SYSTEMATIC STUDIES OF WESTSLOPE CUTTHROAT TROUT

FROM THE

COER D'ALENE IDAHO DRAINAGE SYSTEM

by

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ABSTRACT

Four samples of westslope cutthroat trout were taken from four locations on the Coer d'Alene drainage system. These locations were the east fork of Pine Creek, Big Creek at Dot Creek, Spruce Creek, and Tepee Creek at Riley Creek.

The following morphological characters were measured; gill raker count, pyloric caeca, dentition, scales two rows above the lateral line, scales running obliquely from the lateral line to the anterior edge of the dorsal fin, pelvic fin ray count, and vertebrae count. These characters were compared with those previously established for <u>Salmo clarkii lewisi</u> (eastslope cutthroat) and the yellowstone cutthroat trout to determine if a difference occurs at the sub-species level.

From the data it was determined that there are a number of major morphological differences present between yellowstone cutthroat trout and westslope cutthroat trout. The data did not warrent a differentiation between westslope and eastslope cutthroat trout.

INTRODUCTION

To date it has not been established if all the cutthroat trout of the upper Missouri and Yellowstone drainages, the middle and upper Columbia River basin and South Saskatchawan River systems should be collectively classified as Salmo clarkii lewisi. Dr. Robert Behnke suggests that cutthroat trout native to the Columbia River basin are possibly a separate subspecies from those associated with the Yellowstone drainage and the Missouri drainage. He also states that presently there is not enough evidence to proove that these trout differ at the subspecies level. (1. Behnke 1973)

The Coer d'Alene River system is part of the Columbia River System. This report deals with data collected from cutthroat trout of four different streams on the Coer d'Alene drainage. I plan to present the systematic information collected and then compare it with the well-defined information for the eastslope and yellowstone cutthroat trout. Hopefully this information will shed some light on the problem of establishing taxonomic classification of these fishes.

HISTORICAL BACKGROUND

Before proper systematic analysis can be made the person making the comparisons must be familiar with the geologic history of the specimens being considered. He must be familiar with the isolating mechanisms present and understand those factors which might effect the genetic isolation of that species.

During the Pleistocene great climatic fluctuations occured. Almost every possible combination of conditions occured. These climatic fluctuations brought the extinction of many species that were unable to adapt and severely restricted the range of many others. (2. Miller 1955) The life zones of aquatic fauna oscillated northward and southward several hundred miles as well as thousands of feet up and down the mountainsides in synchrony with these climatic fluctuations. (3. Morrison 1965) As glaciation destroyed some species, it may have simultaneously provided the stimulus for evolution and speciation of such cold water species as the present day salmonids. (4. Miller 1958)

Lake Bonneville, a large pluvial lake, served as a refuge for salmonids during periods of glacial advance. As the climate in the Great Basin fluctuated, Lake Bonneville underwent two or three periods of high water, overflow, and desiccation. This overflow could be a possible excape route from the Bonneville Basin.

As the Altithermal Interval approached about 8,000 years ago (5. Scott 1965), the last great ice sheet, the Wisconsin, began to retreat. As this ice sheet receded great streams eroded away lava flows and other barriers opening up new migration routes for the fishes of the Bonneville Basin. With the dessiccation of the refuge area, fish were forced to migrate up withering streams or face extinction. (6. Miller 1959) With the recession of the Wisconsin ice sheet and new migration routes open, salmonids began to move into the previously ice bound lakes and streams of the Columbia River System and into Yellowstone National Park. It is apparant from zoogeographic and taxonomic evidence that the cutthroat trout native to the Yellowstone drainage were not derived from the Missouri basin, but from the upper Snake River. (7. Behnke 1973) When determining the status of the westslope cutthroat it is important to remember that the major comparison must be made between the "westslope" cutthroat and S. c. lewisi.

METHODS AND MATERIALS

The specimens were originally obtained by Mr. P. Laumeyer from four different collection sights during the summer of 1973. All sights were on the Coer d'Alene River System. The fish were packed in 70% alchohol and sent to Colorado Co-Operative Fisheries Unit.

There are many different diagnostic characters that are helpful in taxonomic analysis. However, since data is available for only a few characters I will only deal with a few of them. The number of vertebrae present, determined by the use of x-ray was one morphological count taken. All vertebrae beginning with the first non-fused vertebrae (the atlas and axis are altered for joining the column to the cranium) including the three upturned vertebrae in the caudal region were counted. The gillrakers and basibranchial teeth were stained with alizarin to facilitate counting. The gill raker count was made above and below the angle or bend of the first gill arch, the upper number being listed first. The raker located on the angle of the arch, is included in the lower arm count. I will deal with only the gill raker totals in this study. The dentition refers to the number of teeth located in the rear lower portion of the mouth on the basibranchial bone.

Pyloric caeca are outpocketings of the intestine that increase the digestive surface. The number of caeca present is a beneficial diagnostic characteristic and I have counted them for each sample, removing them as they were counted. I also determined the number of fully developed rays within the left pelvic fin of each of the specimens. There are two types of scale counts that I also took as diagnostic characteristics. The number of scales running obliquely from the lateral line to the anterior edge of the dorsal fin and the number of scales running laterally two rows above the lateral line.

The lateral line beginning with the first scale next to the operculum, counting laterally all scales in a line up to the last vertebrae, indicated by a fold present when the tail is bent. The scales counted were scraped clean of the mucous and epidermis covering and stained with malachite green to make them easier to count.

The size, shape, and patterns of spotting over the body can also be useful. As a result of hybridization these patterns can become altered from the pure state. If hybridization has occured, analysis using this method becomes difficult. I have directed a few lines to the analysis of the spotting pattern of my samples in the next section.

The mean values for each of these measurements were established for each of the four samples. It is these values that I will use in my systematic studies. The mean values in tables Ia, Ib and Ic used for the composit samples of "typical" westslope cutthroat trout, the Yellowstone Lake cutthroat trout and the "typical" rainbow trout were taken from Dr. Behnke's January 1973 Rare and Endangered Report on Westslope Cutthroat Trout. The figures for the eastslope cutthroat trout were taken from a report by James Roscoe. (8April, 1973) This report gave the eastslope cutthroat trout mean figures for specimens collected from the Gallatin River, Smith River, and Gallatin River drainages. I have listed my figures beside them for each of the four sampling locations.

DISCUSSION OF RESULTS

When reviewing limited data such as mine one must take care not to draw unwaranted conclusions. I do not plan to speculate as to the orgin of all cutthroat trout of the Columbia River system, but I hope to arrive at some conclusions in relation to my data.

In all four samples the specimens exhibited the same spotting pattern. Most of the fish had medium sized, irregular shaped spots that were concentrated on the caudal peduncle and above the lateral line anteriorily. This pattern agrees with that expressed in Dr. Behnke's report, for the "typical" westslope cutthroat trout. A few of the trout had smaller, more star shaped (profuse) spots that extended onto the top of the head. This spotting pattern is likely due to the cutthroat x rainbow hybridization. The hybrid pattern was most prevelent in the Tepee Creek sample.

East Fork of Pine Creek

This creek feeds directly into the Coer d'Alene River. There were ten fish in this sample. The morphological characters compare well with those expressed as typical westslope characteristics by Dr. Behnke. Examination of Table Ia suggests that there is no obvious differance between eastslope and westslope trout that is as easy to see. There does not appear to be any significant difference in the mean morphological values. The only possible significant difference might be in the gill raker counts. The eastslope cutthroat have an average value of 19.2 while the westslope cutthroat have a 18.7 value. This difference might be of benefit if evident in the other samples. It appears also that some hybridization with rainbows has occured. The lateral line series scale count averages at 147.3 and the diagonal count was 38.5. These values don't fit into any group, but the values do fit mid-way between the westslope value and the rainbow value. This suggests hybridization in this case. The low vertebrae count and the slight deviation of it from the norm mean could be due to effect of environmental influences. (9. Gonside 1966) The vertebrae number is determined primarilly by genetic inheritance, however.

