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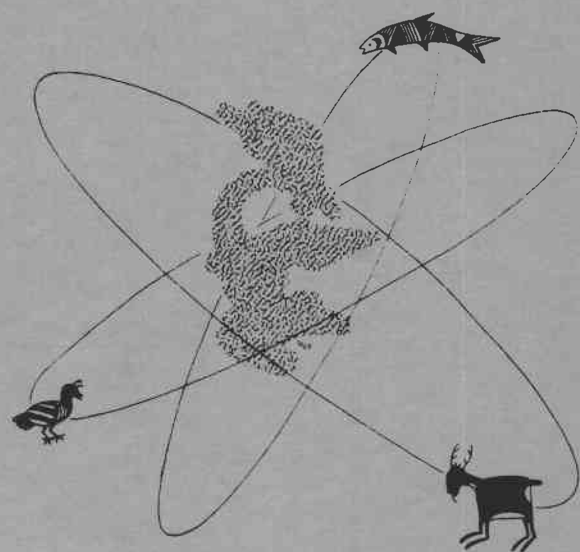

RESEARCH DIVISION

Oregon Wildlife Commission

AFS 62 STREAMFLOW REQUIREMENTS OF SALMONIDS

ANNUAL PROGRESS REPORT

ANADROMOUS FISH PROJECT

Project Title: Streamflow Requirements of Salmonids

Project Number: AFS-62

Job Number: 14-16-0001-4198

Project Period: July 1, 1974 to June 30, 1975

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ABSTRACT

This report presents data collected during the first full field season of a project designed to examine the streamflow requirements of juvenile salmonids. Problems encountered in the original design, changes made in the design and the application of the expected results are discussed.

BACKGROUND

The Oregon Wildlife Commission initiated a study in 1971 of the instream flow requirements for the rearing of salmonids. A literature survey was completed (Giger 1973a) and preliminary field investigations on Elk Creek, near Cannon Beach, Oregon, began in 1973 (Keeley and Nickelson 1974). The field investigations were designed to examine the effects of summer flow reductions of 0, 25, 50, 75 and 100 percent and flow augmentations of 0, 20, 40, 60 and 80 percent of the natural flow on juvenile salmonid production over a period of 5 years. To accomplish this, two similar forks of Elk Creek were connected by a 30-inch pipe to divert the flow from one fork to the other. This report deals with the first full field season of data collection following a design where a natural flow regime was studied.

OBJECTIVE

To determine techniques that can be used in natural streams to estimate the influence of stream discharge on fish production.

PROCEDURES

A. Collect production data from fish and aquatic invertebrate populations in study stream sections subjected to differing streamflow regimes between July 1 and October 31, 1974.

B. Map the physical character of stream channels and document changes in stream hydraulics and fish shelter conditions at different discharge stages between July 1 and October 31, 1974.

C. Analyze contents of fish stomachs and samples of benthos and invertebrate drift organisms collected during the summer field season.

D. Analyze field data from physical and biological investigations through development and utilization of specialized computer programs and statistical techniques; conduct regression analyses of production and physical data.

E. Design and implement similar research under revised flow regimes scheduled for the 1975 field season.

DESCRIPTION OF STUDY AREA

Elk Creek, Clatsop County (Figure 1) was selected as the study site. Flow diversion facilities were constructed in 1973. A detailed description of the study area is included in an earlier report (Keeley and Nickelson 1974).

Four study sections were established in 1973 upon completion of a survey of the North and West Forks of Elk Creek (Figure 1). Permanent markers were installed at 30 m intervals delineating cross sectional transects. The pipeline and flow control facility were used as the diversion between the upper and lower study sections on the two forks. Each of the four study sections was approximately 1200 m long.

Summer streamflows in the North Fork of Elk Creek during 1974 ranged from approximately 3 cfs to an estimated 200 cfs (Figure 2). The flow patterns in the West Fork followed that of the North Fork, however the flows were 1 cfs to 6 cfs greater in the West Fork. Permanent gaging stations were installed in September.

