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AMCHITKA BIOENVIRONMENTAL PROGRAM
FRESHWATER VERTEBRATE AND INVERTEBRATE ECOLOGY
OF AMCHITKA ISLAND

ANNUAL PROGRESS REPORT

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by

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FRESHWATER VERTEBRATE AND INVERTEBRATE ECOLOGY OF AMCHITKA ISLAND

by

William T. Helm and Richard A. Valdez

ABSTRACT

Irreversible damages occurred in at least five study lakes, three with fish populations, and in one stream system on Amchitka as a result of Cannikin. An estimated loss of 10,700 freshwater fishes, of which 7 percent were game fish, was distributed over eight ponds. The greatest effect of Cannikin-generated pressure changes to a fish population was an estimated 15 percent loss of three-spine stickleback in a pond 1,210 meters from SZ. In comparison, the loss of 85 percent of the stickleback in a pond 500 meters from SZ was reported for the Milrow event in 1969.

A survey of Amchitka salmon streams in 1971 revealed markedly fewer returning adults than the previous year; this reduction is not believed to be related to the nuclear testing program since pink salmon spawning migrations are typically different in size between even and odd years in many streams. Only 100 adults were found in 4 of the 23 streams surveyed in 1971 as compared to the estimated 674 in 21 of these streams the previous year.

Oil and silt are two pollutants found to be entering some lakes (<0.2% of total number on Island) and streams (<5% of total on Island) on Amchitka. Drilling mud, containing oil, has caused severe but probably short-term depletion of aquatic populations; silt may have longer lasting effects.

INTRODUCTION

Battelle's Columbus Laboratories' Amchitka Bioenvironmental Program was organized to predict, document, and evaluate the effects of the U. S. Atomic Energy Commission's Amchitka activities on the biota and the environment; to recommend measures for minimizing adverse effects; and to predict radiological hazards to man that might result from radionuclide transport through food chains, should there be an inadvertent release of radioactivity. The purpose of the freshwater vertebrate and invertebrate ecology study is to provide information on Amchitka's freshwater ecosystem to assist in accomplishing these objectives.

Since the fall of 1967, Battelle's Columbus Laboratories and its subcontractors have studied the marine, freshwater, and terrestrial ecosystems at Amchitka Island, Alaska. These studies are designed to predict, evaluate, and document the effects on the biota and environment from underground nuclear tests, to recommend measures for minimizing the effects, and to predict and evaluate the potential hazards to man that might result from the accidental release of radionuclides to the environment and their subsequent transport to humans via food chains. These studies are sponsored by the

U. S. Atomic Energy Commission's Nevada Operations Office as a part of its supplemental nuclear test-site activities.

Biologists from Utah State University have studied Amchitka's freshwater ecosystem under Battelle's Columbus Laboratories Bioenvironmental Program. Efforts on Amchitka during this study have concentrated on (1) defining the status and dynamics of the stream and lake ecosystem, (2) providing an ecological baseline for evaluating and documenting test-related and other effects, and (3) establishing a conceptual analogue model of the freshwater ecosystem of the Island.

Emphasis during FY '72 was on documentation of the prompt effects of Cannikin, follow-up studies to identify and document longer-term effects of Cannikin, continuing studies of the effects of Milrow and of AEC operations on freshwater ecosystems, and continuing surveys of spawning salmon in Amchitka streams.

Nearly all of the relevant data relating to immediate postshot effects of Cannikin on the freshwaters of Amchitka have been presented in the D+2 Months Report (Kirkwood and Fuller, 1972). Since all relevant prompt environmental effects of Cannikin were adequately treated in the D+2 Months report, this annual progress report emphasizes the information obtained since the D+2 Months report. Included are results of a brief analysis of water quality and discussions of efforts to detect the presence of fish in the developing crater lake and of consequences from the draining of ponds and lakes by the event.

A salmon survey of coverage and effort similar to that of 1970 was conducted in 1971, and the two surveys are discussed.