Spruce Creek

This creek feeds directly into Lake Pend Orielle. There are thirteen fish in the sample. Of the four samples taken I would consider this my purest population. Very little hybridization is evident from either the spotting patterns or the morphological characteristics. Once again the differences between yellowstone and westslope cutthroat trout is evident. In this case it also is possible to detect differences between eastslope and westslope cutthroat trout. The main difference lies in the scale counts, gill raker counts, dentition, and pyloric caeca counts. The mean values for the lateral line series and the scales above the lateral line for the westslope were 166.0 and 40.9 respectively. They were 173.2 and 41.7 for the eastslope. The number of basibranchial teeth averaged at 6.7 for the westslope and 8.3 for the eastslope. The mean pyloric caeca count for the westslope fish was 38.0 and the eastslope value is figured to be 32.9. The major difference occurs again in the gill racker counts. The westslope mean is 18.6, the eastslope average is 19.2. Any one of these differences alone is not enough to substantiate an actual difference betweent these samples, but if viewed collectively and if they are also present in other samples then it would be grounds for the naming of a different sub-species.

Tepee Creek at Riley Creek

This creek also eventually feeds into the Coer d'Alene River. This sample contains eleven specimens. The differing characteristics for the westslope v.s. yellowstone cutthroat trout is again evident in this sample. All of the westslope mean values run lower than the yellowstone values and they all fit in the "typical" westslope cutthroat specifications. There is no evident difference between the eastslope and westslope values in this case.

Big Creek at Dot Creek

This creek feeds into the St. Joe River. There are only four fish in this sample. I would hesitate to make any definate assumptions based on this limited sample. The difference of morphological mean values between yellowstone and westslope cutthroat trout is again evident from this sample data. There is also a difference in values for the gill raker counts between westslope and eastslope trout that is apparent. The eastslope value is 19.2 while the mean value for the westslope trout is 18.5.

SUMMARY

The conclusions in this section are primarily derived from Table II using Tables Ia-d and previously stated ideas to arrive at an overall opinion of this data. Table II allows direct comparison between the three geographic groups. The overall means for each of the morphological characteristics can also be compared.

It appears that the cutthroat trout of the upper Missouri Basin(eastslope) are more closely related to the westslope cutthroat trout than either one is to the yellowstone cutthroat trout. On the basis of the data presented in this report I would suggest that the yellowstone cutthroat trout should be given a new subspecies title. The condition of the westslope trout remains vague. There is some evidence that there are morphological differences between the eastslope cutthroat and the westslope cutthroat trout but this report does not present enough evidence to warrent a change in subspecies for the westslope trout. The lower scale counts (40.3, 164.7) and the higher pyloric caeca mean (35.4) lend some evidence to the assumption that they differ but these figures alone can not be offered as decisive proof.

It is possible that the cutthroat trout found in the upper Missouri system and the upper Columbis River system are of recent common ancestory. The transfer from one side of the Continental Divide to the other would have been made by headwater stream transfer or headwater stream capture. Headwater stream capture would occur in low mountain valleys near the Continental Divide where fish in headwater streams may become isolated from the parent drainage by lava flow, landslide, or some such catastrophic event. (Behnke, personal communications)

While the exact taxonomic condition of Salmo clarkii still remains somewhat undetermined it is essential to realize that a variety of different gene pools exist. To best utilize these different gene pools steps must be taken to perpetuate the remaining genetic diversity demonstrated by these different subspecies. To allow these diversified gene pools to blend into a common gene stock by careless fish stocking would be doing the future fish manager a grave injustice.

Table Ia; Comparison of east fork of Pine Creek cutthroat trout with established morpholgical data from other areas.

Character	Eastslope Cutthroat		Westslope Cutthroat		Yellowstone Cutthroat		Rainbow trout		Pine Creek	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Pyloric caeca	32.9	25-58	(32-42)	25-50	42.0	31-51	52.5	40-70	32.0	27-41
Basibranchial Teeth	8.3	1-38	(6 -12)	1-25	22.0	10-46	0.0	0	8.8	4-15
Vertebrae	60.8	59-62	(60-61)	59-62	61.5	60-63	63.0	62-64	59.7	59-60
Lateral Series	173.2	144-204	(155-173)	145-190	175.0	140-200	127	120-140	147.3	144-162
Scales above Lateral Line	41.7	36-50	(38-42)	36-44	42.0	36-48	28.0	25-32	38.5	36-41
Pelvic fin ray	9	9	9	9	9	9	10	10	9	9
Gill Rakers	19.2	17-22	(18-19)	17-21	20.6	18-23	19.5	18-22	18.7	18-19

Table Ib; Comparison of Spruce Creek cutthroat trout with established morphological data from other areas.

Character	Eastslope Cutthroat		Westslope Cutthroat		Yellowstone Cutthroat		Rainbow Trout		Spruce Creek	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Pyloric caeca	32.9	25-58	(32-42)	25-50	42.0	31-51	52.5	40-70	38.0	24-45
Basibranchial Teeth	8.3	1-38	(6-12)	1-25	22.0	10-46	0.0	0	6.7	0-11
Vertebrae	60.8	59-62	(60-61)	59-62	61.5	60-63	63.0	62-64	60.9	60-62
Lateral Series	173.2	144-204	(155-173)	145-190	175.0	140-200	127	120-140	166.0	150-189
Scales Above Lateral Line	41.7	36-50	(38-42)	36-44	42.0	36-48	28.0	25-32	40.9	38-44
Pelvic fin ray	9	9	9	9	9	9	10	10	8.5	7-9
Gill Rakers	19.2	17-22	(18-19)	17-21	20.6	18-23	19.5	18-22	18.6	18-21

1. Data for eastslope cutthroat from a report by James W. Roscoe. A comparison of the morphological characteristics of the eastslope cutthroat trout, _Salmo clarkii lewisi_, and the westslope cutthroat trout. FW495 Special report.
2. "Typical" westslope, yellowstone, and rainbow data taken from Dr. Behnke's January 1973 Rare and Endangered Report on westslope cutthroat trout.

Table Ic; Comparison of Tepee Creek at Riley Creek cutthroat trout with established morpholgical data from other areas.

Character	Eastslope Cutthroat		Westslope Cutthroat		Yellowstone Cutthroat		Rainbow Trout		Tepee Creek	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Pyloric caeca	32.9	25-58	(32-42)	25-50	42.0	31-51	52.5	40-70	33.4	26-41
Basibranchial Teeth	8.3	1-38	(6-12)	1-25	22.0	10-46	0.0	0	6.9	3 -14
Vertebrae	60.8	59-62	(60-61)	59-62	61.5	60-63	63.0	62-64	60.5	60-62
Lateral Series	173.2	144-204	(155-173)	145-190	175.0	140-200	127.0	120-140	171.1	160-181
Scales Above Lateral Line	41.7	36-50	(38-42)	36-44	42.0	36-48	28.0	25-32	41.0	38-43
Pelvic fin rays	9	9	9	9	9	9	10	10	9	8-10
Gill Rakers	19.2	17-22	(18-19)	17-21	20.6	18-23	19.5	18-22	19.1	18-20

Table Id; Comparison of Big Creek at Dot Creek cutthroat trout with established morpholgical data from other areas.