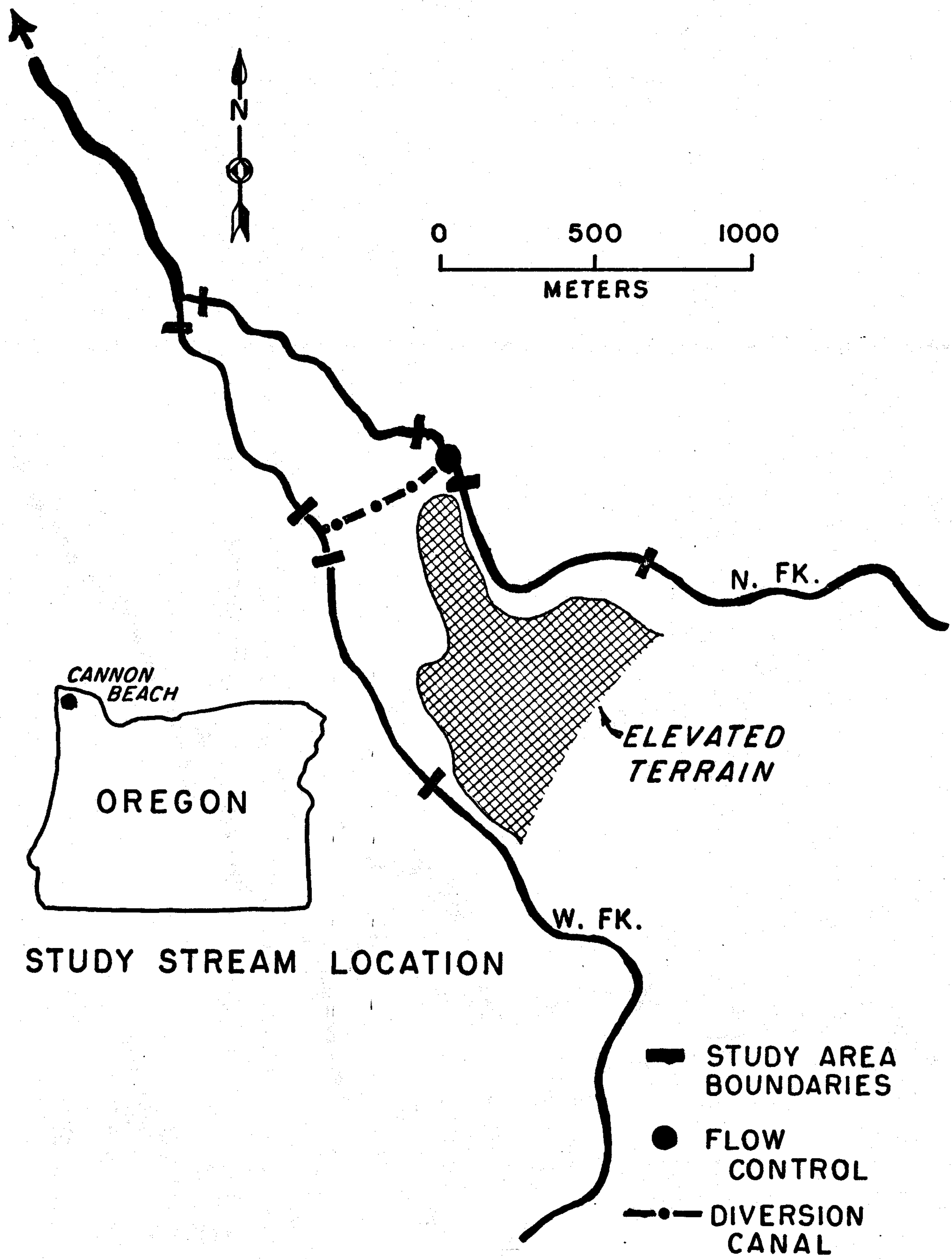

Figure 1. Elk Creek Study Area

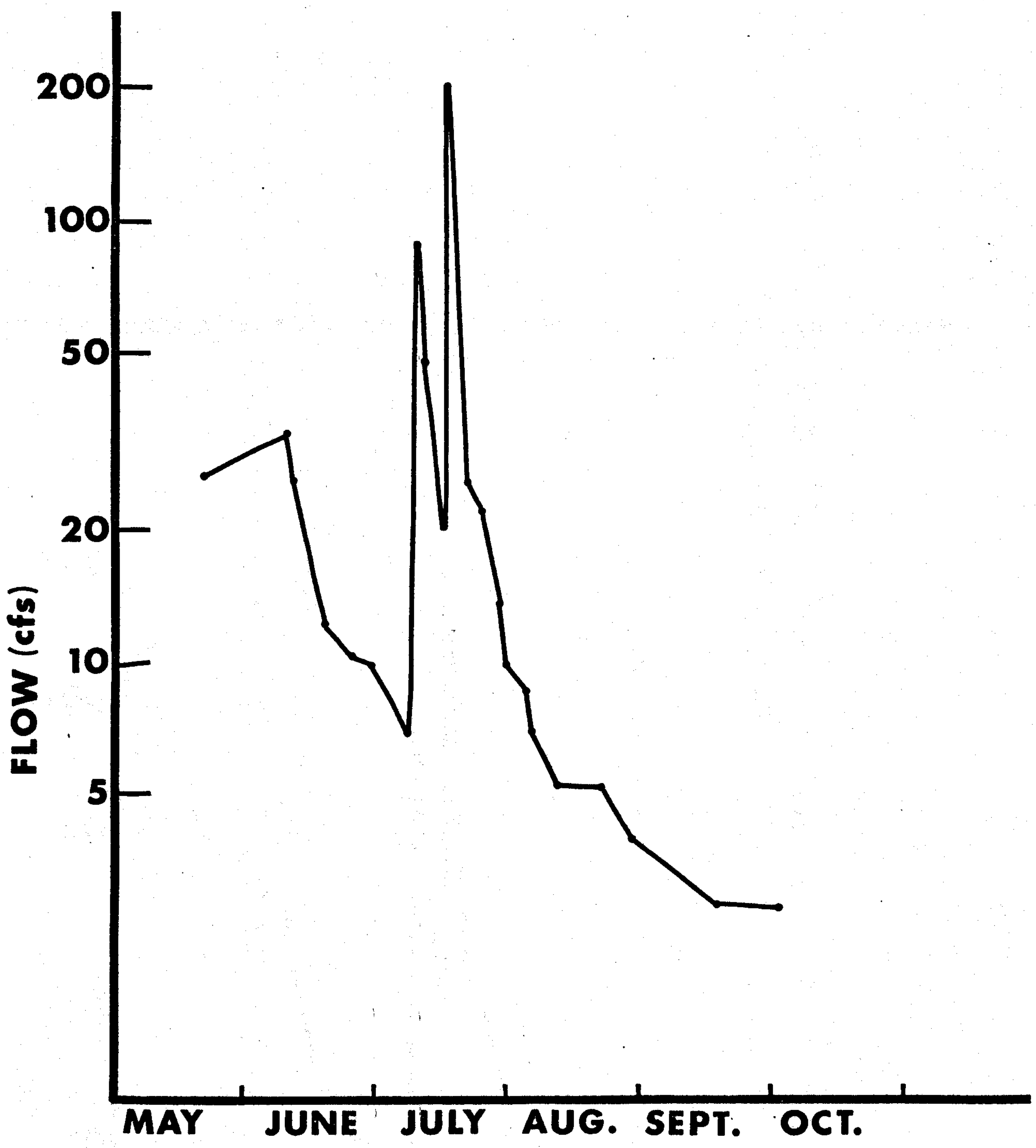

Figure 2. Estimated streamflows for the North Fork of Elk Creek during the summer of 1974.

Monthly mean water temperatures during the summer of 1974 ranged from 12.2°C to 14.0°C in the North Fork as compared with 12.2°C to 14.6°C in the West Fork (Table 1).

Table 1. Mean daily maximum and minimum water temperatures (°C) and the monthly mean daily temperature from June through September 1974 in the West and North forks of Elk Creek.

Month		West Fork	North Fork
June	Maximum	12.6°	12.3°
	Minimum	11.8°	12.0°
	Mean	12.2°	12.2°
July	Maximum	13.2°	13.2°
	Minimum	12.5°	12.9°
	Mean	12.9°	13.0°
August	Maximum	13.9°	14.8°
	Minimum	13.7°	14.6°
	Mean	13.8°	14.7°
September	Maximum	14.1°	14.7°
	Minimum	13.8°	14.5°
	Mean	14.0°	14.6°

COVER CHARACTERISTICS

Channel morphometry and fish cover conditions were mapped for 148 cross sectional transects. Table 2 contains a comparison of the cover characteristics of 38 transects in the Lower North Fork study section in 1973 and 1974. A considerable between-year difference was found in the gravel and the sand/ gravel substrate types, probably reflecting the subjectiveness of the determination of substrate type during the mapping process.

Table 2. Some enviornmental characteristics of 38 transects in the Lower North Fork study section of Elk Creek in 1973 and 1974.

Stream characteristics	1973	1974
Open sky (%)[1/]	9.3	13.2
Cover type (%)[2/]		
Lower tree canopy[3/]	10.0	13.5
Undercut banks	4.1	1.6
Vegetative overhang	1.1	1.7
Leaf litter	3.9	0.1
Small debris	2.3	2.2
Limbs	2.8	0.6
Logs	1.1	2.2
Substrate type (%)[4/]		
Silt	6.4	6.1
Sand	4.1	3.2
Sand/gravel	5.4	32.6
Gravel	71.4	52.1
Gravel/rubble	3.5	0.1

1/ Based on 180° horizon sky.
2/ Percentage of stream width composed of particular cover.
3/ Canopy 0-2.5 meters above water.
4/ Percentage of stream width composed of particular substrate.

STREAM HYDROLOGY

