JOB COMPLETION REPORT

INVESTIGATIONS PROJECTS

State of Montana

Project No.: F-12-R-4 Name: Western Montana Fisheries Study

Job No.: II Name: Biology of the Columbia Squawfish and Columbia River Chub

Period Covered: May 1, 1957 - April 30, 1958

Abstract: See attached manuscript.

Objectives: " " "

Techniques used: " " "

Findings: " " "

Recommendations:

Because of the similarity of the habitat requirements and food habits of these fish with those of desirable game fish, i.e., trout, it is reasonable to assume that removal of these fish from a body of water would result in higher populations and production of game species.

Projects aimed at removal of rough fish by trapping, netting, etc., have almost invariably failed to accomplish the results for which they were inaugurated. The only presently known method of eliminating or substantially controlling undesirable species is by poisoning and restocking with desirable fish. It is recommended that these species be removed by this method where fishing pressure is of sufficient magnitude and where conditions are favorable (economically reasonable volume of water to be treated, presence of suitable barriers or sites for barriers, etc.).

In view of the cost of such rehabilitation projects, it is recommended

that a complete kill of these species be striven for. Under certain circumstances, a nearly complete removal of these species may be justified, since this could be expected to provide a desirable fishery for several years. These species, particularly the Columbia squawfish, require a considerable number of years to attain sexual maturity. The time required for them to regain their population levels may be long enough to justify rehabilitation with an incomplete kill. However, it is reasonable to expect that a sharp lowering of population levels would reduce the age at which sexual maturity is reached. Since several unknown quantities are involved in such a course of action, rehabilitation without reasonable assurance of a complete kill and subsequent control of immigration should be entered into with caution.

Prepared by: Cliff W. Hill Approved by: _____

Date: _____

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Abstract

The life histories of the Columbia River chub and the Columbia squawfish were studied during the summers of 1956 and 1957 in the drainage of the Big Blackfoot River, Montana. Both species occurred in certain lakes of the drainage, in the lower portion of the Big Blackfoot River and in one principal tributary. The Columbia squawfish also occurred in the upper portion of the Big Blackfoot River. Both species inhabited shallow, vegetated areas in lakes. Columbia squawfish were found in areas of relatively calm water in streams. The growth of Columbia River chub was studied by examining the scales from 300 fish. Specimens of this species up to nine years of age were collected. Growth of Columbia squawfish was based on examination of scales from 339 fish. Some individuals of this species attained an age of at least 15 years. Columbia River chub matured sexually at three to five years of age while Columbia squawfish matured at six to eight. Both species spawned in late May and early June while average water temperatures were 55-65° F. The stomach contents of 42 Columbia River chub and 83 Columbia squawfish were examined. Insects were the predominant item in the stomachs of both species. Fish were found in some Columbia squawfish stomachs.

Introduction

The Columbia River chub (Mylocheilus caurinus) and the Columbia squawfish (Ptychocheilus oregonense) are abundant native fishes in the Columbia River drainage of western United States. Both grow to the size of many game fish but are little utilized as food and are generally classified as rough fish. They may compete with trout and salmon for food and space. In one area the Columbia squawfish was found to be an important predator on young sockeye salmon (Ricker, 1941; Foerster and Ricker, 1941). Both take bait readily and are considered a nuisance by anglers.

Until recently, little work was done on these fishes. In view of their abundance and widespread distribution in western Montana, a study of their habits and life histories was undertaken as a part of the fisheries management program for the area. The drainage of the Big Blackfoot River was selected for the present investigation, which was carried out during the summers of 1956 and 1957.

The Big Blackfoot River and its tributaries drain portions of Lewis and Clark, Powell and Missoula counties in Montana. This drainage includes about 2,100 square miles and is bounded on the east and northeast by the Lewis Range, on the north and west by the Swan and Mission ranges and on the south by the Garnet Range. The highest point in the drainage is about 9,000 feet. The elevation of the Big Blackfoot River at its confluence with the Clark Fork, Columbia River is 3,300 feet. Most of the area is characterized by sharp relief and is vegetated by coniferous

forests. The average gradient of the Big Blackfoot River and its principal tributaries is approximately 11 feet per mile.

The Clearwater River is the largest tributary of the Big Blackfoot River. It occupies a narrow wooded valley 32 miles long lying north of the principal drainage. This river flows through eight lakes which make up a large part of the habitat suitable for the Columbia River chub and the Columbia squawfish. These lakes range from 25 to 1,200 acres in surface area. They are generally characterized by having abrupt shorelines and extensive depths (90 to 100 feet). The sharply inclined shoal areas have bottoms of gravel and rubble and those with gradual slopes have bottoms of sand or silt, sometimes covered with considerable debris and limited areas of vascular vegetation.

The water of the drainage is moderately soft (total alkalinity: 12 to 20 p.p.m.). The deeper lakes stratify thermally and chemically in summer but oxygen depletion is not severe.

The two minnows under consideration are among the most abundant fishes of the drainage. Other native fish present are: Redside shiner (Gila balteata), Longnose dace (Rhinichthys cataractae), Longnose sucker (Catostomus catostomus), Columbia large-scaled sucker (C. macrocheilus), Cutthroat trout (Salmo clarki), Dolly Varden (Salvelinus malma), Mountain whitefish (Coregonus williamsoni), Rocky Mountain sculpin (Cottus bairdi punctulatus). Introduced species include: Rainbow trout (Salmo gairdneri), Brown trout (S. trutta), Kokanee (Oncorhynchus nerka kennerlyi), Eastern Brook trout (Salvelinus fontinalis), Yellow perch

(Perca flavescens), Largemouth black bass (Micropterus salmoides), Pumpkinseed (Lepomis gibbosus). Three specimens indentified as hybrids between Columbia squawfish and Columbia River chub were collected during the study. Hybrids between these species were previously reported in Montana by Weisel (1953).