Character	Eastslope Cutthroat		Westslope Cutthroat		Yellowstone Cutthroat		Rainbow Trout		Big Creek	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Pyloric caeca	32.9	25-58	(32-42)	25-50	42.0	31-51	52.5	40-70	38.2	33-42
Basibranchial Teeth	8.3	1-38	(6-12)	1-25	22.0	10-46	0.0	0	6.0	4-8
Vertebrae	60.8	59-62	(60-61)	59-62	61.5	60-63	63.0	62-64	61.5	61-62
Lateral Series	173.2	144-204	(155-173)	145-190	175.0	140-200	127.0	120-140	174.5	163-191
Scales Above Lateral Line	41.7	36-50	(38-42)	36-44	42.0	36-48	28.0	25-32	40.7	40-42
Pelvic fin rays	9	9	9	9	9	9	10	10	8.5	8-9
Gill Rakers	19.2	17-22	(18-19)	17-21	20.6	18-23	19.5	18-22	18.5	18-21

TABLE II

Comparison of overall means for some morphological characters for cutthroat trout of three geographic areas.

Character	Eastslope Cutthroat	Westslope Cutthroat	Yellowstone Cutthroat
Pyloric caeca	32.9	35.4	42.0
Basibranchial Teeth	8.3	7.1	22.0
Vertebrae	60.8	60.6	61.5
Lateral Series	173.2	164.7	175.0
Scales Above Lateral line	41.7	40,3	42.0
Pelvic Fin Rays	9.0	8.7	9.0
Gill Rakers	19.2	18.7	20.6

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SYSTEMATIC ANALYSIS OF WESTSLOPE CUTTHROAT TROUT

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FW 300
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SYSTEMATIC ANALYSIS OF WESTSLOPE CUTTHROAT TROUT

ABSTRACT

In 1973, samples of suspected Montana westslope trout were collected in the Coeur d'Alene river system in northern Idaho. Five of these samples were sent to the Colorado Cooperative Fisheries unit at Colorado State University. With the help of Dr. Behnke and his graduate students, an analysis was done by me and a comparison to know westslope trout, Yellowstone trout (*Salmo clarki lewisii*) and Rainbow trout (*Salmo gairdneri*). The results of these data will be incorporated into a masters thesis prepared by Jim Roscoe and Ted Murphy.

INTRODUCTION

The "Montana Westslope" cutthroat trout is recognized as an endangered species by the United States Department of the Interior. The taxonomic status of this trout is uncertain. This uncertainty will remain for at least another year due to the complexeties in the taxonomic problems involved. In past decades, the cutthroat trout native to the vast areas in the upper Columbia basin on the west slope, and the upper Missouri on the east slope have drastically declined in numbers and now is extremely rare in its pure form. This is due to several factors, the main factor being extensive stocking of hatchery bred rainbow trout. This brings about cross breeding and production of fertile hybrids. (Behnke, Personal Communications). The protection of these rare pure populations should not await the final solution as to the taxonomic status of these trout. Behnke, (1973) says "the ultimate goal of a preservation or enhancement program should be to perpetuate the remaining genetic diversities of a polytypic species, *Salmo clarki*, in areas where this species has become greatly depleted."

This report will point out the differences or similarities of the samples of suspected westslope trout to the rainbow, known westslope cutthroat, and the so-called Yellowstone cutthroat trout. These data will be incorporated into the vast amounts already collected by Dr. Behnke and graduate students Jim Roscoe and Ted Murphy and will be written up as a masters thesis by Murphy and Roscoe.

HISTORY

The cutthroat trout probably had its ancestors in northern Canada and Alaska and as the last glaciation appeared, the fish were pushed down out ot their original areas. Then as the glaciers pulled back, the trout filled in behind them when the environment became suitable. The glaciers had changed the courses of the major river systems into what we call the Columbia, Coeur d'Alene and Missouri drainages. (Mottley 1934)

During this post glacial repopulation, the cutthroat trout attained some diversity in taxonomic characters. This variability is probably due to the dispersion of the cutthroat trout coming from two or more parent subspecies. These parent subspecies were isolated by the change in river drainages after glacial recession. This isolation served to keep the offspring from these stocks from cross breeding and homogenizing the different subspecies into one uniform type. (Behnke 1973)

The reason behind the separated pure population of cutthroat in the upper Columbia river system is due to post glacial invasion of rainbows, and also in the late 1800's, artifical stocking efforts undertaken by private individuals and also government agencies to increase the sport fishing aspect of the area. These rainbow will cross breed with cutthroats, and if natural selection doesn't suppress it, will produce fertile offspring with both parents' characteristics. Only in a very few places in Idaho have the cutthroat and rainbow trout existed without cross-breeding.

Several common subspecies can presently be found all over the mid-west and into Canada. They include the greenback cutthroat of Colorado, the Missouri drainage cutthroat, the Yellowstone cutthroat, a few isolated populations of Salmo clarki alpestris in the Frasier and upper Columbia river, and now the westslope cutthroat which was included in the Missouri drainage series.

METHODS

Several major problems must be understood and dealt with when collecting samples of the westslope cutthroat trout. Great care must be taken as not to collect any of the known varieties of cutthroat. This is usually easy because each variety of cutthroat has its own area and they don't overlap much if any. Hybrid trout usually cannot be identified in the field, a complete characterization must be done in the lab to sort out the hybrids.

Five sample sites were represented in my samples. These are all small tributaries to lakes or rivers. Two creeks, Bayview and Old Maid empty into the Coeur d'Alene River and are quite easily accesable by car.

West Gold Creek is a small tributary to the lake of Pend O'Rielle and this is the largest total sample studied in this report. Careywood Creek is one of the tributaries to the Coeur d'Alene system as is Tumble-down Creek.

Shocking or electro-fishing using a backpack shocker was the pre-dominant method of collection. It is the easiest and collects far more fish than any of the other practical methods. Once collected, the stunned fish were field analyzed and fish that were obviously not cutthroats were put back. Then a look at the top of the head could sometimes differentiate between rainbow cutthroat hybrids and cutthroats. The hybrids would have irregular dark spots on the top of the head and the cutthroats would have round or ovoid spots on its head. After the cutthroats were picked out, they were packed in alcohol and labeled.

In the lab, many measurements and counts were taken. These counts include vertebrae counts using the x-ray machine, gillrakers, bronchiostegal rays,scales in the lateral line, scales above lateral line, pyloric caeca, pelvic fin rays, and dentition. After these counts were made, they were averaged for each tributary. To aide in the dentition and gillraker counts, the mouth and throat were stained with Alizarin.

RESULTS

The diagnostic charactors of the westslope cutthroat are based on samples from the Flathead River drainage. These trout are characterized with small, slightly irregular, numerous spots that are quite sparse or absent below the lateral line anterioraly. They also have fewer vertebrae, scales, pyloric caeca, basibranchial teeth and gillrakers than do the Yellowstone cutthroat.

Along with the spotting pattern mentioned above the rainbow x cutthroat hybrid can also be differentiated by the absence or relatively few numbers of basibranchial teeth, scale counts, caecal counts and vertabrae counts. This is brought out in the accompaning tables.

The rainbow x cutthroat hybrid traits are brought out in the Careywood Creek samples. These fish have no or few basibranchial teeth, fewer and larger scales, fewer gillrakers and an increase in vertebrae number. These traits lead me to believe that these trout are not a pure population of cutthroat.