Stream hydrology measurements (width, depth, and velocity) were made on the majority of the cross-sectional transects each month during summer 1974. The July measurements coincided with the period of high streamflow (Figure 2). Due to the rapidly changing flows during this period, the July data were omitted from analysis.

A summary of the hydrologic measurements for the four study sections is presented in Table 3.

Table 3. Summary of the hydrologic measurements from each study section in June, August and September 1974.

Study section[1/]	Date	Estimated flow cfs	(m^3/s)	Mean width m	Mean depth m	Mean velocity m/sec.	Mean pool depth m	Mean pool vel. m/sec.	Mean riffle depth m	Mean riffle vel. m/sec.
LNF	6/19	12.4	(0.35)	8.89	0.30	0.22	0.42	0.14	0.14	0.35
LNF	8/12	5.3	(0.15)	7.97	0.27	0.17	0.37	0.10	0.12	0.29
LNF	9/10	4.6	(0.13)	7.66	0.26	0.16	0.38	0.08	0.11	0.27
UNF	6/10	33.3	(0.94)	11.29	0.43	0.32	0.57	0.19	0.27	0.47
UNF	8/13	5.3	(0.15)	9.53	0.36	0.10	0.45	0.06	0.12	0.20
UNF	9/11	4.6	(0.13)	8.92	0.35	0.10	0.41	0.06	0.10	0.28
LWF	6/25	13.0	(0.37)	8.76	0.38	0.28	0.46	0.20	0.20	0.44
LWF	8/13	5.3	(0.15)	8.28	0.33	0.18	0.41	0.11	0.14	0.33
LWF	9/12	4.2	(0.12)	7.89	0.30	0.16	0.40	0.09	0.10	0.31
UWF	6/11	29.0	(0.82)	10.22	0.35	0.36	0.43	0.25	0.21	0.63
UWF	8/14	5.3	(0.15)	8.63	0.30	0.17	0.37	0.11	0.12	0.36
UWF	9/10	5.0	(0.14)	8.55	0.29	0.17	0.37	0.12	0.13	0.31

[1/] LNF = Lower North Fork
UNF = Upper North Fork
LWF = Lower West Fork
UWF = Upper West Fork

FISH POPULATIONS

Salmonid populations were studied in three 150-meter study areas in each study section. Study areas were numbered 1-6 on the North Fork and 7-12 on the West Fork. Petersen population estimates (Ricker 1958) were made and length-weight samples were taken monthly from June through September. Study areas 7, 8, 9 and 12 on the West Fork were omitted after the June sampling revealed that the coho numbers were too low to make valid population estimates. Population estimates were not obtained for July due to high streamflows, however, length-weight samples were taken.

