Water Quality Status Report

Salmon River – Main Stem

(Headwaters to below Middle Fork)

Report No. WQ-31

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Idaho Department of Health & Welfare
Division of Environment
Statehouse, Boise, Idaho 83720

WATER QUALITY STATUS REPORT

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(Headwaters to below Middle Fork)

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ABSTRACT

Fifteen water quality stations in the Salmon River Basin were sampled bi-weekly for a year. Eight of the stations were on the Main Salmon River and the remaining seven represented the major tributaries. This portion of the study extended from Stanley to below the confluence with the Middle Fork (a distance of 253 km (158 miles).

Additional samples were collected by an Idaho State University Research team at five headwater stations. These stations were sampled quarterly.

Benthic insect collections were made once at each of the 15 stations. These samples were collected in July of 1976.

The results suggest that the discharge during runoff represents such a large proportion of the total annual flow that runoff loadings are indicative of mean annual loadings. Phosphorus is associated with sediment particles in the Salmon River and fluctuate as a function of turbidity. Nitrogen sources in the Salmon River are not flow related, so the sources seem to be within the channel and remain constant over the year. Total alkalinity is highly correlated with specific conductivity ($r^2 = 0.97$). This indicates that the majority of the anions are carbonates.

The Salmon River meets all general and specific water quality standards. No problems with aesthetics, organic toxicity, or inorganic toxicity were noted. No adverse impacts from non-point sources were identified from these data. The benthic insect community appears healthy, with the exception of one station at the mouth of Panther Creek. The latter drains a mining area and may discharge toxic substances upon occasion. None of these substances were detected in the grab samples reported in this study.

INTRODUCTION

The Salmon River is Idaho's most pristine large river. Flow is unregulated. The watershed is sparsely populated. Ranching and recreation are the most significant human activities in the basin. Only three small cities are located in the upper section of the Salmon River Basin. Stanley is near the headwaters, well above the confluence with the Yankee Fork (Figure 1). Challis is 90 km (55 miles) downstream, below the confluence with the East Fork. Salmon is another 90 km (55 miles) downstream. In this area there are no other significant concentrations of people which are located near the river or its tributaries.

This study was designed to provide background water quality data at selected stations over the entire 20,720 km^2 (8,000 mi^2) drainage area. Relatively few stations were sampled in the interest of reduced costs. The data will provide superficial information that will highlight water quality problems. Detailed collections in particular problem locations would be required as a follow-up to this study. Thus this report is essentially descriptive, and does not attempt to relate cause with specific effects.

Emmett (1975) has documented the channel morphometry and water chemistry of much of the Upper Salmon River Basin. His work dealt primarily with surficial geology, hydrology, and the relations between water chemistry and discharge.

Idaho State University is participating in a major grant from the National Science Foundation. That grant, under the direction of Dr. G. W. Minshall, is investigating several aspects of stream ecosystem function in the Upper Salmon River. Some of the data from this study were collected by that research team. Stations A-E (Figure 1) were part of a joint effort between Idaho State University and the Idaho Division of Environment.

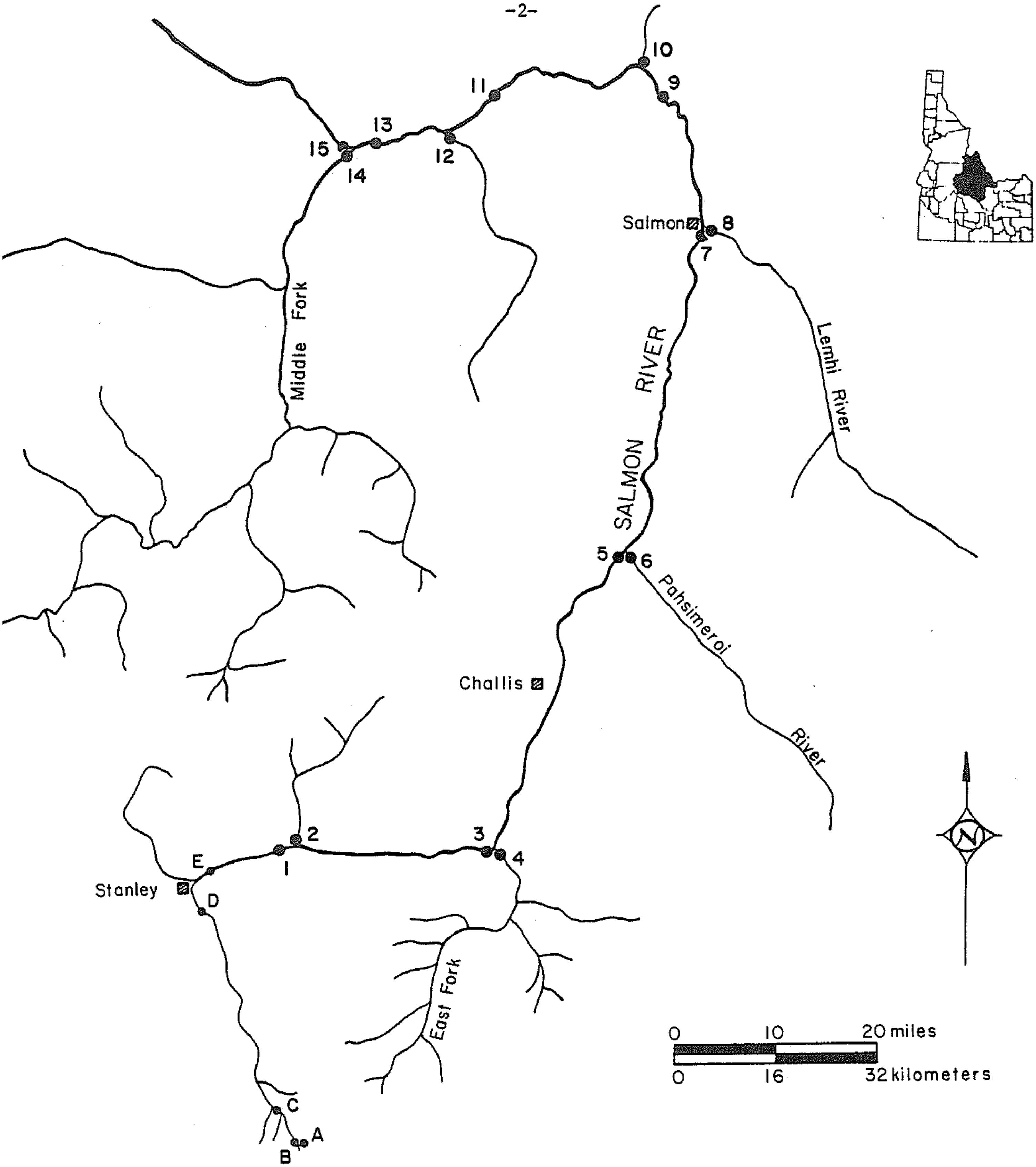

Figure 1. Map of Salmon River Basin showing sampling stations.