The other four samples showed no effect due to hybridization except some variation in spotting patterns. These samples could represent pure populations. Bayview and Old Maid Creeks do show some slight indication of hybridization.

CONCLUSIONS AND DISSCUSSION

A major problem is associated with making an assesment as to whether a population is pure westslope cutthroat trout or not. It is summarized well by Behnke (1973), "... only a limited amount of data is available to diagnose the characteristics of westslope cutthroat trout."

There are relatively few pure populations of westslope cutthroat trout left today. The samples I analyzed were from relatively pure populations with one exception. Even though they, on an average, looked like pure populations, evidence of hybridization shows in individual fish. This shows most evidently as some variation in the spotting pattern. These fish indicate that hybridizaiton is taking place and, in a few generations, there will be very few populations of cutthroat trout life in this area.

These trout populations should be protected to perpetuate these trout in their natural habitat.

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DATA TABLE I

	Vertebra	Gillrakers	Pyloric Caeca	Scales Lat. Line Above Lat. Line	Pelvic Fin Rays	Basibranchial Teeth
"typical" westslope cutthroat	60-61	18-19	32-42	155-173 38-42	9	6-12
Yellowstone cutthroat	61.5 (60-63)	20.6 (18-23)	31-51	(140-200) 175 (36-48) 42	9	22
typical rainbow trout	63 (62-64)	18-22 (19-20)	40-70 (50-55)	125-130 26-30	10	absent
Carywood Creek	62	15.75	25.3	166.3 38.5	9	0-5

DATA TABLE II

	Vertebra	Gillrakers	Pyloric Caeca	Scales Lat. Line Above Lat. Line	Pelvic Fin Rays	Basibranchial Teeth
"typical" westslope cutthroat	60-61	18-19	32-42	155-173 38-42	9	6-12
Yellowstone cutthroat	61.6 (60-63)	20.6 (18-23)	31-51	(140-200) 175 (36-48) 42	9	22
typical rainbow trout	63 (62-64)	18-22 (19-20)	40-70 (50-55)	125-130 26-30	10	absent
Tumbledown Creek	61	17.0	39.5	172.7 39.5	9	5-7
West Gold Creek	60.8	18.5	44.1	179.8 40.0	9	5-15

DATA TABLE III

	Vertebra	Gillrakers	Pyloric Caeca	Scales Lat. Line Above Lat. Line	Pelvic Fin Rays	Basibranchial Teeth
"typical" westslope cutthroat	60-61	18-19	32-42	155-173 38-42	9	6-12
Yellowstone cutthroat	61.6 (60-63)	20.6 (18-23	31-51	(140-200) 175 (36-48) 42	9	22
typical rainbow	63 (62-63)	18-22 (19-20)	40-70 (50-55)	125-130 26-30	10	absent
Bayview Creek & Old Maid Creek	60.8	17.5	35.4	182.5 38.75	8.6	5-9
Kalispeil Creek	60.75	19.5	36.3	183.5 39.7	8.8	4-10

check grad school thesis rules for figures & legends. – (above fig. O.K.?)
list 1-7 ? in fig.

fig 7 of : – fine spotted
– large-spotted
– westslope (?)

Fine-spotted cutt of S.R. characters analyzed group w/ large spotted S.R. – Yellowstone – supports idea that of authochthonous origin from S.R. ancestor rather than invasion of westslope cutt from Salmon R. across S.R. lava plain.

Sof scores (character) set up for spotting pattern discrimination would be more prounced – esp. S.R. fine spotted & east-westslope (lewisi).

– Zero in on target area of Gros Vente R. drainage. This is area where both large, fine spotted forms found – where more detailed study in future should be concentrated in resolving relationships.

– Past & present stocking program add noise to study – early 1900's thru 1950's millions Yellowstone L. stock stocked throughout upper S.R. basin – since then fine-spotted form propagated and widely introduced into large-spotted pop. – despite forced mixing the two forms are remarkably distinct in native habitat – ex. – headwater Spread Crk. at junction w/ Leidy Crk. – large spotted native – fine-spotted hatchery trout (w/ jaw tags) caught but sample from Leidy Crk. all typical large-spotted form.

selective advantage for orig. local gene pool in native waters

– Gros Vente samples – most taken by personnel of Wyo. F. & G. in 1972 – actual collection sites not seen. – but – here what examination of specimens reveals.

– typical Big spotted in — — — — Fine spotted in — —

spec. judged intermed. — — — —

only area where both (sympatric) 1972

<u>Cottonwood</u> Crk. (?) - sample showed — typical big spots and — typical fine spotted -

- Personally Resampled Sept. - 1973 - only fine spotted found

- ~~Evidence~~ ~~Sugg.~~ Since no large spotted trout stocked in Gros Ventre for about 20 years - can't attribute specimen to stocked trout (at least directly) - Suggestion is that range both forms overlapped in Gros Ventre drainage - smaller, colder headwater tributaries inhabited by large spotted form - larger streams by fine spotted.

- sympatric records (Cottonwood Crk 1972) due to occasional downstream drift - Gene Hybridization occur (intermediate spm) but gene flow reduced by nat. select to maintain both form for optimal utilization of total habitat and both form ~~essential~~ retain identity and not hybrid swarm. - Although continuous environment w/ no physical barrier to complete intermixing essentially sympatric the Gros Ventre drainage seems ~~to~~ to be a small scale duplication of the interrelationship betw. situation size v large in the whole upper S.R. watershed - ~~This area should be the me~~ An ~~much~~ intensive study of the whole Gros Ventre drainage would ~~should~~ be critical to a better understanding of the distribution of the two forms and insight into factors of how they partition a continuous environment to avoid ~~mass~~ massive hybridization.

- Check Jim's thesis on native distribution

- Problems – leading to confused state –
Early investigators – clarki – lewisi
- gibbsi
– Facts – 2 distinct forms of cutthroat in Columbia basin (not including coastal subsp.) – (A) Big-spotted (B) small-spotted = westslope = S. c. lewisi,

- Large-spotted form has more primitive distribution – above Shoshone Falls → Yellowstone
- Bonneville – ~~Ev~~ Evidence ~~sa~~ of sporadic & disjunct distrib. – Wash L., Crab Crk. Wash. (Walla-Walla R.) – looks like it was largely replaced by rainbow, S. g., after last glacial period – persisting only as isolated relicts in areas open to S. g. invasion,
- but protected above Shoshone Falls & radiated out from here.
- B – west slope cutt gives rise to lewisi in upper Missouri – 2 separate crossings of Cont. Divide – (1) Two Ocean Pass Snake – Yellowstone, (2) Clark Fork → Missouri ~~near~~ ~~Water~~ vicinity Glacial Nat. Park – This has never been clarified in lit. before

- Other facts: – rainbow in Col. up to Shoshone Falls – "silver trout" called S. gibbsi is a reality – ~~called~~ belongs to group called red-banded trout by Schreck & Behnke (1971), and Behnke (1972). – Museum Specimens from Wood R. Idaho, Yakima Wash. appears to be this trout and not S. gairdneri. Intergradation hybridization ~~must~~ most likely caused S. g. × red-banded

- cite Wallace personal commun. - Clearwater R. steelhead w/ 150-160 scale -
Sg — below Shoshone Falls - (1) occasional cutthroat (2) rainbow (3) red-banded (4) intergrade red banded - rainbow led Evermann + Gilbert & Evermann believe cutt. - rainbows fully intergraded downstream in Col. -

— Snake River —
Notes on field trip Sept. 1973

622 No Main

Tue. 11th

horse trip. → Town & Country Motel Cedar City or F. & G. office in Cedar City — to water Canyon & Forsythe Crk. — or (For. Ser. office.)