Fish biomass was estimated by multiplying the mean weight of a fish at a given time by the estimated population size at that time. Production estimates were calculated by averaging the biomasses of two adjacent sampling dates and then multiplying the mean biomass by the instantaneous growth rate of the fish for that period.

A summary of the age 0+ coho populations is presented in Table 4. The populations of age 0+ trout (Salmo gairdneri and S. clarki) were too small to provide valid estimates. A summary of the trout growth is presented in Table 5.

All trout greater than 90 mm fork length were tagged upon first capture. Only 35% of the 226 tagged trout available for capture in the eight study areas were ever recaptured. However, the data did indicate some movement between study areas.

Table 5. Growth rates for age 0+ trout (Salmo gairdneri and S. clarki) in Elk Creek. The three population sampling areas in each study section have been combined. Sample size is in parentheses.

Study section	June mean weight (g)	Growth rate	July mean weight (g)	Growth rate	August mean weight (g)	Growth rate	September mean weight (g)
LNF	0.42 (94)	0.39	0.56 (31)	1.10	1.94 (45)	0.74	3.95 (34)
UNF	0.33 (155)	0.48	0.63 (26)	0.82	1.33 (92)	0.95	3.49 (43)
UWF	0.39 (54)	0.66	0.88 (14)	1.05	2.39 (30)	0.90	5.13 (27)

INVERTEBRATES

Invertebrate drift was sampled once each month on one riffle in each study section. Three drift nets were placed across a transect for one hour, four times a day (1530-1630, 1130-1230, 1730-1830 and 2330-0030).

Benthic samples were collected on one riffle in each study section each month. Five 0.05 square meter samples were collected across a transect using the benthic sampler described by Keeley and Nickelson (1974). Each month the transect was moved 0.3 meters upstream to prevent sampling of the same area more than once.

Table 4. Computation of production of age 0+ coho salmon in the Elk Creek study areas during summer 1974.

Date	$\bar{W}$ g	G	N	B g	$\bar{B}$ g	P g	
Area 1							
June 15	1.97		261	514			
		0.34			572.5	195	
Aug. 15	3.71		170	631			
		0.31			594.5	184	
Sept. 15	5.03		111	558			Total 379
Area 2							
June 15	2.05		192	394			
		0.36			533.0	192	
Aug. 15	3.98		169	673			
		0.33			616.0	203	
Sept. 15	5.49		102	560			Total 395
Area 3							
June 15	1.29		1,212	1,563			
		0.53			1,394.0	739	
Aug. 15	3.56		344	1,225			
		0.37			1,153.5	427	
Sept. 15	5.01		216	1,082			Total 1,166
Area 4							
June 15	1.36		689	937			
		0.44			1,474.0	649	
Aug. 15	3.67		548	2,011			
		0.56			1,679.5	941	
Sept. 15	6.30		214	1,348			Total 1,590
Area 5							
June 15	1.21		186	225			
		0.46			514.0	236	
Aug. 15	3.39		237	803			
		0.65			594.5	386	
Sept. 15	6.33		61	386			Total 622
Area 6							
June 15	1.39		169	235			
		0.51			556.0	284	
Aug. 15	4.04		217	877			
		0.37			1,036.5	384	
Sept. 15	6.04		198	1,196			Total 668
Area 10							
June 15	1.73		98	170			
		0.42			434.5	182	
Aug. 15	4.34		161	699			
		0.57			772.0	440	
Sept. 15	7.10		119	845			Total 622
Area 11							
June 15	1.62		170	275			
		0.48			418.0	201	
Aug. 15	4.64		121	561			
		0.53			503.5	267	
Sept. 15	7.19		62	446			Total 468

A subsample of 60% of the benthic samples was qualitatively examined. A list of families of insects represented in the West Fork benthic samples appears in Table 6.

Table 6. A list of 19 insect families represented in the benthic samples from the West Fork of Elk Creek

Plecoptera	Diptera
Perlidae	Simuliidae
Perlodidae	Chironomidae
Chloroperlidae	Tipulidae
Nemouridae	Dixidae
Trichoptera	Coleoptera
Rhyacophilidae	Elmidae
Hydropsychidae	
Psychomyiidae	Collembola
Philopotamidae	
Glossosomatidae	Smynthuridae
Ephemeroptera	
Heptageniidae	
Ephemerellidae	
Baetidae	
Siphlonuridae	

PROBLEMS WITH ORIGINAL DESIGN

In October 1974 the design of the project was reevaluated. Two problems were identified: (1) the difficulty in interpretation of the effects of flow reduction using a fluctuating flow regime; and (2) the large sample size necessary for multiple regression analysis.