METHODS AND MATERIALS

Twenty stations in the Salmon River Basin were sampled in 1976 (Figure 1). Fifteen stations were selected on the main Salmon River and its tributaries (Stations 1-15). These were sampled bi-monthly. Five additional stations near the headwaters of the Salmon River were sampled quarterly (Stations A-E). These latter stations were sampled by personnel from the "River Continuum" group from the Idaho State University Department of Biology.

Water quality samples were collected as grab samples from mid-stream at mid-depth. Water samples were cooled to 4° C, and one liter of sample from each station was preserved with 2 ml of concentrated sulfuric acid. Metals samples were preserved with 2 ml concentrated nitric acid per liter. All laboratory analyses were conducted by the Idaho Department of Health and Welfare, Bureau of Laboratories. All laboratory methods followed EPA approved procedures.

Benthos samples were collected with a kick net. Benthos samples were only collected at the 15 main river stations, July 26-27, 1976. They were preserved in 70% Isopropyl alcohol. Samples were sorted and the organisms identified in the laboratory. Standard references such as Edmondson (1972), Pennak (1969), and Usinger (1963) were used for identification. In addition, many specialized references such as Jensen (1966) and Smith (1968) were used in the identification of selected groups of organisms.

Discharge measurements were obtained at the USGS gage stations on each sample trip. Discharge at the other stations has been extrapolated from those data.

RESULTS

Loadings for several parameters have been calculated for the study period. Mean annual discharge and discharge during runoff are presented in Figure 2. In water year 1976, runoff discharges were three times the annual mean values. This causes the two curves to be parallel throughout the river. The extreme effect of runoff discharges skewed annual loadings as well, giving a less-than-accurate picture.

Total phosphorus (Figure 3) shows a gradual increase downstream with a dramatic increase in the canyon below Shoup. This is primarily a result of increased discharge in the lower river; i.e., below River Mile 215. Phosphorus loadings in the major tributaries do not contribute significantly to main stem loadings so increased loadings are apparently from main watershed runoff. Total nitrogen (Figure 4) gradually increases between Stanley and Salmon. The decrease in loadings between North Fork (River Mile 235) and Shoup (River Mile 215) is apparently due to dilution by springs and by the North Fork of the Salmon River. Again, increased loadings in the lower river are the reflection of increased discharge.

Chemical Oxygen Demand (COD) is increased between the Pahsimeroi and the Lemhi Rivers. This part of the Salmon River Basin is agricultural and the higher COD loadings are probably due to organic matter washing in from farmland. Fecal coliform values increase slowly downstream (Figure 6A), but are sharply reduced at the lowest station. One would expect very little fecal coliform input into the lower river, so these reduced values are as expected. All values are very low. The mean coliform levels for the entire watershed are very low except during runoff (Figure 6B). In May, four of six samples exceeded the state standard for Class A_2 waters. That standard is 50 colonies per 100 ml. Turbidity displays a nearly linear increase with river mile (Figure 7). The four uppermost major tributaries; i.e., Yankee Fork, East Fork, Pahsimeroi and Lemhi Rivers, are all more turbid than the main stem. This shows that the tributaries in this section of the river are affecting the turbidity of the main stem. The tributaries were not found to significantly influence any other main stem parameter.

Mean ionic load of the Salmon River (Figure 8) shows that the Salmon is closely related to the Columbia River. The Salmon has a high percentage of calcium, carbonate, and silica among its dissolved ions. These are indicative of the geology of the basin.

Benthic macroinvertebrates were collected at each station in July 1976. A list of the species collected is presented in Table 1.

Heavy metals were analyzed in the water samples from the Salmon River. Metals were examined at each station twice during the study. Most metals were undetectable. No heavy metals were found in concentrations known to be toxic to aquatic life.

