these determinations, including comparisons, will be published during the next fiscal year in a USGS 474 series report.

SUMMARY

The most important bioenvironmental consequences of the nuclear testing activities at Amchitka found during the period of May 21 through June 1, 1974 (about 2-1/2 years after Cannikin) can be summarized as follows:

● Rapid changes were observed along the exposed cliffs northwest of Sand Beach Cove near Cannikin SZ. This area, about 1 km long, damaged by Cannikin is eroding rapidly due to exposure of easily weathered bedrock and to the unstable sand dunes along the cliff top.

● The weathered products from sea cliffs and rock and turf falls constantly are being redistributed by waves and tides. Stabilization will require several years.

● Mechanical and chemical weathering appears to have reduced the elevated intertidal bench near Sand Beach Cove by about 1 to 2.5 cm.

● The revised estimates of minimum rock and turf fall produced by Cannikin are: Bering Sea Coast, 30,000 m³; Pacific Sea Coast, 5,000 m³. The revised estimate of minimum rock and turf fall produced by Milrow is 6,900 m³.

● Erosion is evident at the reclaimed sites near Drill Sites E and F. Erosion of the retaining walls of the mud pits at Drill Site D is continuing at a rate that suggests that the drill-mud will be lost to Falls Creek within a year.

TABLE 2. RADIATION SURVEY OF SELECTED SITES
ON AMCHITKA, MAY, 1974

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

(a) Eberline G-M detector, Model 510

Beta shield closed. The window thickness was 30 mg. cm⁻².

- Vegetation in areas where the organic substrate was only slightly affected by Cannikin is recovering, but in areas where the substrate was destroyed to the mineral soil, there has been very little change.

- Bald Eagle and Glaucous-winged Gull populations are somewhat depressed since Cannikin. This is believed to be directly related to the change in food availability (due to lack of human garbage and lack of deliberate feeding by man).

- Nesting of Bald Eagles and Peregrine Falcons was similar to prior years, except that fewer young birds than average resulted from the Peregrine Falcon nesting. This was believed to be due to weather conditions.

- Five species of birds were observed or collected during the Spring, 1974 field trip that had not been recorded for Amchitka previously. They were: Bristle-thighed Curlew, Numenius tahitiensis, Polynesian Tattler, Heteroscelus brevipes, Mongolian Plover, Charadrius mongolus, Dusky Thrush, Turdus naumanni, and Skylark, Alauda arvensis.

- Cannikin Lake now has periphyton and aquatic macrophytes present; zooplankton are relatively abundant; and Dolly Varden were taken for radiochemical analysis and food studies.

- Biotic populations in Clevenger Creek have recovered from a mud spill that caused short-term damage at the time of the Milrow detonation.

- Species representing the orders of Diptera, Acarina, and Collembola are now colonizing in new supralittoral areas; i.e., areas formally in the upper intertidal zone, now uplifted 1/2 meter or more by Cannikin.

- Communities of algae and invertebrates are now changing rapidly in the uplifted tidal areas.

- Growth of large canopy marine macroalgae communities has not progressed in all areas to the extent predicted.

- In general, subtidal rock surfaces damaged by Cannikin and sampled by observations have now recovered to their pre-Cannikin state. The only current difference observed between areas disturbed by Cannikin and areas not disturbed is the size of individual organisms or colonies of organisms.

- The sea otter population level in Area "A", not changed since 1972, still exhibits about 50 percent reduction in numbers of animals in the area versus counts in June, 1971.

- No radioactivity that could be attributed to nuclear testing was encountered with field radiation detectors.