Wed. 12th Birch Crk. — So. Crk.

Thur. 13th Asay — Beaver

Sat. 15–*4 Leidy Crk. — Spread Crk — Spread Crk. stocked w/ tagged, catchable Snake R. trout. — Leidy Crk, 6 trout in Leidy Crk. 4 resemble typical large spotted, 2 about 3/4 L.S. 1/4 F.S. — but spots pronounced* roundish. — Evidently Spread Crk — Gros Ventre area where 2 forms came together + overlay of introductions — bronze, color — much like Bonneville trout
*— orange cutt mark

— *5 — Darby Crk. — Teton R. — Targhee N.F., Wyo. typical big spotted cutt w/ orange cutt mark — orange shaded lower fins — sparse & large spots on caudal, dorsal fins

— Spread Creek stocking ca. 2000/yr. fine spotted since 1961 N. Fk. — Sagebrush Flat. — 4-5 in, — 8-9 in. fish stocked 1972 (July 28 — 1000, 9 in. fish 267 lbs. — all jaw tagged. 1936–1954 — yellowstone cutts stocked — fry . 5000 — 40,000

* Lake of Woods — fish derived Bar B-C ranch — Spring Crk. — Trib. Gros Ventre — run up from Snake R.

— So Fk. Fish Crk. stocking 68-72 w/ 200-5000 S.R. cutts. 1" — 14". (Lake of Woods stock) — brood fish

Tagged fish from Spring Crk. spawners caught between Highway 22 → Moran.

7/10

Ted Murphy
St 522

9.3-1

$\lambda(t) = a + bt \qquad \mu(t) = c + dt$

$\rho(t) = \int_0^{\tau} [\mu(t) - \lambda(t)]\, d\tau$

$= \int_0^{\tau} [(c-a) + (d-b)x]\, dx$; let $A = c - a$; $B = d - b$

$= \int_0^{\tau} (A + Bx)\, dx$

$= Ax \Big|_0^{\tau} + \frac{Bx^2}{2}\Big|_0^{\tau}$

$\rho(t) = At + \frac{B\tau^2}{2}$

$m(t) = a^* e^{-\rho(t)} = a^* e^{-(At + \frac{B\tau^2}{2})}$ where a^* is initial pop size

$\sigma^2(t) = a e^{-2\rho(t)} \int_0^{T} \{\lambda(t) + \mu(t)\} e^{\rho(t)}\, dt$ where $\lambda(t) + \mu(t) = \overbrace{(a+c)}^{C} + \overbrace{(b+d)}^{D}\tau$

$= a e^{-2(At + \frac{B\tau^2}{2})} \int_0^{T} [C + D\tau]\, e^{At + \frac{B\tau^2}{2}}\, dt$

the portion in the integral may be written as:

$\int_0^{T} C e^{At + \frac{B\tau^2}{2}}\, d\tau$ let $\begin{cases} dv = Ce^{At};\ v = \frac{C}{A}e^{At} \\ u = e^{\frac{B\tau^2}{2}};\ du = B\tau e^{\frac{B\tau^2}{2}} d\tau \end{cases}$

$= \frac{C}{A} e^{At + \frac{B\tau^2}{2}}\Big|_0^{\tau} - \frac{C}{A}\int_0^{\tau} \frac{C}{A} B\tau e^{At + \frac{B\tau^2}{2}}$

let: $\begin{cases} dv = B\tau e^{\frac{B\tau^2}{2}};\ v = e^{\frac{B\tau^2}{2}} \\ u = e^{At};\ du = Ae^{At} \end{cases}$

$-\frac{C}{A}\left[e^{At + \frac{B\tau^2}{2}}\Big|_0^{\tau} - A\int_0^{T} e^{A\tau + \frac{B\tau^2}{2}}\, dt \right.$

$+ \int_0^{T} D t\, e^{At + \frac{Bt^2}{2}}\, dt$ let: $\begin{cases} dv = D\tau e^{\frac{B\tau^2}{2}};\ v = \frac{D}{B} e^{\frac{B\tau^2}{2}} \\ u = e^{A\tau};\ du = Ae^{A\tau} d\tau \end{cases}$

$= \frac{D}{B} e^{A\tau + \frac{B\tau^2}{2}}\Big|_0^{\tau} - \frac{D}{B}A\int_0^{t} e^{A\tau + \frac{B\tau^2}{2}}$

So $\sigma^2(t) = a^* e^{-2\rho(t)} \Big[\frac{C}{A} e^{\rho(t)} - \frac{C}{A} - \frac{C}{A} e^{\rho(t)} + \frac{C}{A} + \frac{C}{A}\cdot A\int_0^{T} e^{\rho(t)}\, dt + \frac{D}{B} e^{\rho(t)} - \frac{D}{B}$

$- \frac{D}{B}A \int_0^{T} e^{\rho(t)}\, d\tau \Big]$

$= a^* e^{-2\rho(t)} \left[\left(C - \frac{D}{B}A\right) \int_0^{\tau} e^{\rho(t)}\, d\tau + \frac{D}{B}\left(e^{\rho(t)} - 1\right) \right]$

if $a^* = 1$; $e^{\rho(t)} = \frac{1}{m(t)}$

$\sigma^2(t) = \frac{D}{B}\cdot m(t) - \frac{D}{B}\cdot m(t)^2 + \left(C - \frac{D}{B}A \cdot m(t)^2\right) \int_0^{T} \frac{dt}{m(t)}$

Ted Murphy

Probability of extinction:

$$\lim_{t \to \infty} \int_0^t \mu(x)\, e^{-\rho(x)}\, dx$$

$$= \lim_{t \to \infty} \int_0^t (C + Dt)\, e^{-(At + \frac{Bt^2}{2})}$$

$A = (c-a)$ $B = (d-b)$
$(a \neq b)$ and $(c \neq d)$

① integral converges for B negative and diverges for B positive $B = (d-b)$, d is death rate coeff. of time and b is birth rate coefficient of time. So if $d \geq b$, $p(0) = 1$. Convergence is controlled by the t^2 form ...

But what do they mean? $\sigma^2 \to \infty$ as $t \to \infty$ is perfectly allowable.

You do need $\sigma^2 \geq 0$ which you ignored.

Simple birth and death process.

For the U.S. population data ; $\lambda = .017$, $\mu = .010$

$$m(t) = 210{,}000{,}000\, e^{(.007t)}$$

$$\sigma^2(t) = 210{,}000{,}000 \left(\frac{.027}{.007}\right) e^{.007t} \left(e^{.007t} - 1\right)$$

Time	$m(t)$	$\sigma^2(t)$
0	210,000,000	0
1	211,475,145	5,729,778
2	212,960,664	11,580,651
3	214,456,620	17,554,563
4	215,963,076	23,653,539
10	225,226,680	62,989,974
100	422,887,983	1,653,571,260
1000	230,285,790,000	973,160,541,270,000

Accuracy goes with σ, not σ^2

Variance increases as time increases. Any predictive precision after about 4 time units is subject to very high variability and the predictive potency of

Ted Murphy

the model is in doubt.

If the time period of interest is relatively short, the use of the average population size may be usefull, where the variance is with prescribed limits.

$p_0(t)$?