The writer wishes to thank Dr. C. J. D. Brown and Richard J. Graham, who directed the study and assisted in the preparation of the manuscript; Arthur N. Whitney, who suggested the problem and gave valuable help; other personnel of the Montana Fish and Game Department for assistance in the field; and my wife, Gail, for field assistance and encouragement. The Montana Fish and Game Department financed the field investigation under Federal Aid to Fisheries Restoration Project F-12-R. The writer was a graduate fellow of the National Science Foundation for a part of the period involved in the study.

Distribution and Habitat

Distribution. The distribution of the Columbia River chub and the Columbia squawfish within the Big Blackfoot River drainage was determined from collections made during the present study and from collections made by the Montana Fish and Game Department in 1954 (Fig. 1). The following sampling methods were used: lakes - gill netting; the Big Blackfoot River - dynamiting; the Clearwater River below Salmon Lake - angling; the Clearwater River above Rainy Lake - poisoning with rotenone; all other stream stations - electrical shocking. A number of small streams tributary to the Big Blackfoot River were sampled without collecting

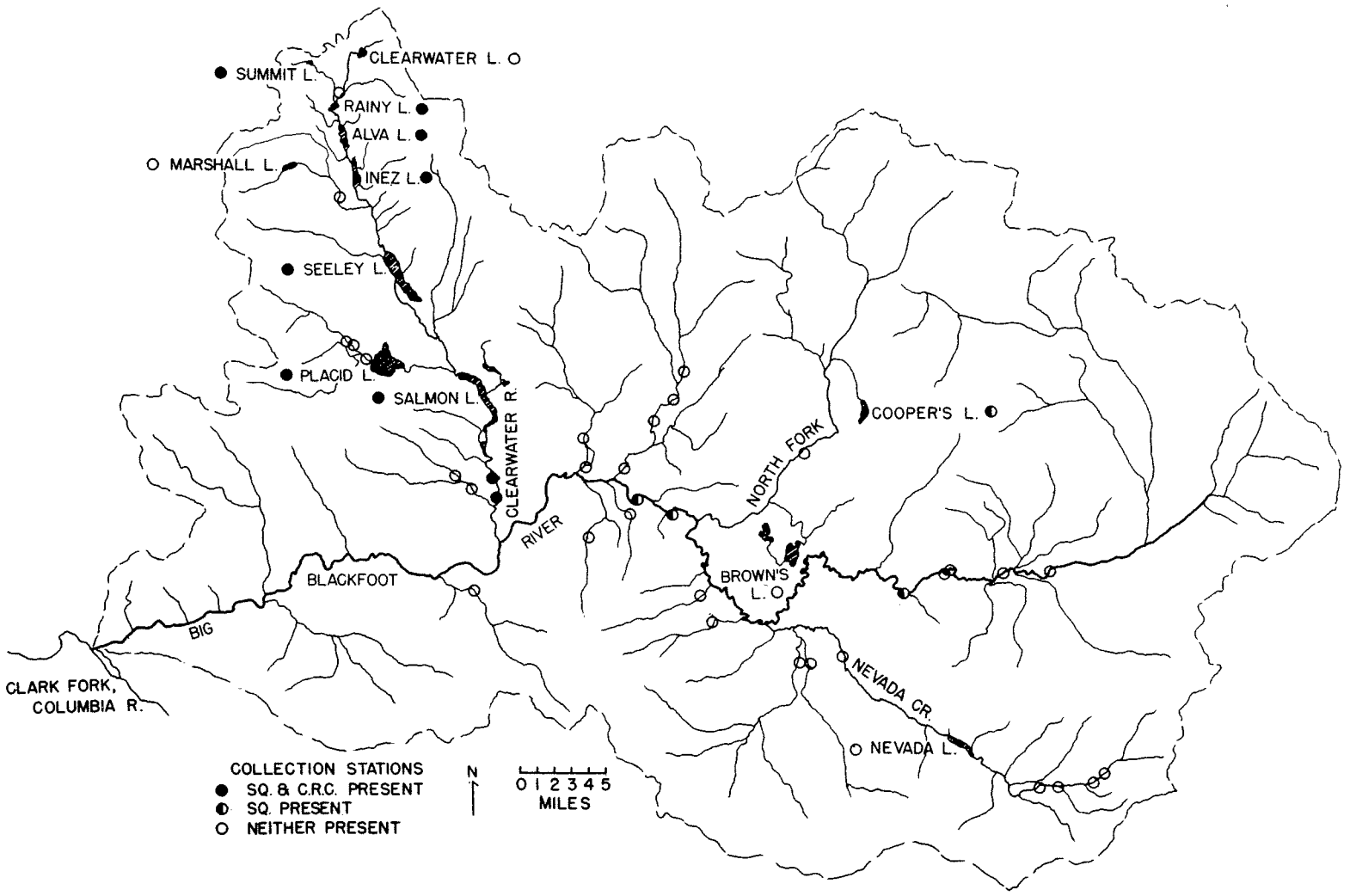

Figure 1. Map of the Big Blackfoot River drainage, showing collection stations and occurrence of the Columbia River chub and Columbia squawfish.

either species. Other small streams with steep gradients were not sampled. No recent collections were made on the Big Blackfoot River below the mouth of the Clearwater River, although records from 1948 are available for this area. Recent creel census records also show that both Columbia River chub and Columbia squawfish are present there.

The Columbia River chub was found to be abundant in certain lakes of the Clearwater River drainage. They occurred in small numbers in the broad, slow areas of the Clearwater River below Salmon Lake and in the Big Blackfoot River below the mouth of the Clearwater River.