The problem of a fluctuating flow regime is seen in the fact that as the flow changes, the values of the hydrologic parameters also change. In essence we are trying to relate monthly point estimates of the values of the hydrologic parameters to fish production which actually occurred in response to a range of values over a three month period.

To obtain meaningful results from multiple regression analysis, a sample size of approximately 10 times the number of independent variables to be examined is required (Draper and Smith 1966). Thus, to relate fish production to the parameters identified by Giger (1973b) using multiple regression analysis would require 90 separate observations of these parameters. However, in 5 summers we would be able to make, at most, 20 observations.

RESEARCH DESIGN FOR 1975

As a result of our project reevaluation we have altered the approach which will be used to achieve our objective. Constant flows rather than fluctuating flows will be studied and multiple regression analysis will not be emphasized.

Eight study sections, each consisting of a riffle and a pool, will be established below the flow control facilities on the North Fork of Elk Creek. Weirs and traps will be placed at the top and bottom of each section and 22 permanent cross sectional transects will be established within each section. The data collected in 1974 have been used to determine the sample sizes necessary to achieve the degree of confidence which we desire (i.e. $\pm$ 5%; 95% of the time).

Six 2-week experiments designed to study the effects of flow reduction on juvenile salmonids and their habitat will begin July 1. Reductions of 25, 50, 75, 85, and 95 percent from the mean natural low flow of 3 cfs will be examined. In each experiment hydrologic measurements will be taken in each section and the number and weight of fish which each section will support at the given flow will be determined. Cover characteristics (undercut banks, overhanging vegetation, submerged logs, etc.) will be mapped at each cross sectional transect.

It is expected that the results obtained will vary with the species of interest, age class and species composition. The expected variance will be due to differences in the habitat requirements of different species of different ages and to interspecific competition. Therefore it is planned to study six sympatric populations of age 0+ coho salmon (Oncorhynchus kisutch) and age 0+ trout (Salmo gairdneri and S. clarki) and two sympatric populations of age 0+ salmon and trout and age 1+ trout.

Data analysis will consist of developing relationships between percent reduction in juvenile salmonid carrying capacity (numbers or biomass) and habitat parameters (depth, velocity, cover, etc.) from the value found at the natural low flow (Figures 3 and 4). Similar relationships will be developed between the various habitat parameters and salmonid numbers (Figure 5) in an effort to apply Elk Creek results to other Oregon streams.

APPLICATION OF EXPECTED RESULTS

At this point it would be relevant to discuss, in relation to the recommendation of minimum streamflow standards, the results which we expect to obtain at Elk Creek. The flow-carrying capacity relationship (Figure 3) which we will develop for Elk Creek could be used to recommend a minimum flow standard for Elk Creek.

The use of the flow-carrying capacity relationship in the recommendation of minimum flow standards would be based on the premise that only a certain reduction in the potential of a stream to support the fish species of interest would be allowed.

To develop flow-carrying capacity relationships for all Oregon streams would be prohibitive. An alternative approach might be to assume that all streams of similar gradient within a geomorphic division (Figure 6) will have a similar flow-carrying capacity relationship for the same species of interest. This approach would require the development of flow-carrying capacity relationships for 9 streams in addition to Elk Creek.