#1 $\lambda = a + b\,t$, $\mu = b + d\,t$ (a, b, c, d must be non-neg)

look at variance

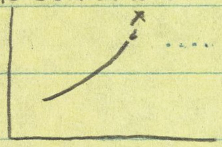
$$\sigma^2(t) = (\text{some term}) \cdot \int_0^t e^{(\ )t^2} \quad (e^{(\ )t^2})$$

$\sigma^2(t)$ either diverge : $b > d$

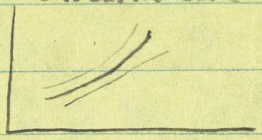
$\sigma^2(t)$ goes to zero : $d > b$ (pop dies out => mean → 0 so σ^2 also → 0)

#2 approximation

deterministic case



stocastic case (X is a RV)



can only define a R.V as a region.

mean is proportional to pop size

VAr " " " pop size

st. dev " " $\sqrt{\text{pop size}}$

check

$p_0(\infty) = 0$ (use deterministic model)

$p_0(\infty) : \left(\frac{\mu}{\lambda}\right)^{x_0} \approx 10^{-70\ \text{millionth}}$

Cutthroat trout collections (see map for localities)

Snake River

fine spotted form

7, 8, 9 (not on map: Crow Creek, tributary to Salt River)

Smith Fork (Bonneville basin introduced)

large spotted form

1, 2, 3, 4, 5, 6, 10 ~~&~~,

Isolated lava plains area (not on map)

Fish Creek, Irving Creek.

- Goose Creek, Nevada not on map

- Upper Missouri basin

- Gallatin R.

1
65
65
65
1 1.9 5
3 5
3 5
2:6 5
2 0
2 85...

Fish Crk. Sept. 6 1972

		Score
3 specimens	very typical fine spotted	1
5 spec.	mainly fine, but slightly larger, more intermed.	- 2
3 spec.	mainly large round, but irregular	- 3
2 spec.	typical large-spot.	- 4

Fish Crk
Sept. 1973

5 = 1

1 = 2
(westslope fig.

Strawberry Crk. Oct. 10, 72

3 = 1

6 = 2

4 = 3

0 = 4

Sohare Crk. → Cottonwood

8 = 1
3 = 2

Raspberry Oct. 17, 72

3 = 1

2 = 3

Cottonwood - 1973
all 1 (or 2)

Pink Crk (head Fish Crk - Moccasin Basin) 1972
6 = 1
3 = (1 or 2)
1 = 3
1 = 4

Maughan, O. E. 1972. Distribution and geographic variation of sculpins in the Clearwater basin. Ph.D. thesis. Washington St. Univ. 213p.

Associations I S. clarki, Sal. malma, Cottus confusus.
higher el.

II C. beldingi, C. bairdi, C. rotheus, Ptychocheilus, Archoceilus, Rhinichthys c. + o., Micropterus d. larger rivers Lampetra tridentata.

III - Catostomus columbianus, Prosop. williamsoni, S. gairdneri
ubiquitous.

Pantosteus platyrhynchus ?

C. beldingi in Clearwater → Great Basin, (big spotted trout) Columbia, Colo-Green.
2 distinct forms ① headwater ② main river
~~Prob.~~ ? from 2 glacial refugia ① Columb. R. ②
Bonneville - - Maughan prefers - independent convergent evolution. - forms called Cottus beldingi tubulatus and Cottus beld. beld.

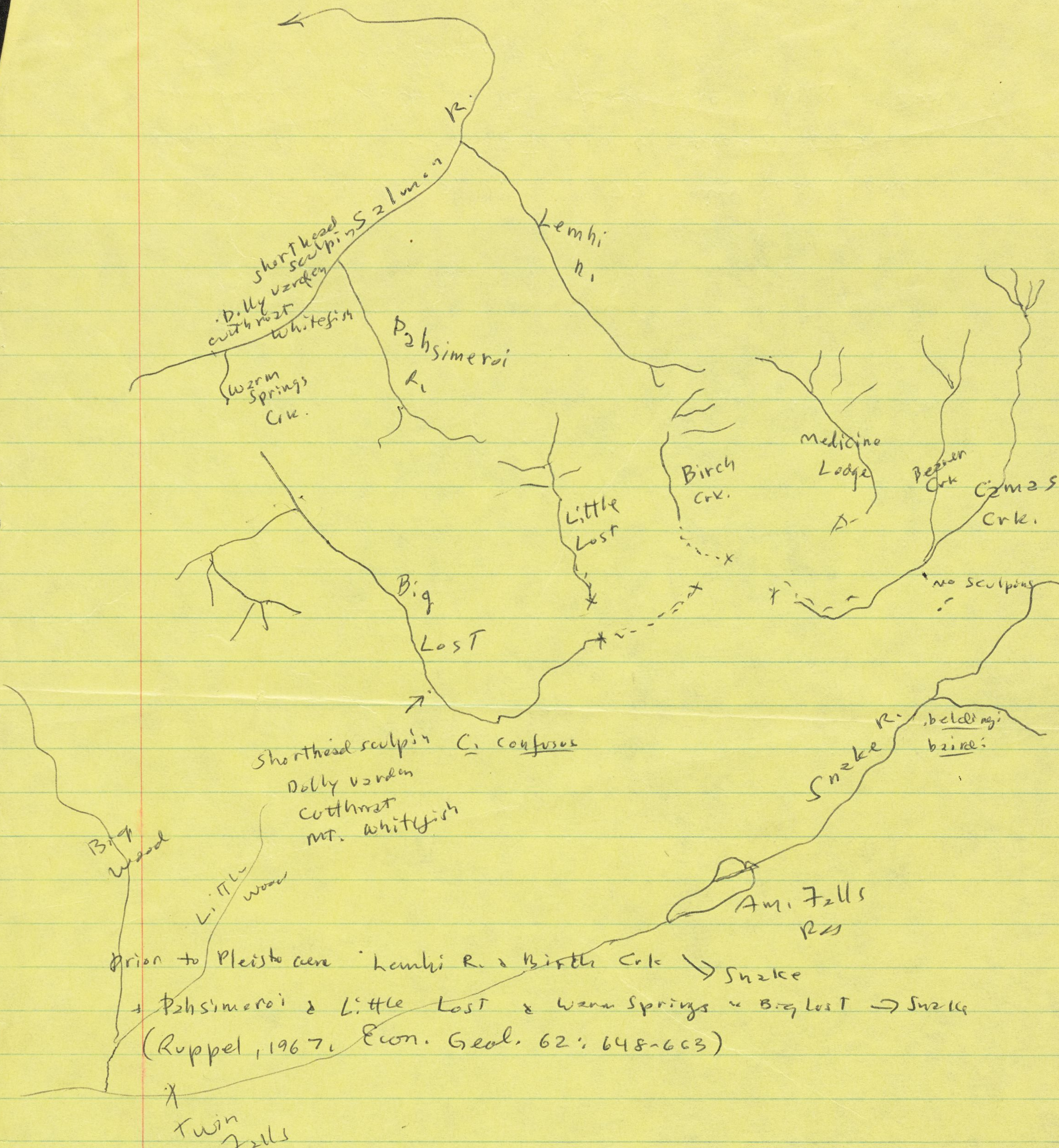
Cottus bairdi - both sides Cont. Divide (from east)
- Snake, Colo., Col. Missouri - - Cottus bairdi of Clearwater named C. hubbsi. Bailey & Dimick 1949. - subsp. C. b. h. which appears to be a Col. R. form - (to B.C.).

C. rotheus widespread. Col. R. - large stream form - Clearwater Salmon, Kootenai - not above Shoshone Falls.

C. confusus - Col. - Puget Sound - Snake R. to Falls - Clearwater - headwater form

- M.S. thesis - Andrews, D. A. 1972. An ecological study of the lost streams of Idaho with emphasis on the Little Lost River. M.S. (Zool). Idaho St. Univ. 57p.