Columbia squawfish were present in the same lakes of the Clearwater River drainage. This species was also present in Cooper's Lake, which has an outlet intermittently flowing into the North Fork, Big Blackfoot River. It was not found in this latter river. The fish from Cooper's Lake were more darkly pigmented than those found in the Clearwater drainage and in the Big Blackfoot River. Columbia squawfish were common in the lower Clearwater River and in the Big Blackfoot River below the mouth of the Clearwater River. They were also found in the Big Blackfoot River upstream to a point about two miles above the mouth of Arrastra Creek. Collections made at stations in the upper portion of this river contained only large fish (those above Arrastra Creek were 11.3 - 15.7 inches in length*). Searches for young of the year at several stations on the Big Blackfoot River disclosed none more than 15 miles upstream from the mouth

* All length measurements used in this report are total lengths; maximum length from tip of snout to the longest part of the caudal fin.

of the Clearwater River. Evidently little or no successful reproduction occurred in the upper portion of the range of this species.

Habitat. In lakes, both Columbia River chub and Columbia squawfish were found to occur almost exclusively in the shallow areas during summer. Few fish were captured in nets set at depths greater than 20 feet. Both species inhabited areas where submerged vegetation was present, except during the spawning period. At that time fish were captured in open areas as well as in vegetated areas. In Seeley Lake during late March, 1957, when ice cover was present, fish of both species were captured in gill nets set in vegetation at depths of eight feet or less but not at greater depths. These fish quite possibly remained in shallow vegetated areas during the period of ice cover.

Young of the year Columbia River chub and Columbia squawfish captured in lakes before July 8, 1957 were found in water less than one foot deep along rubble or gravel shores. After August 1, these fish were found in nearby areas of submerged vegetation at depths less than three feet.

Columbia squawfish in the Big Blackfoot River were captured in large pools (8-12 feet deep and up to 100 feet long). In the Clearwater River they were taken in pools and in other areas of low gradient. Groups of fish less than six inches in length were also observed in riffle areas of the latter river, where they were concentrated in the shelter of the boulders along the river's edge. Young of the year were found in protected places near shore and in backwaters of the Big Blackfoot River and the Clearwater River.

Growth

Methods. Young-of-the-year fish were collected with a dip net until mid-August, but at that time the fish were able to evade this net. A seine was used for subsequent collections in lakes.

The growth of older fish in certain lakes was determined by examining scales from fish captured in gill nets. The nets used were 125 feet long with 25 foot sections of 3/4, 1, 1¼, 1½ and 2 inch square mesh. The largest mesh was of a size capable of capturing fish larger than any encountered during the study. Some young age groups were not vulnerable to the nets and were not collected. Scales were taken from each fish in the area between the base of the dorsal fin and the lateral line. Measurements of scale radii were made with the aid of a scale projector. Total lengths at formation of annuli were calculated with a nomograph. A linear relationship between scale radius and body length was assumed.

A length-frequency distribution was also used for evaluating the growth of Columbia squawfish in the Clearwater River. Fish used were captured by seining and angling.

Columbia River chub. Young-of-the-year Columbia River chub from Placid Lake attained an average length of 2.2 inches by September 12, 1957 (Table I).

Scales of 300 fish collected during 1956 were used for determining the growth of Columbia River chub in Placid Lake. Collection periods were mid-June and late August and early September. The youngest fish in the sample were two years old. Age class II was not represented in the June collections but had attained a size vulnerable to the 3/4 inch gill

Table I. Growth of young-of-the-year Columbia River chub and Columbia squawfish in Placid Lake, 1957.

Date	Columbia River chub			Columbia squawfish		
	Length, inches			Length, inches		
	Av.	Range	No.	Av.	Range	No.
Aug. 6	1.2	1.1-1.3	15	1.4	1.3-1.5	12
Aug. 16	1.5	1.4-1.7	7	1.7	1.6-1.7	5
Sept. 12	2.2	2.0-2.4	30	2.1	1.6-2.4	15

net mesh by late August. Scales from young-of-the-year fish were examined in order to evaluate growth in the first summer and to aid in locating the first annulus. The scales of young fish (2.0-2.2 inches in length) collected in September had 9-12 circuli.

The average size of female Columbia River chub was greater than that of males. This resulted from greater longevity and from a slightly faster growth rate in females (Table II). The average calculated length of females was 0.2 inches greater than males at five years and 0.7 inches greater at seven years, the oldest group in which males were represented. The oldest female in the sample (13.5 inches in length) was aged at nine years. Several males (10.4-11.1 inches in length) were aged at seven years.

Columbia squawfish. Young-of-the-year of this species from Placid Lake attained an average length of 2.1 inches by September 12, 1957 (Table I). Columbia squawfish collected in the Clearwater River below Salmon Lake were considerably smaller than those taken from Placid Lake at comparable times. On August 3, 1957, fifteen fish averaged 0.9 inches in length (range: 0.8-1.0) and on August 21, eight fish averaged 1.2

Table II. Calculated growth of Columbia River chub in Placid Lake.

Age Class	Sample size				Average length at annulus formation								
	I*	M	F	T	1	2	3	4	5	6	7	8	9
II	6			6	2.4	4.6							
III	76	18		94	2.6	4.8	7.0						
IV	10	8	6	24	2.7	4.8	6.9	8.6					
V	1	41	9	51	2.7	4.7	6.7	8.5	9.8				
VI		23	31	54	2.6	4.5	6.5	8.3	9.6	10.7			
VII		6	53	59	2.6	4.4	6.4	8.1	9.5	10.5	11.4		
VIII			11	11	2.7	4.5	6.4	8.3	9.8	10.9	11.7	12.6	
IX			1	1	3.1	4.5	6.7	8.7	9.8	11.3	12.0	12.7	13.5
Average	93	96	111	300	2.6	4.6	6.7	8.3	9.6	10.6	11.5	12.6	13.5

* I: immature; M: male; F: female; T: total.

inches in length (range 1.1-1.5). Growth of young in the Big Blackfoot River was similar to that in the Clearwater River.