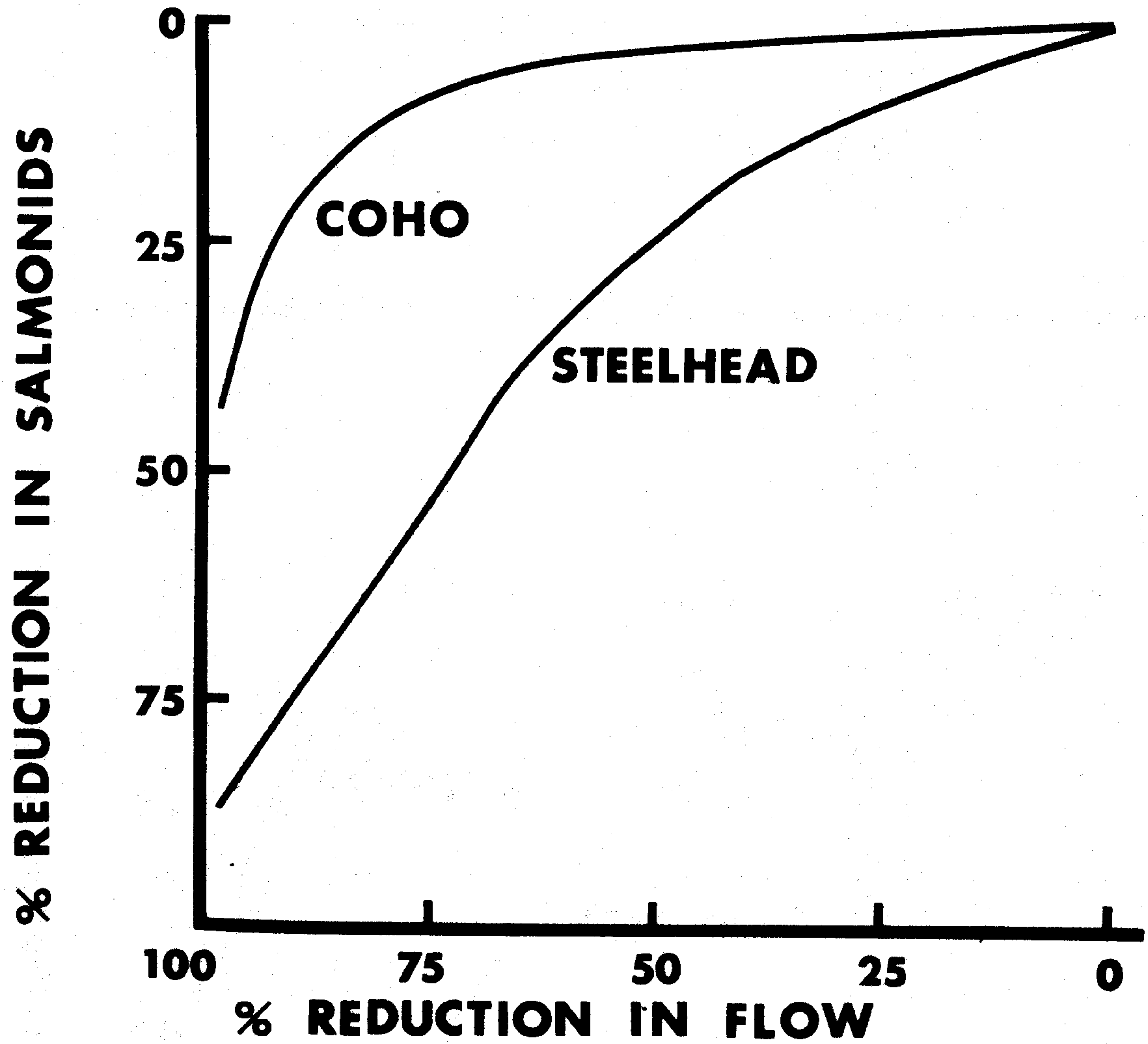

Figure 3. Hypothetical relationships between reduction in salmonid carrying capacity and reduction from the natural low flow.

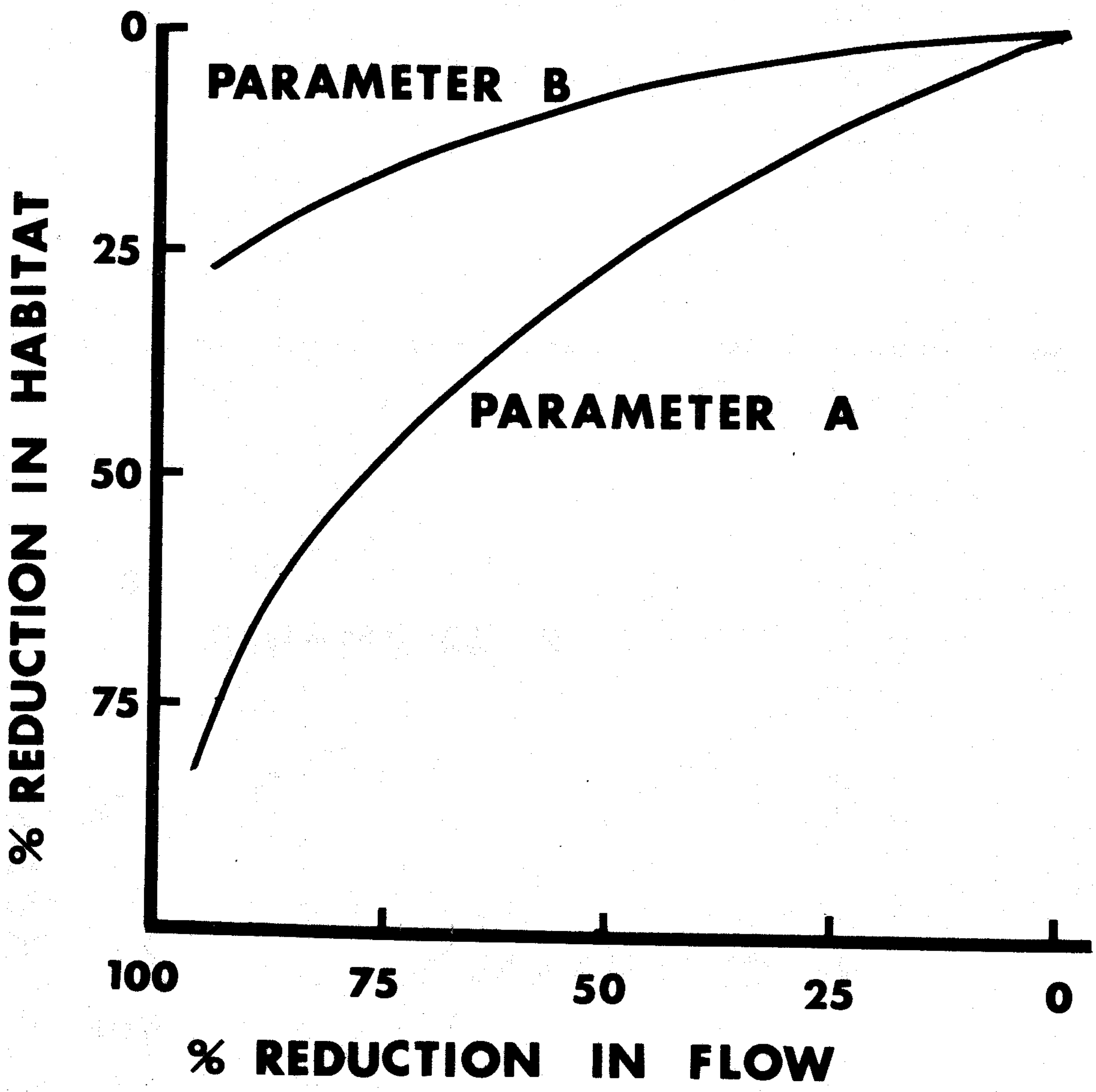

Figure 4. Hypothetical relationships between reduction in salmonid habitat and reduction from the natural low flow.