2



Prior to Pleistocene Lemhi R. & Birch Crk → Snake
+ Pahsimeroi & Little Lost & Warm Springs + Big Lost → Snake
(Ruppel, 1967, Econ. Geol. 62: 648-663)

Hubbs & Miller - Camas, Medicine Lodge, Birch, Little & Big Lost R. -
endemic subsp. cutthroat, Dolly Varden, 5 local races of Cottus
none are Bonneville types - represents Snake R. prior to lava flows

Pantosteus?

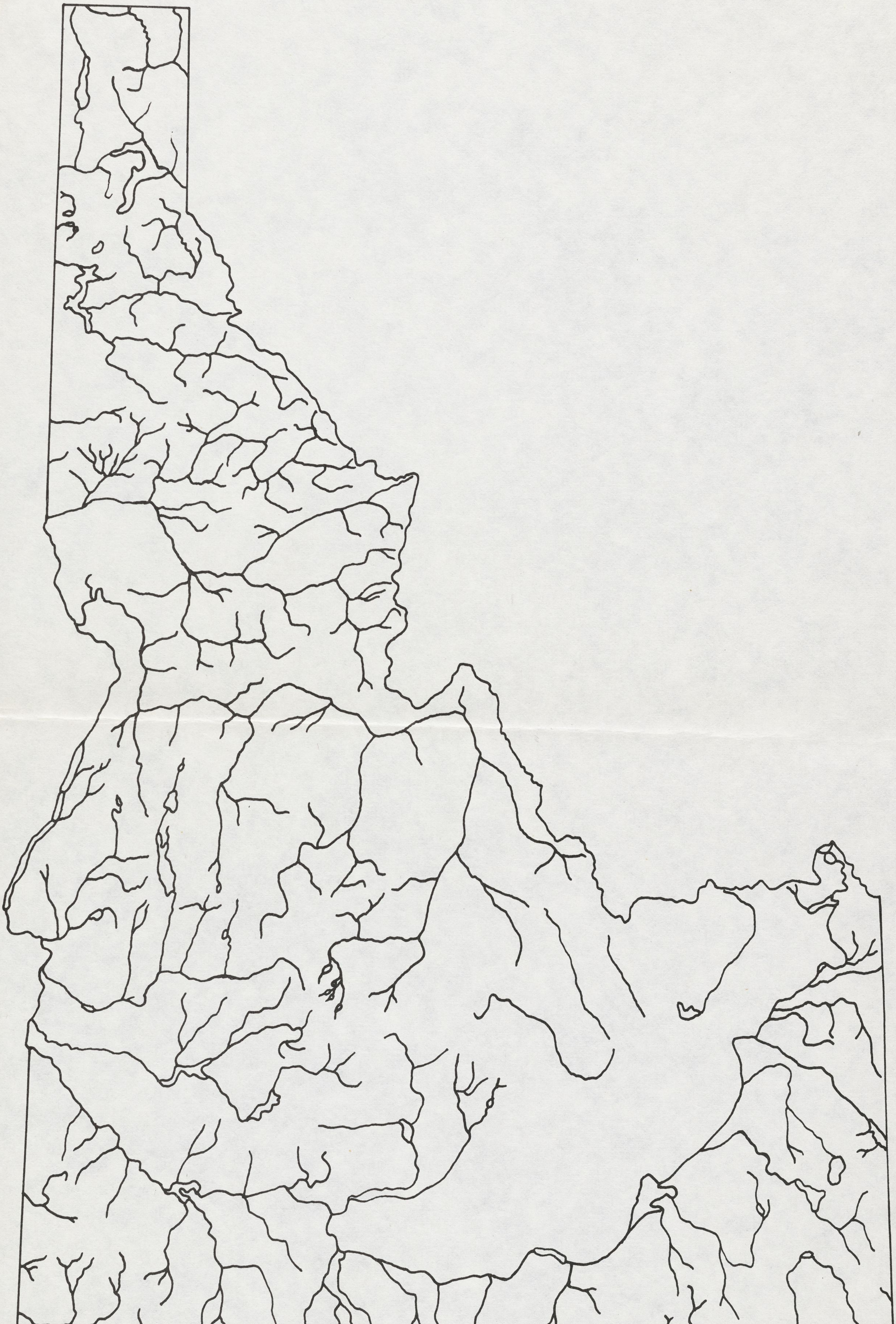
Wood R. - S. clarki, Catost. syncl., Rhinichthyes (?),) prob old
Snake R. fauna + Snyderichthys Bonneville, local race
?— of Cottus leiopomus.

Bourke, John Gregory. 1891. On the border with Crook. Charles Scribner's Sons. 491 p.

Apache trout

p. 142: 1860's Camp Apache, surrounded by high hills running back to first plateau of Mongollon Rim - Two branches of Sierra Blanca River unite in front of camp - being fairly well stocked with trout - a rarity in other sections of the territory.

Trout in Tongue R. - p. 293 - suckers in Clear Crk. of Powder drainage - trout in Tongue. - 294 L. De Smet alkali - variety of pickerel said to abound. 299: trout caught; 321; Tongue a Trib. great trout waters p326 - lake drains both ways ← Big Horn → Tongue. 329, 30, 31; 33: 1000s caught, to 316. - 100+ / day / man. sometimes refuse to hit flies. 2+ lbs 15,000 in 3 wks. 340-41 Shoshone fishing.



Proposal for a comprehensive study of the systematics of the westslope cutthroat trout: A basic prerequisite for their preservation and management.

INTRODUCTION

Two years of collections of specimens and accumulation of data has prepared the foundation to initiate a graduate student thesis project on the systematics of westslope cutthroat trout, which should provide definitive conclusions on diagnostic characters and the taxonomic position of this fish.

Formerly, the westslope cutthroat was listed as an endangered, but undescribed species in the U.S. Dept. Interior's "red book." Currently (1973), because of its uncertain taxonomic status, it has been assigned an "undetermined" status. There is no doubt, however, that pure populations of the cutthroat trout indigenous to the upper Columbia River system have been eliminated from the bulk of their former range, are rare and in need of special attention to preserve the remaining stocks.

The basic problem obstructing efforts to protect or manage the westslope cutthroat is the taxonomic confusion surrounding this fish. How can a pure population be recognized if it is found when no adequate published description exists? The native cutthroat trout of the upper Columbia River system are a subspecies of *Salmo clarki*, but to what subspecies they should be assigned is not yet known.

The information necessary to answer these questions will be developed from this proposed study.

STUDY PLAN

Collections, including museum material, consisting of more than 50 samples and almost 1000 specimens are now available in the Systematics

Laboratory of the Colorado Cooperative Fishery Unit. These samples are from diverse areas of the upper Columbia, South Saskatchewan and upper Missouri river basins. Several characters, such as the number of vertebrae, scales, gillrakers, pyloric caeca and spotting pattern are recorded, compared and evaluated to reveal consistant modes of similarity providing a definition of the characters possessed by the cutthroat trout native to the upper Columbia River drainage and allow for the recognition of essentially pure populations. Comparisions with samples of cutthroat trout from the upper Missouri River system of Montana will determine if the name Salmo clarki lewisi also applies to the westslope cutthroat. Comparisons of museum specimens from diverse segments of the Columbia basin will determine the original distribution of westslope cutthroat and provide an indication to the possibility that more than one subspecies of cutthroat trout (excepting S. c. clarki) is native to this large drainage.