A length-frequency distribution was made from 127 Columbia squawfish collected in the Clearwater River below Salmon Lake (Fig. 2). Fish 1.9-4.3 inches in length were collected by seining on July 17, 1956 and fish

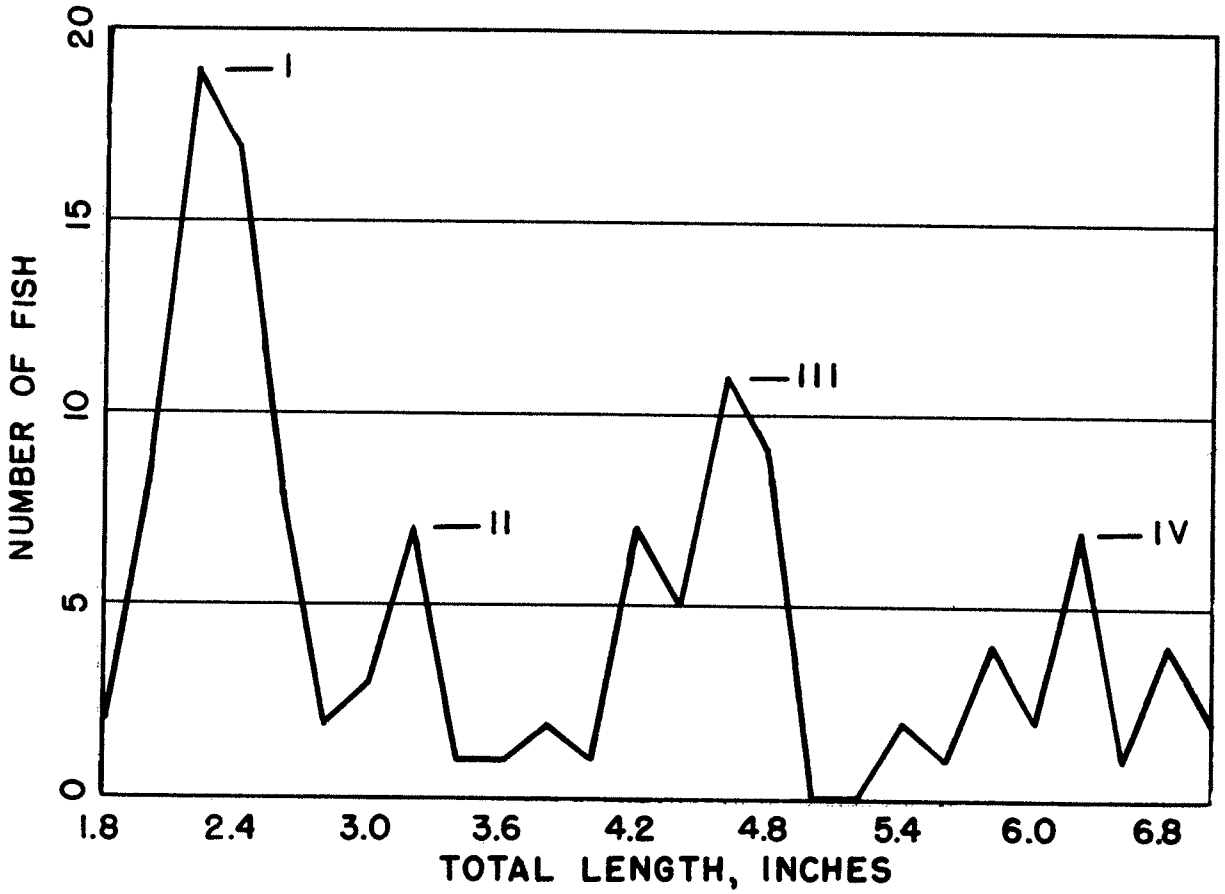

Figure 2. Length-frequency distribution of 127 Columbia squawfish collected in the Clearwater River, July 17 and 27 and August 3, 1956.

4.2-11.3 inches in length were collected by angling on July 27 and August 3, 1956. The length-frequency distribution of these combined samples ex-

hibited modes at 2.4, 3.3, 4.6 and 6.1 inches. Modes at greater lengths were not evident. An examination of the scales of these fish indicated that the above modes represented age classes I through IV. The comparative weakness of the mode at 3.3 inches was due to the low vulnerability of this size group to both collection methods used.

Information on growth of Columbia squawfish in Alva Lake was obtained from scales of 267 specimens collected during the summers of 1956 and 1957 (Table III). Age classes IV through XV were represented in this sample. Since no smaller fish from Alva Lake were available, younger fish from the Clearwater River and from Placid Lake were used to aid in evaluating growth in the first few years of life. Young-of-the-year Columbia squawfish collected in Placid Lake in September (2.0 inches in length) had 9-12 circuli.

Females grew slightly faster and attained a greater age than males. The difference in growth, noted in all age classes in the Alva Lake sample, was 0.7 inches at formation of the ninth annulus. The oldest males in the sample (13.0 and 13.2 inches long) were aged at 11 years. One female 18.3 inches long was aged at 15 years. Several other females up to 22.3 inches in length were collected, but they could not be aged with any degree of confidence and are not included in the growth data.

The growth of Columbia squawfish in Seeley Lake, based on an examination of the scales of 72 fish, was slightly greater than in Alva Lake. Age classes VI through XV were represented in this sample. Average calculated lengths at annulus (A) formation (sexes and age classes combined) were: A1 - 2.2; A2 - 3.5; A3 - 5.0; A4 - 6.5; A5 - 7.9; A6 - 9.2; A7 -

Table III. Calculated growth of Columbia squawfish in Alva Lake.

Age Class	Sample size				Average length at annulus formation											
	I*	M	F	T	1	2	3	4	5	6	7	8	9	10	11	12
IV	4			4	2.0	3.6	5.1	6.5								
V	30			30	1.9	3.0	4.4	5.7	7.1							
VI	52	1		53	2.0	3.2	4.5	5.8	7.2	8.3						
VII	54	8	5	67	2.1	3.3	4.6	6.0	7.2	8.4	9.5					
VIII	26	9	5	40	2.2	3.5	4.7	6.0	7.2	8.3	9.5	10.5				
IX	3	21	11	35	2.2	3.4	4.7	6.1	7.5	8.7	9.8	10.9	11.8			
X		14	8	22	2.1	3.3	4.7	6.0	7.1	8.2	9.2	10.2	11.2	12.1		
XI		2	5	7	2.4	3.4	4.7	5.8	7.2	8.3	9.4	10.4	11.5	12.5	13.4	
XII**			9	9	2.1	3.3	4.5	5.7	7.0	8.3	9.4	10.5	11.5	12.5	13.5	14.4
Average	169	55	43	267	2.1	3.3	4.6	5.9	7.2	8.4	9.5	10.5	11.5	12.3	13.4	14.4

* I: immature; M: male; F: female; T: total.