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APPENDIX A

APPENDIX A

ORGANIZATIONS AND INDIVIDUALS PARTICIPATING IN THE
SPRING, 1974 FIELD STUDIES

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

Liaison for U.S. National Marine Fisheries Service

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Geomorphology

The Ohio State University
Dr. K. R. Everett (Principal Investigator)

Plant Ecology

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

Avian Ecology

U.S. Fish and Wildlife Service
Dr. C. M. White (Principal Investigator)

Hydrology

U.S. Geological Survey
Mr. W. C. Ballance
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Limnology

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

Freshwater Vertebrates and Invertebrates

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Dr. J. B. Kirkwood
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Intertidal Marine Ecology

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Mr. C. E. O'Clair
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Subtidal Marine Ecology

U.S. National Marine Fisheries Service
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Mr. R. M. Martin

Marine Mammals

U.S. Bureau of Sport Fisheries and Wildlife
Mr. C. E. Abegglen (Principal Investigator)
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State of Alaska, Department of Fish and Game
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Radioactivity

University of Washington, Laboratory of Radiation Ecology
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U.S. Geological Survey
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APPENDIX B

Photographs B-1 through B-5 by K. R. Everett.
Photograph B-6 by C. E. Abegglen.

(a)

(b)

FIGURE B-1. TYPICAL HEADLAND COLLAPSE INDUCED BY CANNIKIN, BERING SEA COAST

Photo (a) taken in September 1972; (b), May 1974. Note that only minor changes are observable between these dates.

(a) September, 1973

(b) May, 1974

FIGURE B-2. ROCKFALL PRODUCED BY CANNIKIN, PACIFIC COAST

Note increase in amount of "fines" added to rocks. Also note turf islands on fine debris which may form nuclei for revegetation.

FIGURE B-3. SEA CLIFFS NORTHWEST OF "SAND BEACH COVE", MAY 1974

Displaced turf at foot of bedrock face. After storm wave erosion has reduced this material beyond further effective wave erosion, Elymus will probably colonize deposits. Sands and fines along with some clasts from exposed bedrock are being added to upper part of displaced veneer. Loss of turf support from brow of cliff has resulted in fragmentation and sliding of sand accumulation (dune) at top of cliff. This appears as turf islands moving down cliff face. This slope will remain active for some time.

(a) September, 1973

(b) May, 1974

FIGURE B-4. PART OF MASSIVE SANDSLIDE NORTHWEST OF "SAND BEACH COVE"
CAUSED BY CANNIKIN

In November 1971 slide extended far out onto beach. (a) effect of storm wave sapping and redistribution of fines by small stream. (b) same feature further reduced in May 1974. Increased sand accumulation in Spring 1974 is probably a seasonal phenomenon.

(a) September, 1972

(b) May, 1974

FIGURE B-5. SMALL CANNIKIN-INDUCED TURF SLIDE

(a) some wave redistribution of fines on beach. (b) stream removal of material beachward into zone of active storm wave erosion.

FIGURE B-6. CANNIKIN LAKE MAY 25, 1974

The white line is 100 feet long. The lake, with a surface of 12 ha (30 acres) and a storage capacity of 325 acre-ft, is about 655 m (2150 ft) long and averages 198 m (650 ft) wide. Its shoreline is 2.1 km (1.3 mile) and average depth is >6 m (20 ft).

APPENDIX C

APPENDIX C

NMFS PLASTIC WASTE SURVEYS AT AMCHITKA
MAY 21 - JUNE 4, 1974

Beginning in April, 1972, NMFS biologists began a series of surveys of Amchitka beaches to assess the extent of pollution by plastic garbage. Excepting the World War II military debris, synthetic litter on the beaches is the most evident and permissive evidence on Amchitka of man's activities. Ten 1000-meter sections of beach have been surveyed by NMFS biologists during each of the periodic diving observation trips to Amchitka. Beach surveys have been made during periods when weather or mechanical breakdowns of boats prevented diving. The results of the surveys are being analyzed for publication. In general, most of the plastic garbage and other waste originates from Japanese and Soviet fishing fleets. Only insignificant amounts are attributable to the AEC testing program. Trawl webbing is by far the most prevalent form of debris, and by weight, totals more than all other synthetic materials combined. Gill-net floats from the Japanese high seas are the most numerous individual identifiable items.

This plastic waste is of environmental concern from several standpoints: it may be a source of polychlorinated biphenyls (PCB's) in the oceans; aesthetic degradation of remote beaches; fouling of ship's propellers and cooling systems; and entanglement of marine mammals and birds in derelict floating nets. Synthetic garbage on Amchitka beaches appears to represent an accumulation over a period of years; and once on the beach, it stays there, gradually being broken down by physical processes and by the gnawing of rats.