CANNIKIN STUDY

Effects Summary

The study area comprising lakes and streams within 2 km of Cannikin SZ is shown in Figure 1. Of the study lakes, five freshwater lakes were drained by fissures and tilting resulting from the Cannikin detonation and/or crater subsidence. Most are tilted and any rainfall or water received will run off onto the tundra or into the yet-open fissures in the lake beds. Except for a few shallow and insignificantly small puddles that may form, these lakes are not expected to refill and support fish.

As stated in the D+2 Months report, an estimated 10,700 freshwater fish (10,000 threespine stickleback (Gasterosteus aculeatus) and 700 Dolly Varden (Salvelinus malma) were killed by Cannikin. The numbers killed in each lake and the manner of death were also given. The estimated percentage kills in those lakes with fish mortalities attributed to the Cannikin event are presented in Table 1. In comparison (Neuhold, et al., 1971) it is estimated that in Milrow's two closest lakes 85 percent of the stickleback in Clam Lake (Lake BI) and 50 percent in Lake AM were killed by the Milrow detonation. Three lakes experienced 100 percent kill since these were completely drained. Lake DK was estimated to have undergone a 15 percent kill (estimated number of stickleback in Lake DK was 13,500; estimate made just prior to Cannikin) of stickleback with no Dolly Varden mortalities. Estimates of 3, 5, and 8 percent were made in other ponds (Table 1). Necropsy indicated that deaths here were caused by rapid change in ambient pressure.

FIGURE 1. MILROW (SZ AND ADJACENT STUDY AREAS)

TABLE 1. ESTIMATED^(a) FRESHWATER FISH KILL
IN PONDS AFFECTED BY CANNIKIN

Lake	Stickleback			Dolly Varden			Pond Drained
	Preevent Population ^(b)	Number Killed	Percentage Kill	Preevent Population	Number Killed	Percentage Kill	
BO	2,030	2,030	100	300	300	100	X
DF	5,000	5,000	100	0	0	0	X
DH	0	0	0	300	300	100	X
DK	13,500	2,000	15	200	0	0	
DL	325	15	5	0	0	0	
DM	2,000	65	3	0	0	0	
DN	11,000	890	8	No estimate available	0	0	
Pump Pond	0	0	0	300	100	33	X
		10,000			700		Partial

- (a) All preevent population values are estimates obtained by mark and recapture or seining methods. Where a lake was completely drained the entire population was eliminated. In those lakes where only part of the fish were killed, the loss was determined either as a finite number of fish or as a percentage of the original value, and the other value computed.
- (b) Preliminary estimates for BO and DF (Neuhold, et al., 1971 p. 19) were lower than the actual population size. All other estimates in this Column were made just prior to the Cannikin event and are believed to be accurate.

About 72 percent of all fish killed by Cannikin died from lakes being partially or totally drained as opposed to pressure-related deaths. These lakes are not expected to refill. Those lakes whose populations were affected by pressure kills only are expected to recover at least as rapidly as Clam Lake and Lake AM after Milrow (approximately 2-1/2 years).

Surface Waters in the Subsidence Crater

Surface-water levels in Cannikin's subsidence crater have fluctuated sufficiently to cause difficulty in biological and limnological studies. In mid-March the lowest elevation point of the crater flooded to about 0.5 meter, forming two small ponds with a total of about 1350 square meters surface area (Figure 2). Further upstream toward SZ, a third pond, contaminated with a mud-oil mixture, covered about 450 square meters to a depth of 0.7 meter. The water level in the latter pond has remained quite stable. After a dry May, the lowest elevation point in the crater was found to be nearly dry and the only vestiges of the two ponds were some muddy areas near the stream. Reportedly, most of the surface water in the crater is draining into the underground Cannikin-created fissures which should fill by late summer, 1972 (personal communication, M. Merritt) after which time it can be speculated that most of the water now draining into the crater should remain on the surface.

A 38-meter experimental gill net (mesh sizes ranging from 13 to 64-mm square mesh in approximately 13-mm increments in 7.6-meter frames) was set for 24 hours in the largest pond of the crater center in March. No fish were taken or seen.