** includes fish 12 years and older.

10.3; A8 - 11.4; A9 - 12.6; A10 - 13.9; A11 - 14.8; A12 - 15.9. One female, 17.4 inches in length, was aged at 15 years. Others up to 19.5 inches in length could not be aged with any degree of certainty.

Reproduction

Fecundity. Fish of both species were collected on March 25-27, 1957 in Seeley Lake for the purpose of estimating egg numbers. About two months in advance of the spawning seasons, this was a favorable time for collecting ovaries since eggs were large enough for accurate enumeration, yet there was no danger of loss during capture. Ovaries were removed from the fish and preserved in formalin. After removal of adhering fatty tissue, total volume of the ovaries was determined by displacement in water. The ovaries were than broken up and two or three samples, representing 5-10 percent of the total volume, were selected at random. The eggs contained in these samples were counted. Volumes of the samples were determined by displacement and an estimate of the total number of eggs was calculated.

Estimated egg numbers for seven Columbia River chub (11.8-12.8 inches in length) ranged from 11,800 to 18,900 (Table IV). Estimated egg numbers for seven Columbia squawfish (11.3-13.8 inches in length) showed much greater variation between individuals than Columbia River chub. Two fish, 12.1 and 12.3 inches long, contained 27,500 and 6,700 eggs, respectively. No relationship between fish size and number of eggs was noted in either species within the size ranges of the samples.

Age at sexual maturity. The sample discussed previously (see

Table IV. Estimated numbers of eggs contained in the ovaries of fish collected in Seeley Lake, March 25, 26 and 27, 1957.

Species	Total length, inches	Weight pounds	Number of eggs
Columbia River chub	11.8		11,800
" " "	11.9	0.66	16,400
" " "	12.1	0.70	18,900
" " "	12.3	0.73	15,200
" " "	12.4	0.69	16,400
" " "	12.6	0.83	16,800
" " "	12.8	0.76	15,400
Columbia squawfish	11.3	0.46	18,200
" "	11.4	0.48	9,800
" "	11.5	0.48	19,200
" "	12.1	0.51	27,500
" "	12.2	--	20,700
" "	12.3	0.54	6,700
" "	13.8	0.78	20,000

"Growth", p. 10) indicates that Columbia River chub in Placid Lake matured at three to five years of age. Mature males made up about 20 percent (18 of 94) of age class III. Mature females were well represented in age class IV, the first age class in which they were found. Only one of fifty-one fish in age class V was immature. The average calculated length at annulus formation of the mature three year old males was 6.5 inches; that of the mature four year old females was 8.4 inches.

Columbia squawfish collected in Alva Lake matured later in life than Columbia River chub in Placid Lake. Attainment of maturity by these Columbia squawfish also extended over a longer period of years. The youngest mature male in the sample was six years of age and the youngest mature female was seven. Immature fish made up the majority (26 of 40) of age class VIII and were present in small numbers (3 of 35) in age class IX. Average calculated lengths at annulus formation of mature seven year old males was 9.9 inches, that of females was 10.0 inches.

Spawning season. Gonad condition was recorded for adult fish of both species collected in Placid Lake between May 28 and July 6, 1957 and in Seeley Lake between June 3 and July 4, 1957. Females were classed as: full (including 'ripe' and 'green' individuals) or spent. These two conditions were readily recognized; the former is characterized by large ovaries with distinct large eggs, and the latter by small, flaccid ovaries colored dark red by abundant vascular tissue and containing occasional large eggs. The distinction between green and ripe fish could not be readily established and these classes were combined. An additional ovary condition (discussed below), representing non-breeding fish, was common

among Columbia squawfish. Males were classed as: ripe - with large white testes from which sperm could be squeezed; or spent - with flaccid, red testes in which sperm was no longer apparent. All fish used in evaluating the spawning seasons were collected in gill nets, except the June 9 and 16 collections from Placid Lake, which were obtained with a box trap set at the outlet.

Maximum-minimum water temperatures were taken to the nearest degree F. at the outlets of the above lakes at intervals of 1-4 days from May 9 to July 1, 1957. The thermometers were suspended 1-2 feet below the surface of the water and were protected from direct sunlight. These temperatures were believed to be about the same as those in the shoal areas which the fish inhabited, although no comparisons were made. Water temperatures expressed in Figures 3 and 4 were determined by averaging the maximum and minimum readings for each three day period.

Spawning activity of Columbia River chub in Placid Lake was in progress when collections began on May 28, 1957. Thirty-nine percent (12 of 31) of the females captured on that day were spent. Of the females collected in nets set near the inlet, few (2 of 18) had spawned while most (10 of 13) females collected near the outlet had spawned. The inlet side of the lake is characterized by extensive shoal areas with sand and silt bottoms and abundant vascular vegetation while most of the shoal area within one mile of the outlet has a bare bottom of gravel or rubble. The latter is similar to that used in spawning by Columbia River chub in Washington Lake (Schultz, 1935). It is probable that those individuals which became ripe early had concentrated in the areas favorable for spawn-

ing. All males (108 individuals) collected in both areas on May 28 were ripe.