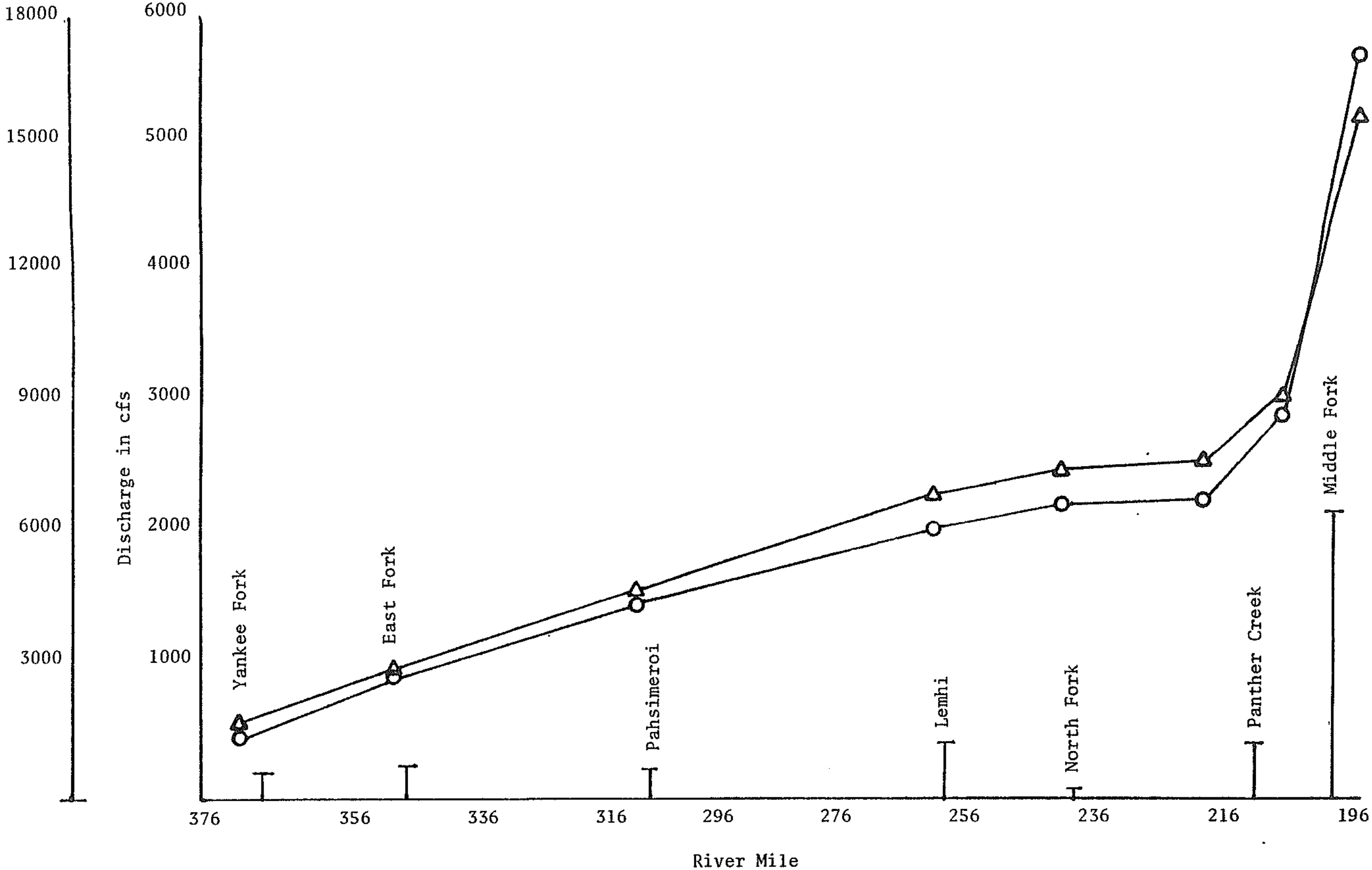

Figure 2. Hydrograph of the Salmon River, November 1975 to November 1976. Δ's are mean annual flows and O's are runoff discharges. Vertical bars are mean annual discharge of tributaries.

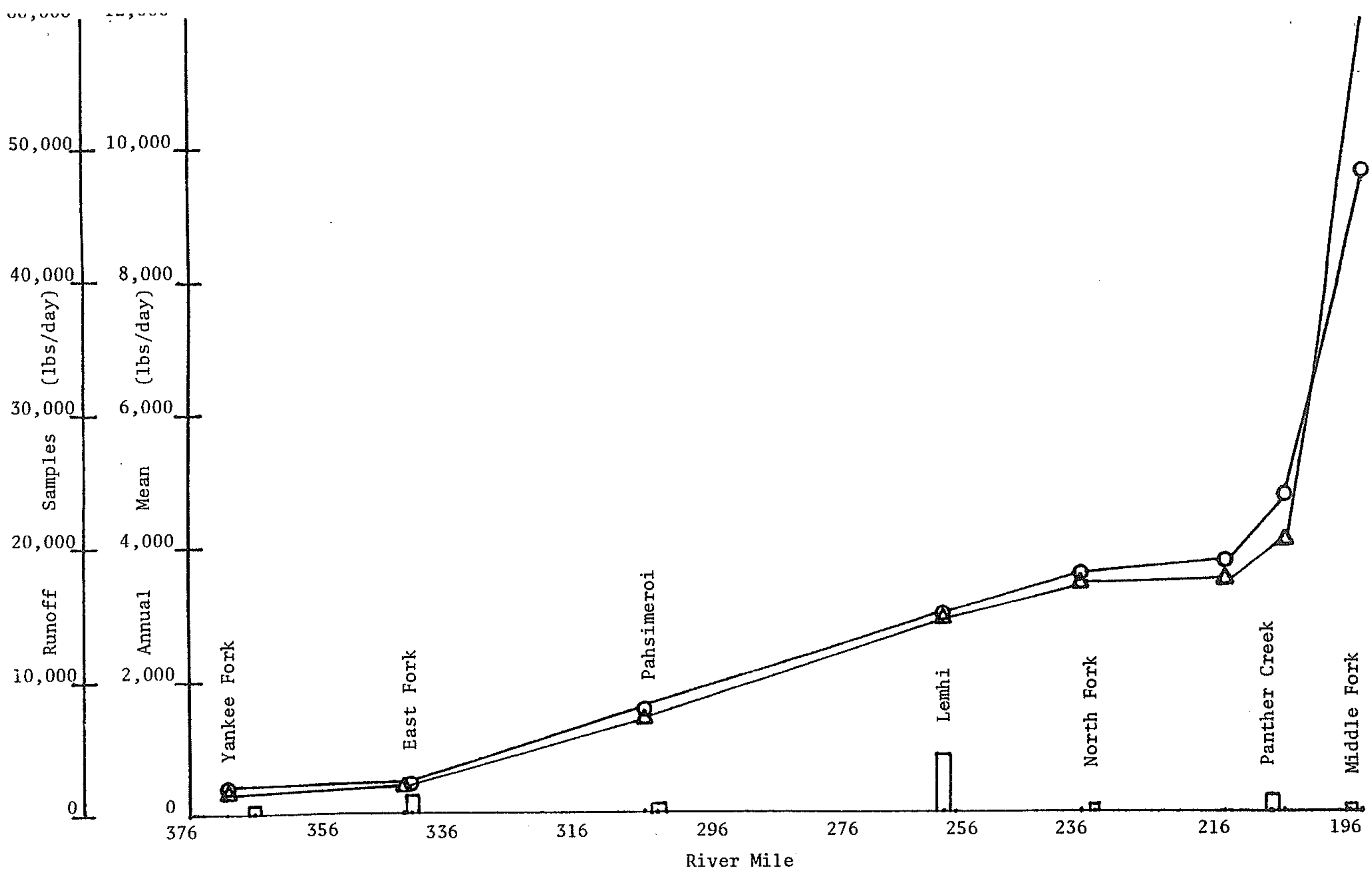

Figure 3. Total phosphorus loading in the Salmon River. △'s are annual means, and O's are samples taken during runoff. Note the different scale for samples taken during runoff. Histograms are annual mean tributary loadings.