Samples of water were collected in March, 1972, from each of the three ponds in the Cannikin subsidence crater (Figure 2) and analyzed for dissolved oxygen, secchi disk transparency, turbidity, specific conductivity and pH (Table 2). Pond 1, closest to SZ, had been used as a sump for drilling mud during drill-back operations. Part of the drilling mud was left in the pond and it had a distinct odor of oil and a characteristic oil film on its water. While Pond 2 appeared to have received some drainage from Pond 1, neither of the other ponds appeared to be so contaminated. It is doubtful that fish and invertebrates could live in Pond 1. Mud fluids from all holding ponds on the Island should be stored properly to prevent any recurrence of "spills" as such fluids are highly toxic and have resulted in the deaths of a high percentage of the invertebrates and fish in a receiving stream.

Data given in Table 2 show that only Pond 1 would be detrimental to aquatic life and as the water levels rise all three ponds will coalesce and the resulting condition will be similar to conditions in many other ponds on the Island.

TABLE 2. SOME PROPERTIES OF WATERS FOUND IN
THE CANNIKIN CRATER, MARCH 18, 1972

Pond	Dissolved Oxygen, ppm	Secchi Disc, cm	Turbidity, Jackson units	Specific Conductivity, Micromhos/cm	pH
1	9.6	4.5	>395	582	8.2
2	10.0	24.0	112	342	6.5
3	10.0	>70.0	42	287	6.1

FIGURE 2. CANNIKIN SZ AND ADJACENT STUDY AREAS

AMCHITKA SALMON SPAWNING - 1970, 1971

Continuation of salmon-spawning surveys was inadvertently omitted from specific tasks proposed for FY 1972; nevertheless, the surveys were conducted because of their value as indicators of habitat changes. Streams considered capable of supporting salmon runs on Amchitka were surveyed in August and September, 1971, to determine the location and abundance of spawning salmon. As the pink salmon (Oncorhynchus gorbuscha) is most abundant, the survey was oriented primarily toward examining the intertidal areas and the lowermost stream sections near the effluence. Few individuals of salmon species other than pink or coho have been recorded on Amchitka (McCann, 1962; Neuhold, et al., 1971).

Twenty-three Amchitka streams were visited periodically from June 8 to September 14, 1971; each stream was surveyed by helicopter from an altitude of 20 to 30 meters to locate concentrations of fish, then chosen sections of streams were electro-fished, usually near the stream effluence. Captured fish were weighed, measured, sex determined, and then released.

Pink Salmon

Distribution and Abundance

A marked reduction in numbers and distribution of returning adult pink salmon was seen in Fall, 1971, as compared to those for 1970. One hundred adults were sighted in only four streams (19 streams also surveyed had 0 fish) (Table 3) (Figure 3) as compared to the estimated 674 in 21 streams (2 streams also surveyed had 0 fish) earlier (Neuhold, et al., 1971).

TABLE 3. PINK SALMON ADULTS SIGHTED IN AMCHITKA
STREAMS; SUMMER, 1971

Stream	Map Coordinates ^(a)	Date First Sighted	Total Fish Seen		Peak of Run	Date of Spawning
			Male	Female		
Signal Cove	222 168	Found 3 redds on 9-6-71				
Burr House Cove	206 218	8-27-71	1	4	8-27-71	8-28 to 9-1-71
Fumarole Cove	316 136	8-26-71	15 ^(b)		8-28-71	8-28 to 9-1-71
Midden Cove	234 208	8-16-71	49	31	8-23-71	8-25 to 9-1-71

(a) U. S. Army Corps of Engineers, Aleutian Island (Amchitka) map 2024 III NW.

(b) Represents total count made from helicopter, others were captured in traps so they could be seen.

FIGURE 3. STREAMS ON AMCHITKA USED BY SPAWNING PINK SALMON IN AUGUST, 1971

ss denotes spawning areas.