The number of spent females in the collections of May 29 through June 9 rose rather steadily from 50 to 94 percent (Fig. 3) except for the

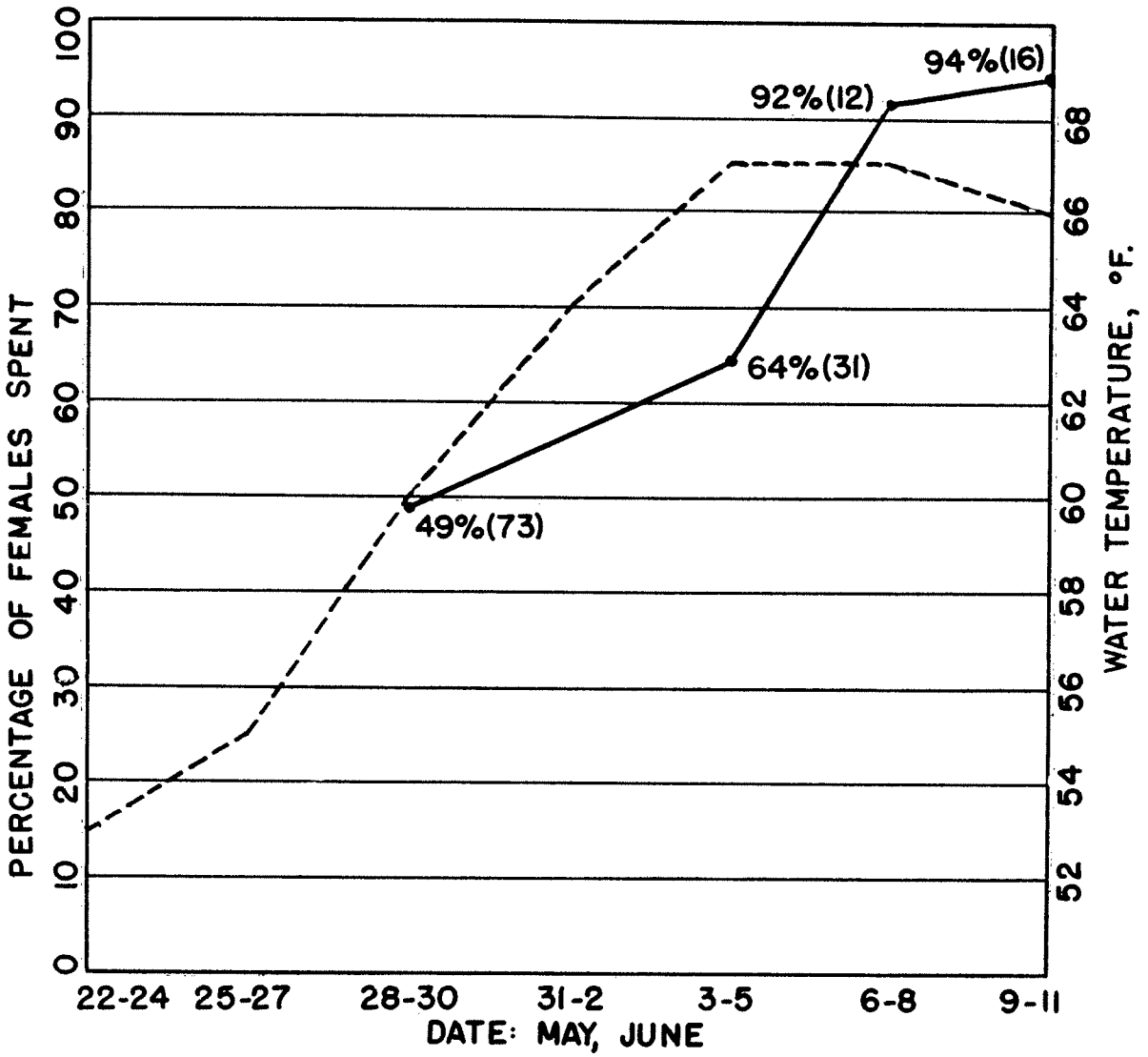

Figure 3. Gonad condition of female Columbia River chub collected in Placid Lake, 1957. Dotted line indicates average water temperature at outlet.

collection of June 5. All nets lifted on this latter date were set in soft bottomed areas with abundant vegetation. Some unspawned females were present in early July collections.

Average water temperatures at the outlet of Placid Lake rose rather steadily during the latter half of May and reached a maximum of 67° during the first week in June. Average water temperatures at the beginning of spawning activity by Columbia River chub (probably about May 24 or 25) was approximately 54°. Extremes of water temperatures during the peak of spawning activity were 52° on May 29 and 72° on June 3 and 4.

Spawning activity of Columbia squawfish in Seeley Lake occurred somewhat later than that of Columbia River chub in Placid Lake. Only 15 percent (3 of 20) of breeding females collected on June 3-5 had spawned (Fig. 4). The spawning season of Columbia squawfish was also less abrupt than that of the Columbia River chub. Forty-seven percent (8 of 15) of the breeding females collected on June 15 and 86 percent (24 of 28) of those collected on June 26 were spent.

Temperature conditions in Seeley Lake during the period prior to spawning were similar to those in Placid Lake. Average temperatures during the first two weeks in June did not reach the level of those in Placid Lake (Fig. 4). Average temperature at the beginning of spawning activity by Columbia squawfish (probably about June 1) was approximately 58°. The lowest water temperature during the period of spawning activity was 53° on June 6; the highest was 72° on June 4 and 6.