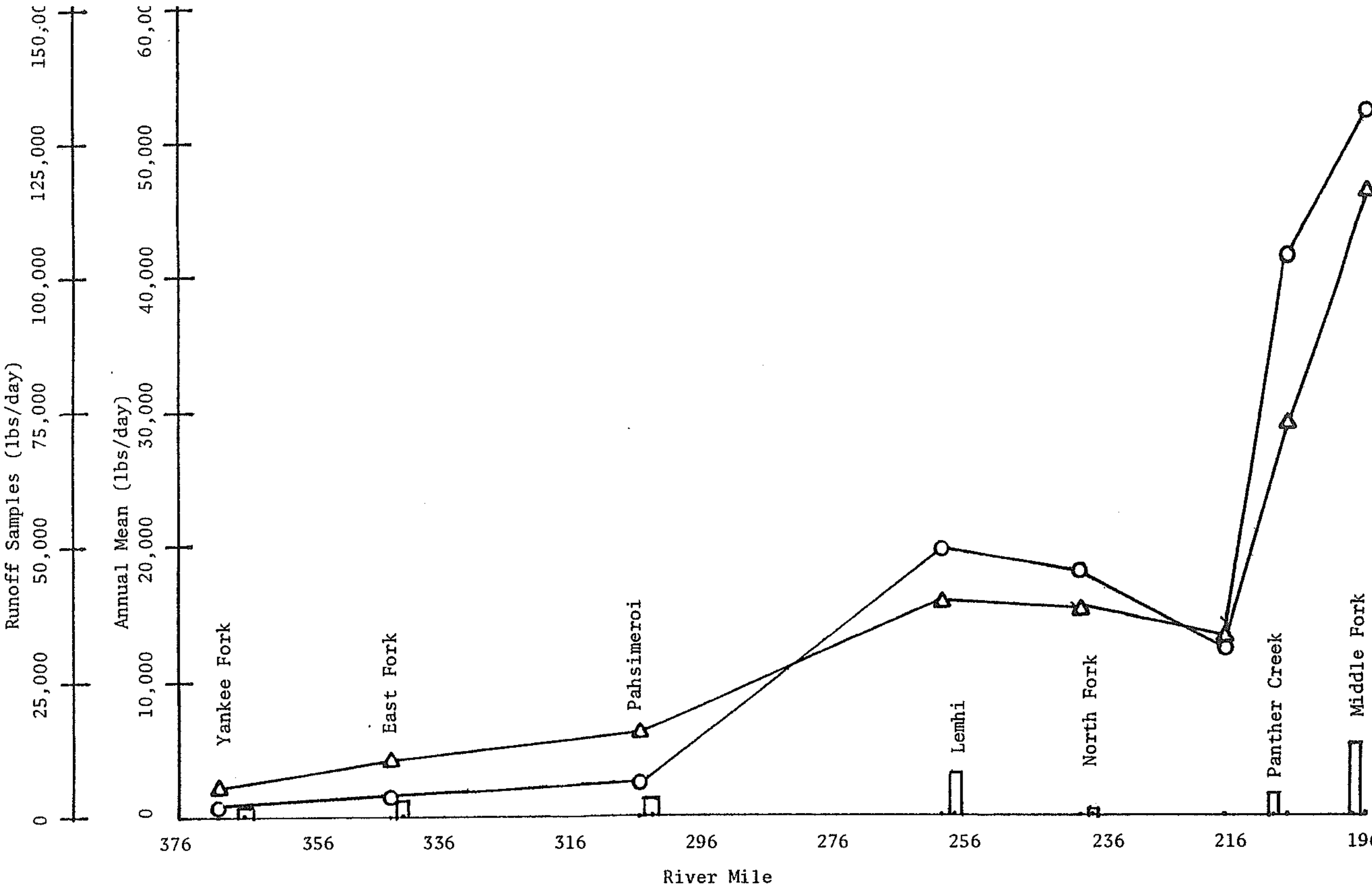

Figure 4. Total nitrogen loadings in the Salmon River. △'s are annual means, and O's are samples taken during runoff. Note the different scale used for runoff samples. Histograms are annual mean tributary loadings

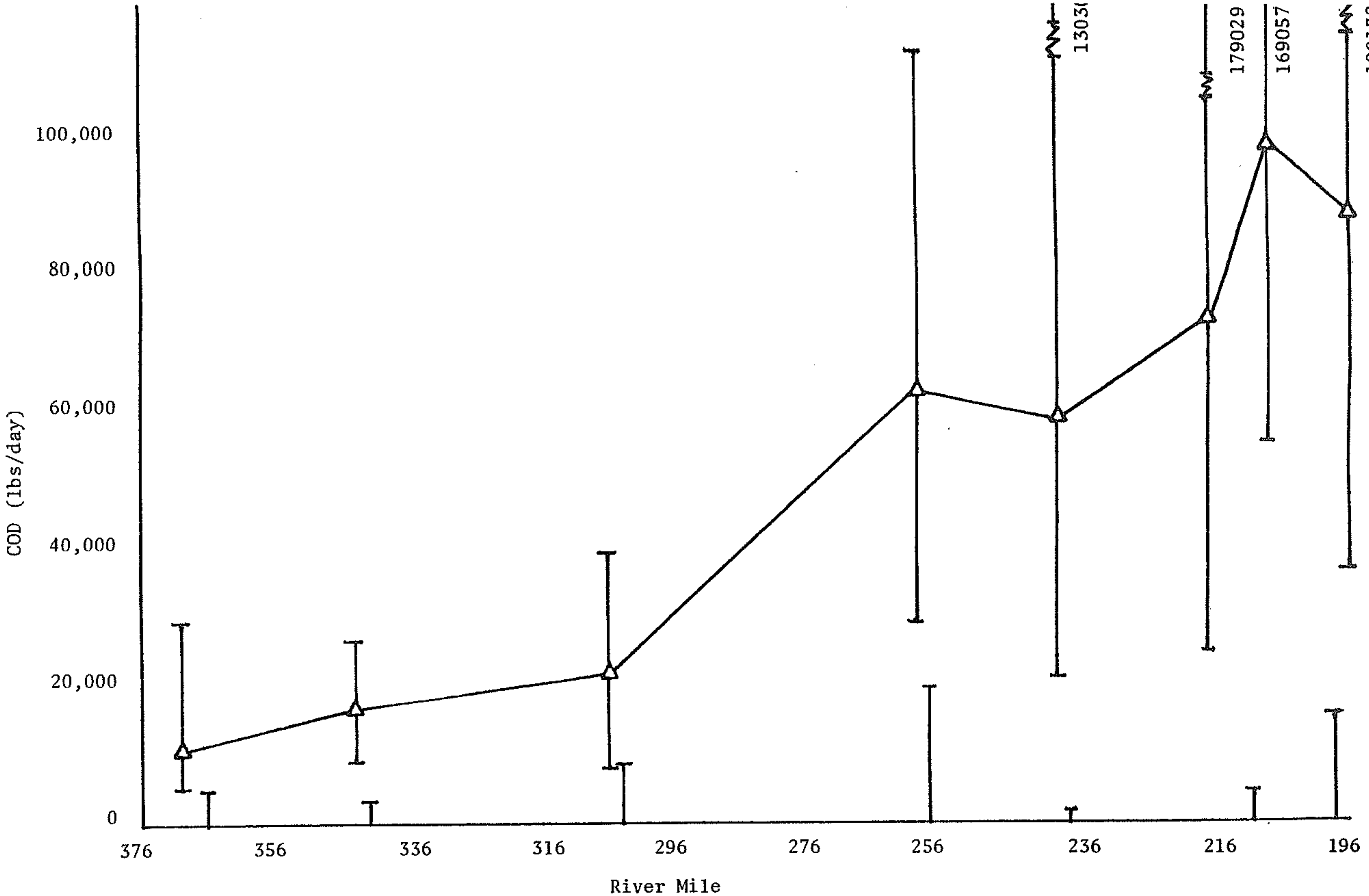

Figure 5. Annual mean Chemical Oxygen Demand (COD) in the Salmon River. Vertical bars about the means are ranges. Vertical bars from the baseline represent mean annual tributary loadings.