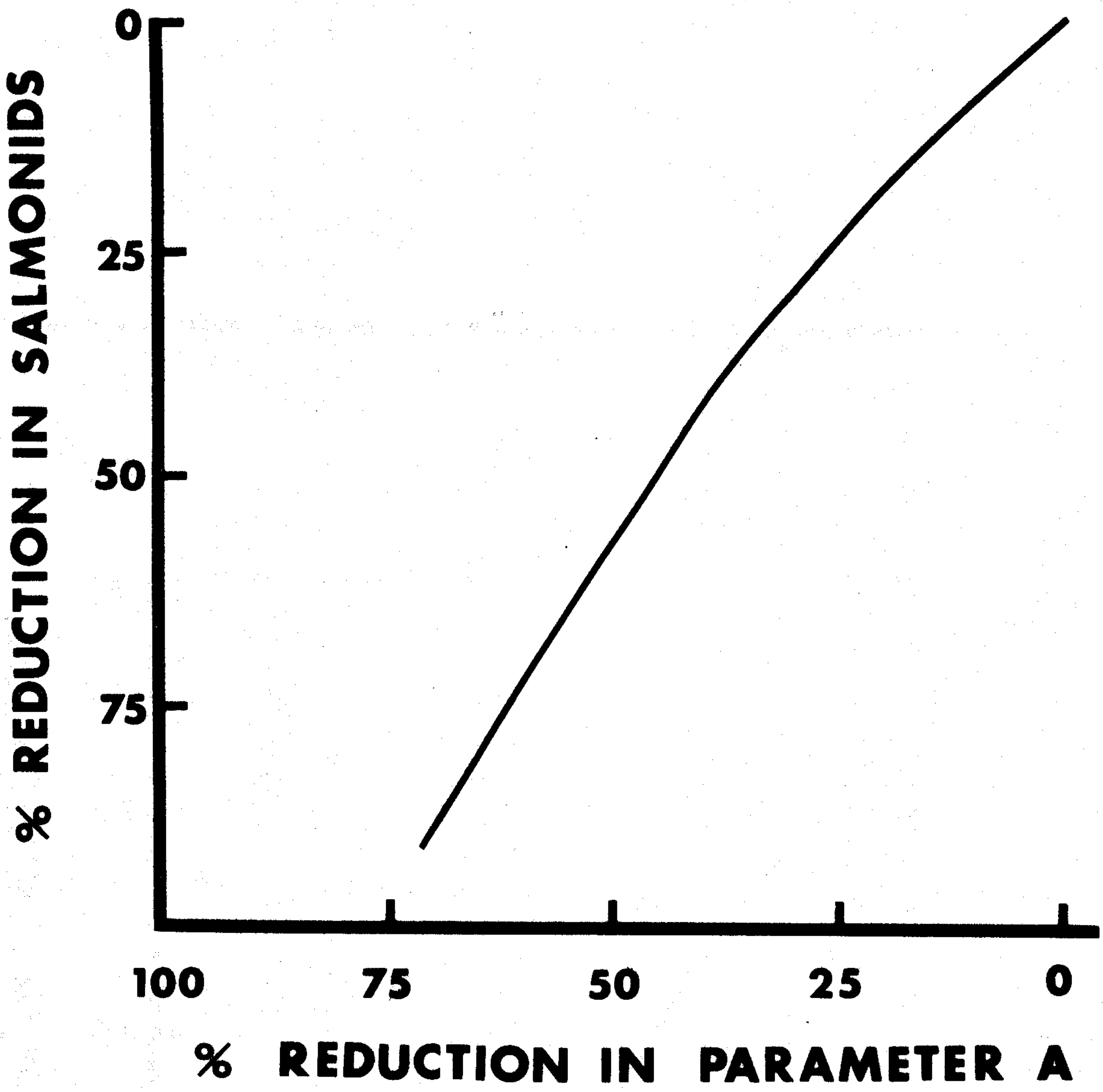

Figure 5. Hypothetical relationship between reduction in salmonid carrying capacity and reduction in a given habitat parameter.