During both years of the study considerable numbers of female Columbia squawfish were found to have ovaries containing small grey eggs

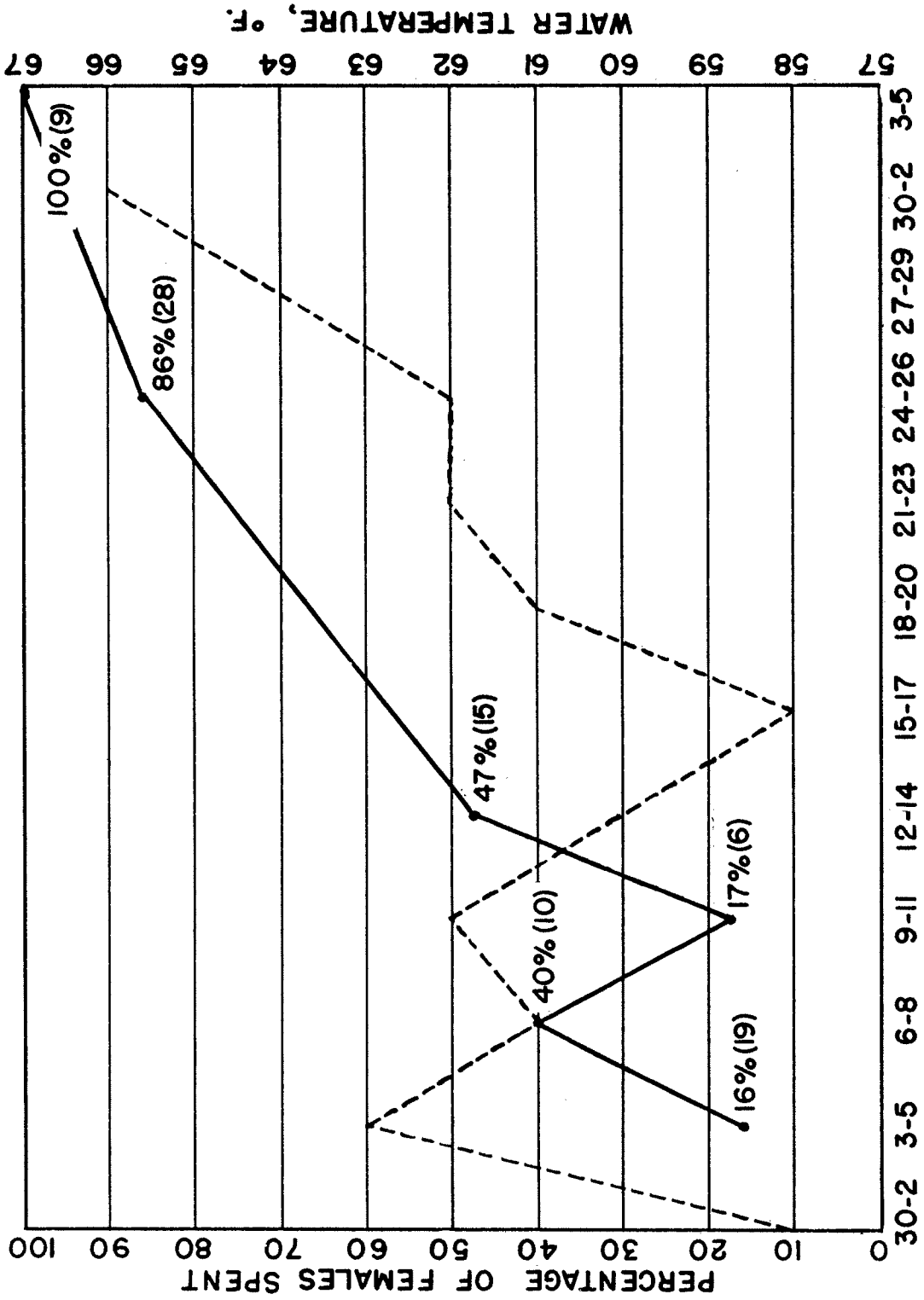

Figure 4. Gonad condition of female Columbia squawfish collected in Seeley Lake, 1957. Dotted line indicates average water temperatures at outlet.

which apparently would not have ripened during the breeding season of collection. These non-breeding fish were present in the collections of March, 1957 and in all collections throughout the summers of 1956 and 1957. They could be distinguished readily from the ripening fish of early collections as well as from the spent fish of late summer, whose ovaries contained very minute developing eggs of the next season. Twenty-five percent (29 of 117) of female Columbia squawfish collected in Seeley Lake during June, 1957 exhibited this ovary condition and were classed as non-breeding fish. Comparable numbers were found in other lakes of the Clearwater drainage. The fate of these eggs was not determined. Since they were found in a similar condition throughout the summer, it is unlikely that they were resorbed or that they represented late spawning fish. Probably they were retained in this green state over one or more years, perhaps to ripen during some subsequent spawning season. This ovary condition was not found in the Columbia River chub.

Although records of gonad condition in 1956 were limited, it was apparent that the spawning seasons of both species were about two weeks later than in 1957. Data from the weather station at Seeley Lake showed that temperature conditions in 1957 were about two weeks in advance of those in 1956.

Numerous attempts to observe spawning were made during the study but none was successful. A school of several hundred adult Columbia squawfish, believed to be a spawning group, was observed from 3 to 11 p.m. on June 18, 1957 in Cooper's Lake. The fish were concentrated within a few yards of shore over a rubble bottom. Occasionally one fish would dart toward

another, but most of the activity consisted of slow mass movement back and forth along the shore. No activity interpreted as actual spawning was noted. The fish did not appear to be disturbed by the light from a gasoline lantern suspended over the water, but dispersed gradually over a period of several hours. Jeppson (1957) reported that Columbia squawfish spawned over a rubble bottom at depths of two to twelve inches. Schultz (1935) described a similar spawning site selected by Columbia River chub.

None of the three Columbia squawfish x Columbia River chub hybrids collected during the study were sexually developed.

Food Habits

Methods. Stomachs from selected Columbia River chub and Columbia squawfish were preserved for study. Methods used in capturing fish used for stomach analysis were angling in streams and gill netting in lakes. Net sets of short duration (two hours or less) were employed, but since only a small number of fish was caught in the short daylight sets it was necessary to use the stomachs of some fish collected in overnight sets. Fish selected from the latter were those which appeared to have been in the nets a short time. Stomachs were preserved in 10 percent formalin, either after removal from the fish or in situ. The contents of each stomach were observed under magnification and the kinds of organisms present were noted. Visual estimates (to the nearest 10 percent) were made of the fraction each item contributed to the total.