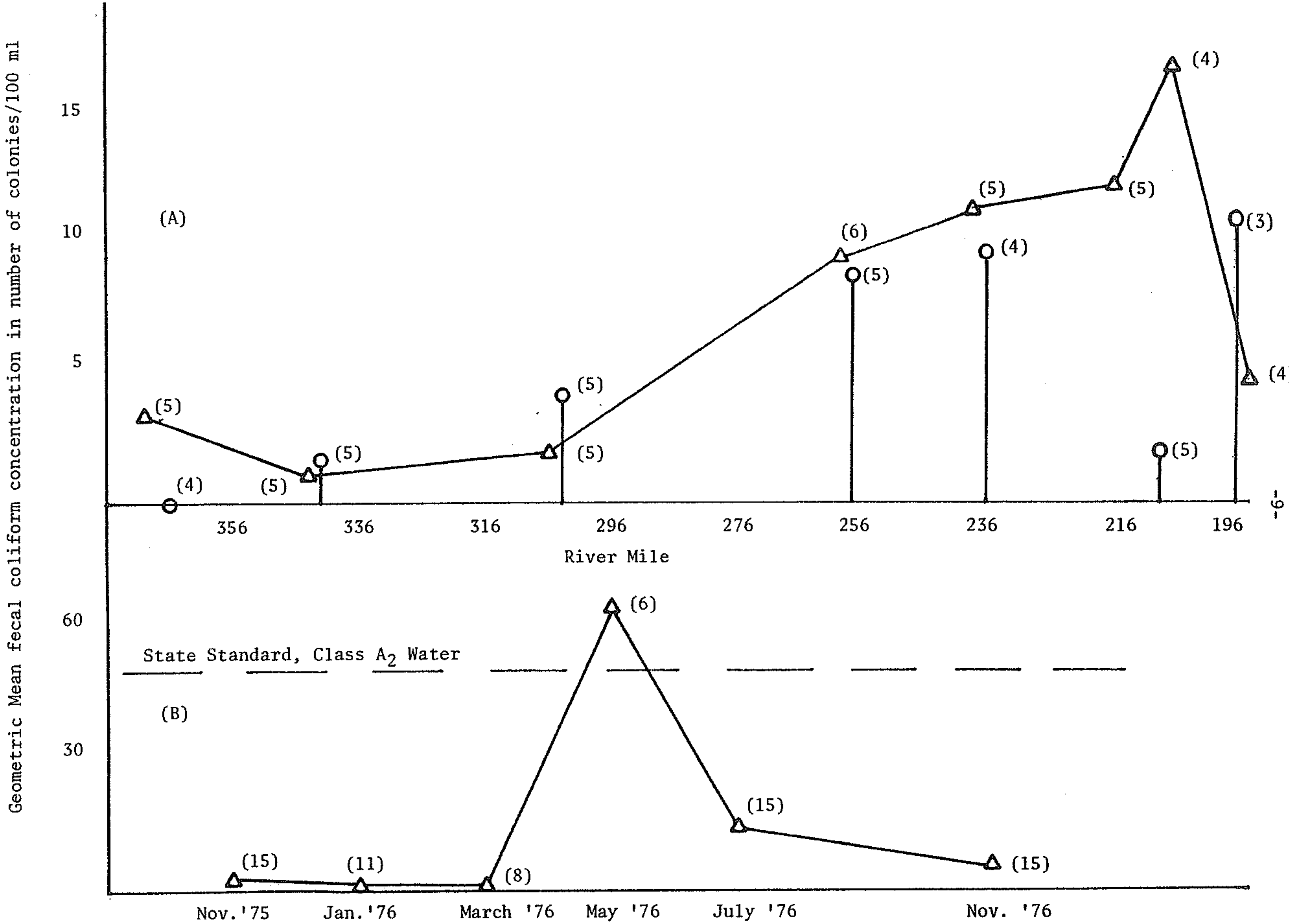

Figure 6. Geometric mean fecal coliform levels in the Salmon River. (A) Annual geometric mean at the Salmon River sample station. Vertical bars represent tributary concentrations. (B) Geometric mean for the entire Salmon River basin at several sample periods. Numbers in parentheses beside sample points represent number of samples for that point.