Ascent and Spawning Time

Earliest ascending adults were seen later in 1971 than in 1970. These were observed as early as August 4 in Midden Cove stream and as late as September 1 in Duck Cove Stream in 1970, and somewhat later and over a shorter period in 1971. The 1971 earliest movement of adults in Midden Cove was August 16 and in Burr House Cove Streams, August 27. Most fish entered the streams both years between August 20 and 28.

Definite spawning activity was observed as early as August 25 and as late as September 10 in 1970. In 1971, this activity began about the same time but was not seen after September 1.

While intertidal activity by adult pinks was observed both years, no intertidal redds were found. One redd found in 1970 was in the stream channel and at the very high intertidal zone where salt water covered it only at very high tides.

Mr. Vern Byrd of U. S. Fish and Wildlife Service reports that pink salmon on Adak Island (about 250 kilometers east of Amchitka) generally ascend and spawn about one week to 10 days earlier than reported on Amchitka (personal communication, Amchitka, Alaska, June, 1972).

Length and Weight

Total lengths and weights were recorded for prespawning adults in 1970 and 1971 (Table 4). As can be seen, differences in mean size from year to year and between sexes were minor. When compared statistically there were no differences in the mean lengths and weights from year to year or between sexes.

TABLE 4. AVERAGE TOTAL LENGTH (TL) AND AVERAGE TOTAL WEIGHT (TW) FOR PRESPAWNING PINK SALMON IN AMCHITKA STREAMS, 1970 AND 1971(a)

<u>1970</u>					
<u>Average TL, mm</u>			<u>Average TW, g</u>		
Male	Female	Both	Male	Female	Both
N=12	N=10	N=22	N=12	N=10	N=22
527.8	484.0	501.7	1446.2	1146.6	1311.6
<u>1971</u>					
N=48	N=37	N=85	N=48	N=37	N=85
511.1	515.1	512.8	1272.9	1345.5	1304.4

(a) The average values presented here are believed representative of Amchitka pink salmon.

Fecundity and Production

Five adult females were sacrificed from Amchitka streams in 1971 and the number of eggs in each was estimated by volumetric displacement. This method was verified by actual counts of some egg aliquots. An average of 2,000 eggs per female was found from this sample of five; values ranged from 1,750 to 2,157 eggs per female.

Neuhold, et al (1971) used the figure 1,546 [an average fecundity for Kamchatka pink salmon (Kaganovskii, 1949)] to arrive at a total egg production value of 521,000 and escapement of 67,730 fry for 1970 Amchitka pink salmon.

For a comparable return of 674 adults to occur in 1972, survival from egg to adult will have to be at least 0.10 percent and from escaping fry to returning adult, 0.78 percent.

Survival estimates will be made on the 1970 year class during the 1972 August and September survey. The information gathered from this survey will be of great value for comparing survival of Amchitka salmon with those of other areas.

Evidence of yearly high and low density cycles, characteristic of pink salmon, is being indicated on Amchitka. Much higher numbers of adults were seen in 1970 than in 1971.

Coho Salmon

A total of 103 coho salmon (O. kisutch) smolts was captured in a downstream trap, analyzed, and released during downstream movements from Midden Cove Stream the summer of 1971 (mid-June to early September). Additional movement probably occurred before the trap was established. The estimated 500 Age Group I and II smolts (1 and 2 year olds) from Midden Cove Creek (Neuhold, et al., 1971) is thus believed a maximum value of smolt production for this stream. No estimate of Age Group 0 fish (young of the year) is available.

Mean total length for Age Group I migrating smolts in June, 1972, was 112.2 mm, and 141.6 mm for the Age Group II migrants; 1971 figures were 107.3 and 152.3 mm, respectively.

Only two adult coho were found ascending Midden Cove Creek in early September, but the fish trap became inoperable shortly thereafter. More adults were expected to have ascended later, although none were found in electrofishing operations in October. The two adults, both males measured 575 mm and 630 mm TL and weighed 2,327 and 3,065 grams, respectively. Both fish, as with those adults taken in the Silver Salmon drainage in 1970, were Age Group III, their scales indicating 2 years in freshwater and 1 in saltwater.