Columbia River chub. Insects made up 51 percent of the stomach contents of 42 Columbia River chub (4.0-11.0 inches in length) taken between

August 6 and September 12, 1957 in Placid Lake and Rainy Lake (Table V). Adult ants (26 percent of the total) were the most abundant item. These insects were swarming in great numbers in the Clearwater drainage during August. Many of them fell on the surfaces of the lakes, resulting in extensive use by fish. Diptera larvae and mayfly nymphs were also present

Table V. Stomach contents of 42 Columbia River chub captured in Placid Lake and Rainy Lake, August and September, 1957.

Food organism	Average percentage of contents	Frequency of occurrence
Gastropoda	6	5
Pelycopoda	1	2
Cladocera	20	10
Hymenoptera	26	13
Diptera	5	12
Ephemeroptera	4	3
Coleoptera	2	1
Hemiptera	2	1
Odonata	1	1
Trichoptera	tr.*	1
Unidentified insects	11	14
Unidentified invert.	4	7
Debris	18	15
Plant material	tr.	1

* tr. means trace.

in moderate numbers. Nearly all of the mayfly nymphs were of one bottom dwelling species. Cladocerans constituted 20 percent of the stomach contents. These organisms were noticeably abundant in Placid Lake during late August and in Rainy Lake during early September. Snails made up six percent of the contents. Large amounts of sand were usually present in stomachs containing snails and Diptera larvae. Plant material occurred in

only one stomach.

Columbia squawfish. Insects made up 92 percent of the stomach contents of 32 Columbia squawfish (4.0-10.1 inches in length) collected in Placid Lake and Rainy Lake between August 8 and September 12, 1957 (Table VI). Adult ants were the most abundant item (23 percent of the total) and occurred in half of the stomachs. Water boatmen made up 20 percent of the contents. Adult damselflies and bottom dwelling forms (Diptera larvae and mayfly nymphs) also occurred in moderate numbers. Only one stomach contained the cladocerans which were abundant in the Columbia River chub stomachs. One stomach contained two small toads.

Table VI. Stomach contents of 32 Columbia squawfish captured in Placid Lake and Rainy Lake, August and September, 1957.

Food organism	Average percentage of contents	Frequency of occurrence
Hymenoptera	23	16
Hemiptera	20	9
Ephemeroptera	13	8
Odonata	10	6
Diptera	4	3
Coleoptera	2	4
Orthoptera	2	1
Unidentified insects	17	16
Cladocera	2	1
Unidentified invert.	tr.	1
Anura	2	1
Plant material	2	2
Debris	2	2

Fish remains were found in four of eight Columbia squawfish stomachs collected in Alva Lake on June 19, 1956. Each contained the remains of

one fish. One of the remains was identified as a Columbia squawfish, another as a Yellow perch. The other two were not identified. Insects and plant material made up the remainder of the contents of the eight stomachs.

The stomach contents of 43 Columbia squawfish (4.0-10.1 inches in length) collected in the Clearwater river below Salmon Lake were also principally of insects (76 percent). Two bottom sprawling species of mayfly nymphs constituted 25 percent of the total. Moderate numbers of grasshoppers and caddis larvae were also present. Fish remains (cyprinids) occurred in two stomachs (Table VII).

Table VII. Stomach contents of 43 Columbia squawfish captured in the Clearwater River below Salmon Lake in mid-summer.

Food organism	Average percentage of contents	Frequency of occurrence
Gastropoda	2	2
Ephemeroptera	25	19
Orthoptera	11	6
Trichoptera	7	12
Plecoptera	2	1
Hymenoptera	2	2
Coleoptera	2	1
Diptera	1	4
Odonata	1	1
Unidentified insects	25	23
Unidentified invert.	8	4
Fish	4	2
Plant material	6	9
Debris	4	10

Ricker (1941) found that Columbia squawfish over 100 mm. long in Cultus Lake fed largely on fish except during early summer. Fish are

apparently a minor item in the summer diet of this species in the Big Blackfoot drainage. Insects made up the bulk of the contents of the stomachs examined.

Summary

1. The life histories of the Columbia River chub and the Columbia squawfish were studied during the summers of 1956 and 1957 in the drainage of the Big Blackfoot River, Montana.

2. Both species occurred in certain lakes of the drainage, in the lower portion of the Big Blackfoot River and in one principal tributary. The Columbia squawfish also occurred in the upper portion of the Big Blackfoot River.

3. Both species inhabited shallow, vegetated areas in lakes. Columbia squawfish were found in areas of relatively calm water in streams.

4. The growth of Columbia River chub was studied by examining the scales from 300 fish. Specimens of this species up to nine years of age were collected.

5. Growth of Columbia squawfish was based on examination of scales from 339 fish. Some individuals of this species attained an age of at least 15 years.

6. Columbia River chub matured sexually at three to five years of age while Columbia squawfish matured at six to eight.

7. Both species spawned in late May and early June while average water temperatures were 55-65° F.

8. The stomach contents of 42 Columbia River chub and 83 Columbia squawfish were examined. Insects were the predominant item in the stomachs of both species. Fish were found in some Columbia squawfish stomachs.

Literature Cited

Foerster, R. E. and W. E. Ricker.
1941. The Effect of Reduction of Predacious Fish on Survival of young Sockeye Salmon at Cultus Lake. J. Fish. Res. Bd. Can. 5(4):315-36.

Jeppson, Paul.
1957. The Control of Squawfish by Use of Dynamite. Prog. Fish-Cult. 19(4):168-71.

Ricker, W. E.
1941. The Consumption of young Sockeye Salmon by Predacious Fish. J. Fish. Res. Bd. Can. 5(3):293-313.

Schultz, Leonard P.
1935. The Spawning Habits of the Chub, Mylocheilus caurinus — a Forage Fish of Some Value. Trans. Am. Fish. Soc. 65:143-7.

Weisel, George F.
1955. Three New Intergeneric Hybrids of Cyprinid Fishes from Western Montana. Am. Midl. Nat. 53(2):396-411.