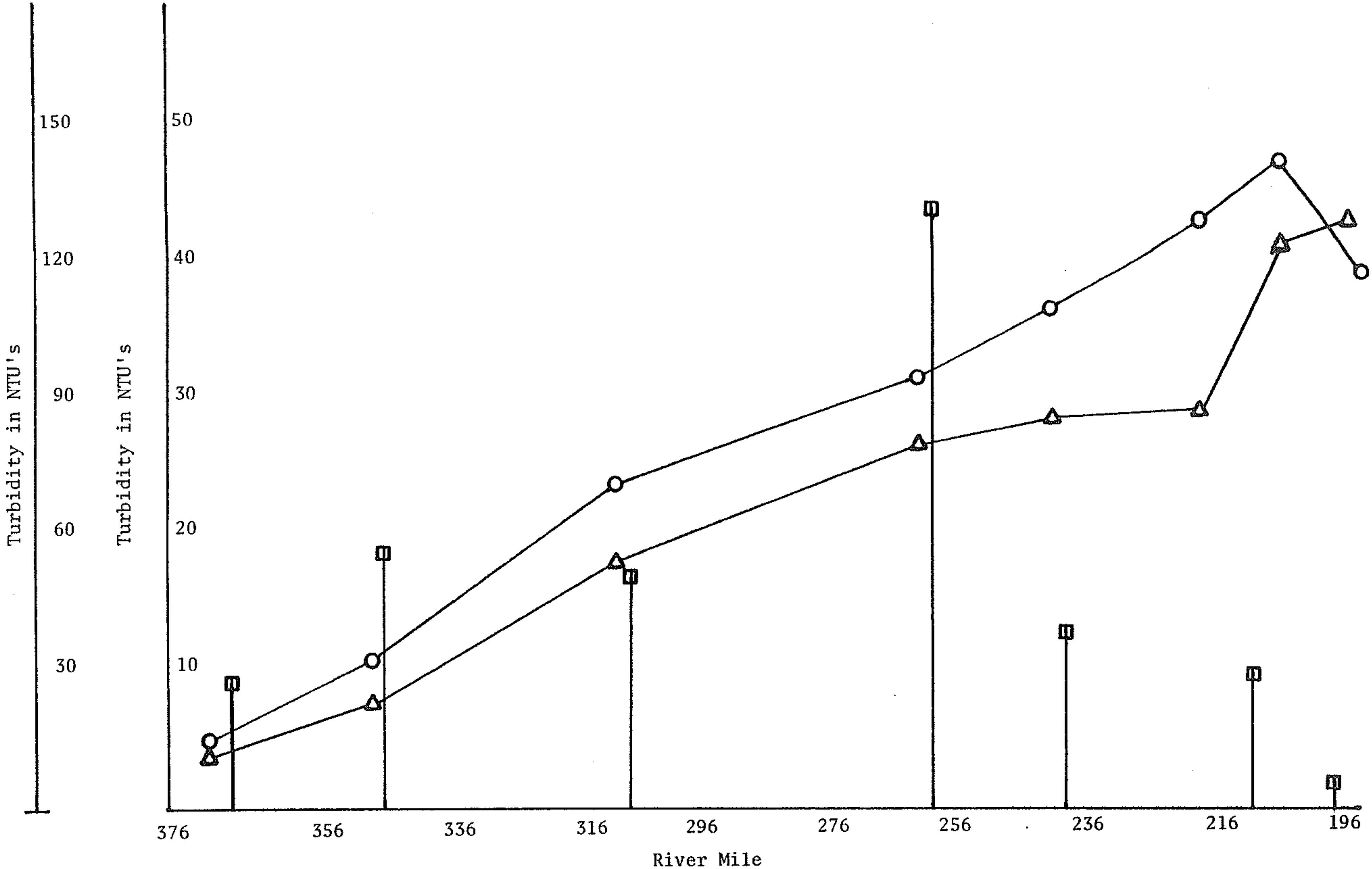

Figure 7. Mean annual turbidity in the Salmon River (Δ) and runoff turbidity (O). Vertical bars are mean annual turbidity contributions from tributaries.

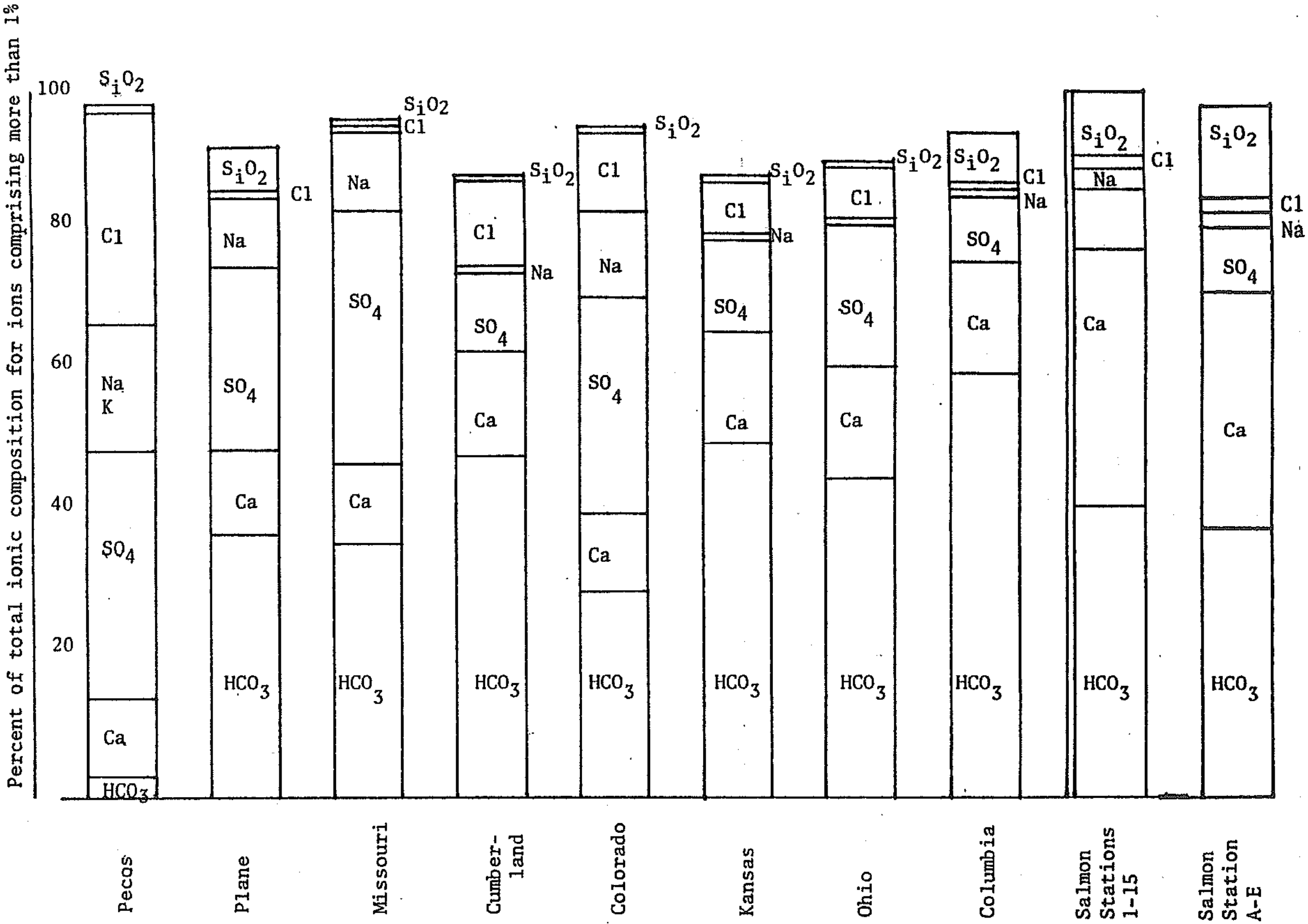

Figure 8. Mean annual ionic concentration of selected rivers. All data except those from the Salmon are from Morisawa (1968). They represent annual mean concentrations at a single station. Salmon River data are from this study and represent annual mean concentrations for the entire study area.

Table . Species list of benthic macro-invertebrates collected from the Salmon River drainage. Collection made July 26-27, 1976.

	Stations														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
EPHEMEROPTERA															
Baetis alexanderi								X						X	
B. bicaudatus			X	X	X						X				
B. intermedius	X									X					
B. parvus				X				X	X		X			X	X
B. tricaudatus		X													
Cinygma integrum							X								
Cinymgula sp.		X													
Epeorus albertae	X		X	X							X			X	X
E. longimanus		X		X											
Ephemerella doddsi		X													
E. flavilinea	X	X	X	X						X	X			X	
E. hecuba									X						
E. heterocaudata		X													
E. inermis					X	X		X	X	X	X		X		X
E. infrequens					X										
E. tibialis	X	X	X	X			X				X		X	X	
Heptagenia criddlei					X				X	X	X				
H. simplicoides			X												
Paraleptophlebia debilis							X		X						
Tricorythodes minutus									X	X		X			
PLECOPTERA															
Acroneuria pacifica		X	X								X			X	X
Claassenia sabulosa															X
Isogenus sp.										X				X	
Isoperla mormona				X	X										
I. patricia								X							
I. sordida								X							
Paraperla frontalis														X	
Pteronarcys californica														X	
P. dorsata				X											
P. principes			X		X			X							
TRICHOPTERA															
Arctopsyche sp.										X					
Athripsodes sp.														X	
Brachycentrus sp.	X	X	X		X	X				X			X	X	
Chimarra sp.											X				
Diplectrona sp.				X											
Hydropsyche sp.		X	X	X			X	X			X			X	X
Hydroptila sp.			X												
Leptocella sp.	X							X						X	
Micrasaema sp.								X							
Parapsyche sp.		X			X										
Rhyacophila acropedes										X					
R. tucula		X													