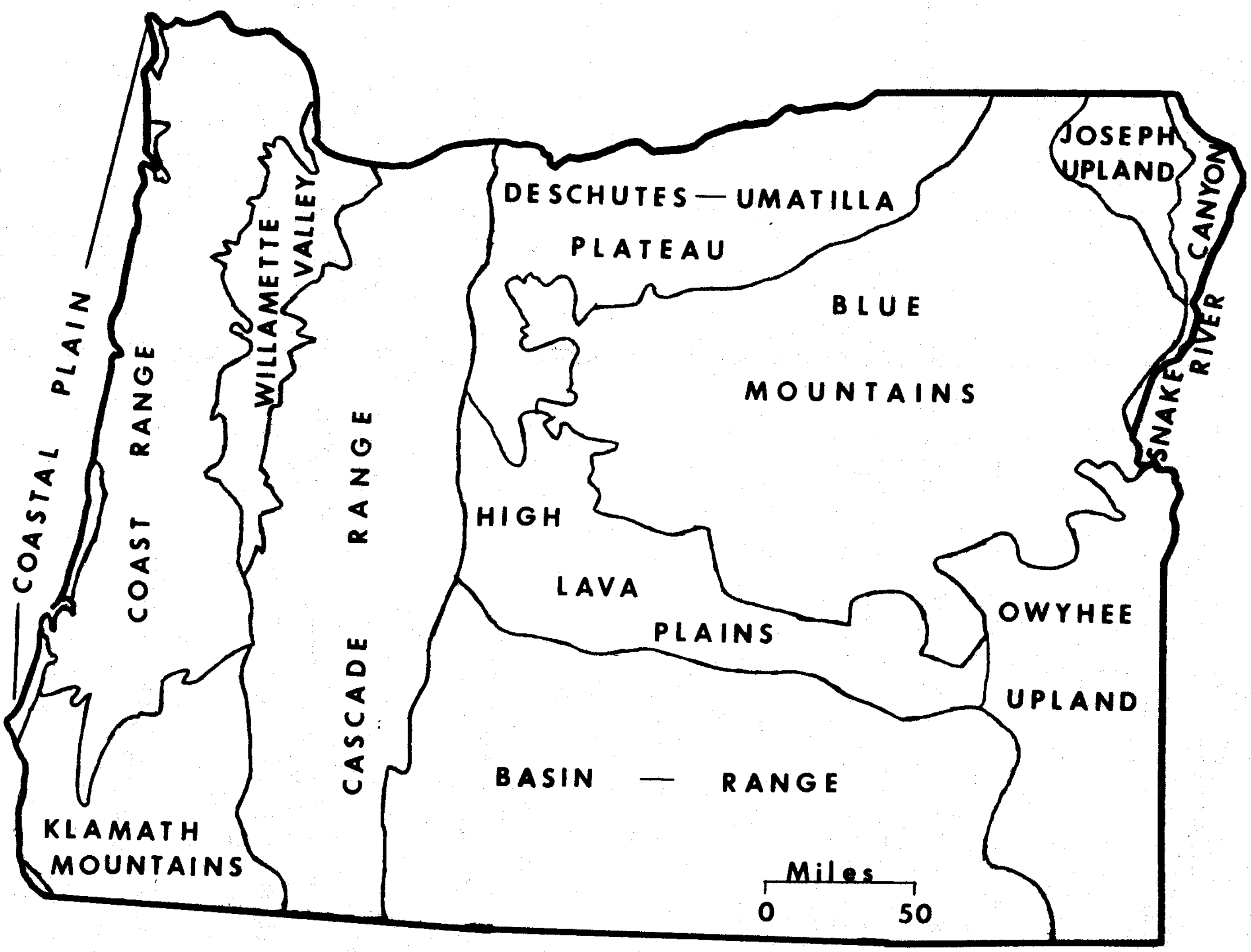

Figure 6. Geomorphic divisions of Oregon. After Oregon Department of Geology and Mineral Resources (1959).

A less costly approach might be to assume that the habitat-carrying capacity relationship (Figure 5) for a given species will be valid for all Oregon streams and that the flow-habitat relationships (Figure 4) will be similar for all streams within a geomorphic division. This would require the development of flow-habitat relationships on the same 9 streams and the use of the Elk Creek habitat-carrying capacity relationships.

Still another approach would be to assume that the flow-carrying capacity relationship developed for Elk Creek will be valid for all Oregon streams and use it to recommend minimum streamflow standards statewide, based on the Elk Creek relationships. This approach is not recommended.

Table 7 summarizes the alternative applications of the results of the Elk Creek streamflow study discussed above, and the assumptions which must be made when using each. This scheme is an example of only one of the many possible applications of the results in the recommendation of minimum streamflows.

It should be noted that the results of this study will have far reaching applicability not only for the recommendation of minimum streamflows but in all aspects of salmonid management concerned with fish habitats. Essentially this is a study of salmonid rearing habitat and the relative importance of the various components of the lotic environment.

Table 7. Levels of resolution in the application of Elk Creek streamflow study results.

Level of resolution	Application of Results	Assumptions
1	Base flow recommendations in all Oregon streams on Elk Creek flow-carrying capacity relationship.	1. Assume that the flow-carrying capacity relationship (Fig. 3) developed for Elk Creek will be valid in all Oregon streams.
2	Develop flow-habitat relationship for 9 other streams each representative of a geomorphic division (Fig. 6).	1. Assume that the habitat-carrying capacity relationship (Fig. 5) for Elk Creek will be valid in all Oregon streams. 2. Assume that the flow-habitat relationships (Fig. 4) developed for these streams will be valid for other streams in their respective geomorphic division.
3	Develop flow-carrying capacity relationships for these same 9 streams as was done for Elk Creek.	1. Assume that the relationships developed in these streams will be valid for other streams in their respective geomorphid divisions (Fig. 6)
4	Develop flow-carrying capacity relationships for all Oregon streams as was done for Elk Creek.	None

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