Coho salmon were not seen in any other drainage on Amchitka in 1971 except for 12 smolts migrating downstream in Bridge Creek. During the 1970 survey, coho smolts were reported in five Amchitka streams. Small runs of adults into the Silver Salmon drainage were noted in late September of 1969 and early October of 1970. As October, 1971, was spent preparing for Cannikin, coho salmon surveys were hindered, although surveys were adequate to determine the magnitude of spawning adults in all major (3) spawning areas. Two coho salmon were observed in Midden Cove Stream and 7 were observed in Silver Salmon Stream. As in previous years no adult coho salmon were found in Bridge Creek.

SAMPLES FOR RADIOCHEMICAL AND STABLE ELEMENT ANALYSIS

Samples of Dolly Varden (9) and stickleback (several hundred) were collected and frozen for use by the Laboratory of Radiation Ecology, University of Washington.

CONTINUED SURVEILLANCE IN MILROW AREA

Lake AM (Figure 1) in which many dead threespine stickleback were found after Milrow, was sampled to determine the condition of the stickleback population. Number captured per seine haul and size distribution indicate that this population has essentially recovered from the mortalities suffered at the time of Milrow. Clam Lake (BI), however, was not sampled because unexpected rise in water level of this lake, caused by partial blocking of the outflow from the lake, made seining impossible with the equipment available. Live stickleback observed along the shoreline indicate that members of the population here, as in Lake AM, have survived to enhance recovery of this species in Clam Lake.

Efforts to collect bivalves (Anodonta beringiana) from Clam Lake have been unsuccessful. Several shells have been collected, and from the condition of the outer layer it appears these animals have been dead less than 2 years. This would indicate survival through the Milrow event. Our failure to locate specimens of these previously rare organisms does not necessarily indicate they have not survived in this lake.

EVIDENCE OF DAMAGE TO FRESHWATER ECOSYSTEMS

Drill Site D

Ground motion during Cannikin caused a partial failure of the walls of drilling mud retaining ponds at Site D (Figure 3). Liquid containing a mixture of bentonite, cement, diesel oil, sodium bicarbonate, ferrochrome lignosulfonate, and calcium lignosulfonate flowed into a small pond (created by the spill, just below the retaining ponds) and on down the north branch of a small stream (stream draining Site D). At a later date (February 27, 1972) additional liquid (about 20,000 barrels personal communication, B. Cater, U. S. Fish and Wildlife Service) was released through a series of valves.

A survey in June, 1972, revealed the presence of live aquatic invertebrates and Dolly Varden in the lower portion of this stream, below the junction of the two main branches. Invertebrates included chironomids and simuliids, but not mayflies, one of the common inhabitants of streams in this part of the island.

A subsequent examination of the upper portion of the north branch of the stream revealed no living invertebrates or fish. The vegetation along most of the upper portion of the stream was dead, and the stream bottom was covered with silt and Sphaerotilis natans. Oil oozed from the shoreline vegetation and the stream bottom when disturbed, and was readily visible on many cut-off pools. Living filamentous algae were observed in many areas, and patches of what appeared to be iron bacteria were noted in a few locations.

The pond, into which the liquid first flowed, appeared just as devoid of life as the stream below, with an oil film and pale, floating scum visible near the shoreline. A few living plants were on the shore, and some living Sparganium sp. in the lake.

Dilution of the poor-quality water from the north branch by flow from the south branch can probably be credited for the presence of invertebrates and fish in the lower portion of the stream. A recovery trend similar to that noted in Clevenger Creek (Neuhold, et al., 1971) can be expected if no further pollution occurs.

Silt and/or Oil Near Roads

Several examples can be cited of this commonly observed problem. There was oil on the side of the main road and in the ditch by a small stream flowing from near C-site to the Pacific Ocean (Figure 2). Silt from the access road to Site C, accumulating in the stream, has formed a small delta upstream from the culvert passing under the road. Oil has been spilled on Infantry Road near Bridge Creek (Figure 1) where some can be washed into the stream during rainstorms.