	Stations														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
DIPTERA															
Atherix sp.	X			X								X			
Chironomus sp.	X	X	X	X	X	X	X	X		X					
Simulium sp.				X							X				X
Tipula sp.			X							X					X
COLEOPTERA															
Optioservus sp.	X	X								X				X	X
ODONATA															
Libellula sp.							X								
MOLLUSCA															
Fluminicola sp.							X		X	X			X		X
Lymnaea sp.										X				X	
Physa sp.			X												
Planorbidae					X										
OTHER															
Cottus sp.									X						

DISCUSSION

Discharge during runoff comprised 46% of the annual flow in the basin during the study period. Runoff also caused increased turbidity in the waters, as would be expected. Turbidity increased from a low water basin-wide mean of 7.0 units to a high water mean of 79.7 units. This increased sediment also caused a dramatic increase in phosphorus concentrations. Mean total phosphorus concentration at low water was 0.04 mg/l and at high water was 0.37 mg/l. The relationship between total phosphorus and turbidity was very strong: $r^2 = 0.92$. This indicates that the majority of the phosphorus in the Salmon River system is adsorbed onto the surface of sediment particles.

This relationship does not seem to hold with very low concentrations of turbidity and total phosphorus. Emmett (1975) measured these parameters at many stations in the headwaters of the Salmon River. A regression on 120 of his reported values shows an r^2 of 0.39. The turbidity range was 0 to 31 and the phosphorus range was 0.01 to 0.35 mg/l. The majority of the values were even on the low end of these scales.

Mean low water total nitrogen concentration was 1.09 mg/l and mean high water concentration was 0.96 mg/l. The turbidity: Total nitrogen correlation (r^2) was 0.08. This indicates that the nitrogen sources in the Salmon River Basin are relatively constant and are not affected by high discharges in the spring. Emmett (1975) only measured nitrite and nitrate nitrogen. The correlation between those parameters and discharge showed a median r^2 of 0.44.

Minshall (personal communication) collected water samples at 80 stations in the Salmon River Basin in October 1976. The samples were analyzed for specific conductance and alkalinity. The correlation (r^2) between these two variables at this one time was 0.96. Data from this study were examined for the same relationship. The correlation (r^2) between alkalinity and conductivity at 15 stations over a full year was 0.97. The regression equation for data from this study was: Conductivity equals 2.29 alkalinity -6.88 ($r^2 = 0.97$, N = 85). The combined equation for this data and Minshall's data was: Conductivity = 2.09 alkalinity -8.68 ($r^2 = 0.87$, N = 165). This shows that the relationship is valid over a wide range of stations and at all seasons.

Emmett (1975) did not discuss the relationship between conductivity and alkalinity. He did, however, find a median r^2 of -0.90 in the relationship of alkalinity to discharge. He also comments that alkalinity varies as the -0.21 power of discharge and conductivity varies as the -0.23 power of discharge.

The headwaters of the Salmon River (Stations A-E) were not found to vary significantly with regard to any parameter. That is, within the scope of this work, the five uppermost stations have similar water quality amongst themselves and that water quality does not vary significantly over the year. These results are attributable to several factors: (1) The scales we are working with are rather coarse for detecting minor differences. (2) The ranges of concentration are nearly all within the limits of the tests. (3) The water quality results are based on quarterly grab samples. (4) This portion of the Salmon River is quite pristine. (5) Our scope of analysis is geared toward detecting major degradations caused by man. Other scales of analysis for other interest groups may indeed be able to detect "significant" differences among these five headwater stations.

CONCLUSIONS

1. Discharge during runoff skews the mean annual hydrograph to such an extent that all samples are a function of runoff loadings. Therefore, if one uses the relationships developed in this study, loadings taken during runoff can be extrapolated to base flow loadings. One could derive a general knowledge of the annual loadings in the Salmon River from a series of samples collected during high flow.

2. Phosphorus in the Salmon River is essentially a function of suspended sediment load. The phosphorus is adsorbed onto the surface of sediment particles, and phosphorus loadings fluctuate as suspended sediment does. The correlation between total phosphorus and turbidity was very high (r^2 = 0.92, N = 68, turbidity range = 0.6 to 140, phosphorus range = 0.01 to 0.89 mg/l). In the headwaters of the basin, both turbidity and phosphorus levels remain low and the correlation falls to 0.38 (Emmett 1975).

3. Total nitrogen in the Salmon River is unaffected by runoff and other changes in hydrology. The nitrogen concentrations do not fluctuate annually. The correlation between total nitrogen and turbidity (an indicator of sediment loading) was 0.08. Thus, nitrogen sources are within the river channel and are able to maintain relatively constant concentrations all year.

4. Total alkalinity is highly correlated with specific conductivity; i.e., the predominant anions are carbonates. The annual relation between alkalinity and conductivity, based on this study, showed an r^2 of 0.97. Previous data, based on 80 samples taken over the whole basin in October 1976 showed an r^2 of 0.96 for the same two parameters.

5. The Salmon River usually meets all specific water quality standards. Only four of 70 fecal coliform samples failed to meet the limit for Class A_2 waters. The four samples that exceeded the 50 colonies per 100 ml standard were all taken from the main Salmon River in May. They came from the four main stem stations from Salmon downstream.

6. The Salmon River also meets the general water quality criteria for toxic substances, trophic status, and other areas of concern.

7. No adverse affects from non-point sources were shown by these data.

8. The Salmon River benthic insect community is indicative of a healthy high quality stream. Only the station at the mouth of Panther Creek (SAR-12) showed discernible stress.

RECOMMENDATIONS

The Salmon River is a great asset to the State of Idaho and every effort should be made to maintain the resource at its present high quality.

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APPENDIX A: GLOSSARY OF TERMS

Benthos: Organisms living on the bottom of a stream.

Bi-weekly: Once every two weeks.

cfs: See "Cubic Feet Per Second."

Cubic Feet Per Second (cfs): An expression of discharge water passing a given point in one second. Also called "second-feet."

Cubic Meters Per Second (cms): A metric expression of discharge measurement. One cms equals 35.31 cubic feet per second (cfs).

Geometric Mean: The Nth root of the product of N numbers. Used as a way of calculating the mean of a series of numbers where the extremes vary widely from the mean. Also used for mean population levels of animals.