A marsh along the stream downstream from the road has received considerable silt deposit during the past few years. Where the marsh bottom was formerly organic detritus, it now has a heavy layer of silt on top. During rainstorms, water has been observed flowing off the road and down the ditches toward Bridge Creek. This water was very turbid, and caused above normal turbidity in Bridge Creek.

Deposits of silt have been noted between the main road and Pratfall Lake (Lake AP) (Figure 1), in a low area that apparently served as a channel for runoff water flowing from the road to the lake.

Bottom sediments in Pratfall Lake have become softer as a result of increased siltation, and the upper end of Silver Salmon Lake (Figure 1), in the same drainage, has also been affected. Drainage from Galion Pit, a gravel pit, has flowed into the stream between Pratfall Lake and Silver Salmon Lake. This has resulted in the deposition of silt in the vicinity of the stream mouth in Silver Salmon Lake.

Spilled oil has saturated the ground around a number of old water-pumping stations. One of these by Lake DP (Figure 2) is readily visible from the road. When examined, the ground was dark brown or black, the plants were dead, and there was evidence some oil had drained into the lake.

Oil spills, although readily visible, may not be as damaging as the less readily observed deposition of silt in lakes and streams. Studies of Clevenger Creek (Figure 1) which was severely damaged by spills of drilling mud in 1968 and 1969, have revealed a pattern of recovery. Continual dilution and degradation, providing the pollution is terminated, eventually cleanses the stream. Silt, on the other hand, particularly when the source remains, causes long-lasting effects. A detailed description of the total biological effects of the pollution in Clevenger Creek drainage will be incorporated into a Ph. D. dissertation by Valdez.

SUMMARY

The five freshwater ponds drained by Cannikin are not expected to refill and support fish populations. Of the estimated 10,700 freshwater fishes reported killed by Cannikin, 7 percent are considered game fish (Dolly Varden) and the remainder were stickleback. A 100 percent kill of fish occurred, of course, in the three fish-supporting ponds that were drained. The greatest stickleback mortality from pressure change was seen in Lake DK, about 1,210 meters from SZ, where an estimated 15 percent of the population was killed. Estimates of 3, 5, and 8 percent were made in other ponds further from SZ. This compares to a calculated 85 percent kill of stickleback in Clam Lake and 50 percent in Lake AM, 500 and 684 meters respectively from Milrow SZ.

Analysis of data from salmon surveys of 1970 and 1971 on Amchitka reveals markedly fewer spawning adults returning during the odd-numbered year. This indicates a cycle typical of pink salmon runs in many areas, so the reduction in spawning adults should not necessarily be viewed as an effect of AEC activities on the Island.

Escape of drilling mud from ponds at Site D at the time of Cannikin, and a subsequent release of additional liquid has severely depleted the aquatic population in one branch of a stream near the site. Spilled oil and silt from roadside and gravel pit runoff have caused additional damage in other lake and stream systems.

REFERENCES

- Kaganovskii, A. G. 1949. Some problems of the biology and population dynamics of pink salmon. (Taken from Pacific Salmon, selected articles from Soviet periodicals translated from Russian). Israel Program for Scientific Translations. pp. 127-183.
- Kirkwood, J. B. and Fuller, G. 1972. Amchitka Bioenvironmental Program. Bioenvironmental safety studies, Amchitka Island, Alaska; Cannikin D+2 months report. Battelle Columbus Laboratories, U. S. AEC report BMI-171-147, 99 pp.
- McCann, J. A. 1962. A summary of biological field work done on Amchitka during the summer of 1962. Progress report submitted to Aleutian Islands National Wildlife Refuge, Cold Bay, Alaska. 42 pp.
- Neuhold, J. M., W. T. Helm, and R. A. Valdez. 1971. Amchitka Bioenvironmental Program. Freshwater vertebrate and invertebrate ecology of Amchitka Island. Annual progress report, July 1, 1970 - June 30, 1971. Battelle, Columbus Laboratories, U. S. AEC report BMI-171-142, 25 pp.