Hydrograph: A graph of the discharge of a river at several points over time.

Loadings: The weight of a concentration of a dissolved or suspended substance in water. Use of a loading calculation allows one to express the relative importance of water quality parameters in streams of various sizes.

m^3/sec. (cms): See "Cubic Meters Per Second."

mg/l: See "Milligrams Per Liter."

Milligrams Per Liter (mg/l): The number of milligrams (thousandths of a gram) of a substance in one liter of water equivalent to parts per million (ppm).

Macro-Benthos: See "Benthos."

NTU: Nephelometric Turbidity Unit. NTU is the unit of measure of the intensity of scattered light in comparison to a standard reference suspension. Readings are essentially equivalent to the Jackson Turbidity Unit (JTU) differing only by the instrument used which is called a nephelometer.

Non-point Source: Pollutants entering a stream from a broad, poorly defined area. The contrast of a "Point Source" in which pollutants are discharged to a water body directly; e.g., through a pipe.

Point Source Discharge: A direct, discrete effluent to a water body. Also see "Non-point Source."

SAR: See "Sodium Absorption Ratio."

Sodium Absorption Ratio: The relation between sodium, calcium, and magnesium in a water body. Abnormally high sodium concentrations may be detrimental to plant growth. SAR's of less than 4.00 are not considered harmful.

Water Quality Limiting: A designation given a stream segment indicating that the segment will not meet water quality standards after implementation of "secondary treatment" for publicly-owned treatment works and "Best Available Treatment" for all other point source dischargers.

APPENDIX B: FINAL STUDY PLAN OF SALMON RIVER STUDY

The Salmon River drains a major watershed which is extensively and intensively used for recreation. The river has great aesthetic appeal and offers many benefits to fish and wildlife. A portion of the river, such as the Middle Fork, drains areas that are under consideration as wilderness areas. Our data base on the water quality of the Salmon River is presently insufficient to allow rational judgement of the Classification Schemes available. Although the loading of pollutants in the Salmon River is expected to be very low, additional data will be needed for two reasons:

1. To document the current level and provide baseline data against which to monitor future changes, and

2. To provide an adequate data base to make decisions regarding the stream classification of the river.

This study has been designed in conjunction with the Planning Section and should fulfill two objectives:

1. Adequate characterization of the pollutant load of the Salmon, in regard to current water quality standards, and

2. Provide information that may be of use in new water quality standards.

The study will begin in November 1975 and continue through November 1976. Samples will be taken bi-monthly at eight main stem river stations and at the mouth of seven tributaries. The primary data collected will be chemical-physical water quality data. We acknowledge the superiority of biological monitoring for assessing long-term trends. On a large river sampled bi-monthly, however, it does not seem feasible to attempt biological monitoring. That aspect of the program should be reserved for a more detailed study that will investigate smaller portions of the river on a more intensive basis.

The stations to be sampled are as follows:

SAR-1: Salmon River below Stanley, above the confluence with the Yankee Fork; sampled from the Rough Creek Bridge.

Stream Segment: SB-10
Latitude : 44°15'N
Longitude : 115°49'W

SAR-2: Yankee Fork of the Salmon River at the mouth; sampled from the bridge at Sunbeam.

Stream Segment: SB-110
Latitude : 44°15'N
Longitude : 115°44'W

SAR-3: Salmon River at East Fork; sampled from the bridge at the mouth of the East Fork.

Stream Segment: SB-10
Latitude : 44°15'N
Longitude : 114°19'W

SAR-4: East Fork of the Salmon River at the mouth; sampled from the highway bridge at the mouth.

Stream Segment: SB-120
Latitude : 44°15'N
Longitude : 114°19'W

SAR-5: Salmon River at Deer Gulch Bridge above Ellis.

Stream Segment: SB-20
Latitude : 44°40'N
Longitude : 114°05'W

SAR-6: Pahsimeroi River at mouth; sampled from the bridge at Ellis.

Stream Segment: SB-210
Latitude : 44°41'N
Longitude : 114°03'W

SAR-7: Salmon River at Salmon; sampled above the confluence with the Lemhi River.

Stream Segment: SB-30
Latitude : 45°11'N
Longitude : 113°53'W

SAR-8: Lemhi River at the mouth; sampled from the bridge in Salmon.

Stream Segment: SB-310
Latitude : 45°11'N
Longitude : 113°54'W

SAR-9: Salmon River at the bridge; sampled two miles above Wagonhammer Springs.

Stream Segment: SB-40
Latitude : 45°24'N
Longitude : 113°58'W

SAR-10: North Fork of the Salmon River at the mouth; sampled from the bridge at North Fork.

Stream Segment: SB-410
Latitude : 45°25'N
Longitude : 113°59'W

SAR-11: Salmon River below Shoup, at the bridge below Pine Creek.

Stream Segment: SB-40
Latitude : 45°22'N
Longitude : 114°19'W

SAR-12: Panther Creek, from the bridge at the mouth.

Stream Segment: SB-430
Latitude : 45°18'N
Longitude : 114°24'W

SAR-13: Salmon River from the Cove Creek Bridge, just above the USGS gage station.

Stream Segment: SB-40
Latitude : 45°19'N
Longitude : 114°25'W

SAR-14: Middle Fork of the Salmon; a bank sample at the mouth.

Stream Segment: SB-440
Latitude : 45°17'N
Longitude : 114°36'W

SAR-15: Salmon River from the Stoddard Pack Bridge, below the Middle Fork.

Stream Segment: SB-50
Latitude : 45°17'N
Longitude : 114°37'W

The analyses to be run on each trip, at each station, will be as follows:

Temperature (field)	Silica
Dissolved Oxygen (field)	Hardness
*Turbidity	Magnesium
**Fecal Coliform Bacteria	Sodium
**Fecal Streptococci Bacteria	Potassium
**Total Coliform Bacteria	Alkalinity
***COD	Sulphate
Nitrate	Chloride
Ortho-phosphate	Fluoride
Total Kjeldahl Nitrogen	Specific Conductance
Total Phosphorus	

*Run in the Pocatello Benthos Lab as long as equipment is available.
**Run by the Salmon Hospital for Stations 1 through 8.
Run by the Pocatello Lab for Stations 9 through 15.
***Run by the Pocatello Lab.

In addition, samples will be taken for heavy metal analysis on the first, fourth, and seventh sampling trips; i.e., November 1975, May 1976, and November 1976. The following heavy metals will be analyzed on those samples:

Cobalt	Silver
Copper	Mercury
Lead	Antimony
Iron	Vanadium
Manganese	Uranium
Zinc	Cadmium
Arsenic	

These elements have been chosen on the basis of their known occurrences with minerals being mined in the Salmon River Basin; thus they might be expected to occur, or may occur, should mining activity increase.