Supplementary data on protein polymorphism should be available from research on biochemical analysis of westslope cutthroat trout by Mr. Gary Reinitz, a graduate student at the University of Montana. Mr. Reinitz' research, however, will not provide definitive information on the diagnosis of westslope cutthroat trout. This is due to the minute fraction of the total genotype that is surveyed by biochemical techniques and to the fact that almost certainly no qualitative differences between the proteins of westslope cutthroat trout and other cutthroat (and probably rainbow) trout will be found. That is, the genes governing the proteins are not specific to the cutthroat trout native to the upper Columbia River basin, but are shared with other cutthroat and most likely, rainbow trout. The best evaluation of the total genotype, for systematic purposes, is still a critical study of several phenotypic characters.

PROGRESS TO DATE

The determination of the diagnostic characters is largely completed. Consistant similarities of several characters from many samples allows us to place quantitative values on characters expected to be found in pure westslope cutthroat trout populations. From this data, the effects of hybridization with rainbow trout and/or Yellowstone cutthroat trout can be detected. Samples can now be run through the examination process and their relative pureness determined.

A compilation and synthesis of information available from field biologists and from the literature on ecological and life history aspects of westslope cutthroat trout will be made. Bringing diverse bits of information together on the biology of this trout, including such items as habitat preference, migratory tendencies, lacustrine populations, age, growth, food habits, etc., will be a valuable source of data for the management of this trout.

During the past year, Mr. James Roscoe has been assigned to the westslope cutthroat project while he was employed as a work-study student. Mr. Roscoe is now enrolled as a graduate student and plans to complete the project for his graduate research and thesis. Mr. Roscoe is presently supported by work-study funds, supplemented by a modest grant from the National Park Service.

Dr. Richard Wallace, Department of Zoology, University of Idaho has long been interested in the native cutthroat trout of Idaho. Dr. Wallace has made numerous significant collections from key segments of the Columbia River basin and plans to bring his collection to Colorado State University during a sabbatical leave this winter and spring and collaborate in this study. His contribution should insure comprehensive authoratative treatment of a difficult systematic problem.

Native Distribution of Some Montana Fishes

	East Slope			West Slope	
	Upper Missouri	Yellow-stone	South Saskatch	Clark Fork	Kootenai
Salmo clarki[1]	+	+	+	+	+
Salvelinus malma			+	+	+
S. namaycush	+		+		
Prosopium williamsoni[1]	+	+	+	+	+
P. coulteri			+	+	+
Thymallus arcticus	+		+		
Rhinichthys[1]					
cataractae	+	+	+	+	+
catostomus					
catostomus	+	+	+	+	+
C. plytyrhynchus[1]	+	+			
Lota lota	+	+	+		+
Cottus bairdi[1]	+	+	+		
C. ricei			+		
C. cognatus				+	+
C. rotheus					+
C. confusus				+	

[1] Present also in Bonneville basin and upper Snake River.

~~[illegible]~~

I

Outline of ~~Activities~~ Projects

I. Projects directly ~~relating~~ related to rare and endangered fishes.

1. ~~Info~~ Information book on rare and endangered fishes of ~~the states~~ region II of the U. S. B. S. F. W.

A source of documented, authoratative information, detailing the status of rare and endangered fishes and the factors that threaten them, with suggestions for remedial action, is the first, basic step for any comprehensive rare and endangered program. Region II (Albuquerque) has supplied funds through the Colo. Coop. Fish. Unit for Colorado State University to ~~provide~~ produce a book of information on the rare and endangered birds, mammals, reptiles, amphibians and fishes of the region. I am in charge of the reptiles, amphibians and fishes. Enclosures 1A, 1B, 1C ~~concern how I am going handling~~ relate to this project. I view this as a pilot project, laying the ~~ground~~ foundation for a revision of the "Red Book" on a national level.

2. Consultant for National Park Service on native trouts. The Park Service has

outline II

provided me with $5,000 per year, through the Coop. Unit to ~~study~~ study the native trouts of National Parks and contiguous waters. ~~All~~ Most of the trouts involved are rare and endangered subspecies of cutthroat trout and the project is ~~directly~~ an integral part of my Bureau program on rare and endangered fishes. The funds ~~have been used~~ are being used to hire a ~~summer~~ part time assistant, ~~conduct~~ vehicle rental, field trips, ~~and purchase~~ equipment, and ~~cover~~ publication costs. This project has also attracted active cooperation with the Montana and Wyoming departments of fish and game and the U.S. Forest service which have provided ~~man~~ personnel and vehicles for a comprehensive sampling program covering the upper Columbia and upper Missouri river basins. in ~~Montana, Wyo~~ [illegible]

Enclosure 2 ~~was~~ used to alert the ~~various cooperating~~ several biologists of the cooperating agencies of the objectives of a field trips made in September, and request their assistance. ~~This trip was successful in achieving the goals. A large area was covered, numerous samples from key localities were made, data on the factors causing the demise of native cutthroat trout from some localities were noted, and~~ Enclosure 3, a progress report to the Park Service discusses the scope and results to date of this project. A ~~useful~~ full report will be available to the Park Service and the Bureau by next June on the status of several forms of native trout of highly restricted distribution. I would re-emphasize that I could not have gathered this amount of material for my research without the active and enthusiastic cooperation of several people with ~~the~~ state fish and game ~~agy~~ departments, U.S.B.S.F.W. ~~biologist~~ and the U.S. Forest Service, which share a common interest in documenting the status of the native trouts of this region.

3. Taxonomy of rare ~~trouts~~ fishes and ichthyological services for ~~st~~ public agencies.

Several species and subspecies of fishes of highly restricted distribution (limited to a single spring or to a few small streams) have not yet been described. Personal communication with ichthyologists having personal knowledge of these fishes ~~will~~ provide the basic information allowing Bureau people to become aware of these fishes and consider them for special attention. Informally, by personal contacts I have →

¶ My summer's field work ~~has~~ provided sufficient material to proceed with the formal description of ~~three~~ 3 new subspecies of desert basin cutthroat trout. ~~My~~ Personal contacts with biologists from Nevada Fish and Game, ~~the~~ Oregon Game Commission, the BLM and U.S. Forest Service ~~have~~ has stimulated an active program to protect these trout and expand their range via transplants prior to ~~a~~ their ~~publication officially describing~~ of official recognition in publications.

→ set up an ~~central~~ information synthesis center, bringing this hitherto unavailable information together for dissemination.

IX

Throughout the year I receive samples of specimens from state and federal agencies for identification and opinions on the status of the populations represented by the samples. ~~This facet of ma Providing~~ The magnitude ~~task~~ of ~~providing~~ this ~~ichthyological service has~~ work involved has rapidly increased ~~to~~ with a more general awareness of rare fishes and a desire to initiate protective measures by the various agencies. This year I will process well over 1000 specimens. ~~Ex~~ Complete examination and data recording requires about one hour per specimen. ~~This,~~ Adequate performance of this laboratory work plus the analyses and interpretation of data and report writing would ~~to~~ require a full time position. ~~If x~~ The work is done, however, mainly with work-study students ~~assis~~, graduate assistants and ~~part~~ part-time labor, hired in periods of peak demand. This year, ~~they~~ ichthyological services were provided to the fish and game departments of California, Oregon, Nevada, New Mexico, Arizona, Utah, Colorado, Wyoming and Montana and to ~~the~~ biologists with the USBSFW, U.S.F.S., U.S.N.P.S. and BLM. The fishes examined included Lahontan cutthroat trout, Bonneville cutthroat trout, Rio Grande cutthroat trout, Colorado River cutthroat trout, greenback cutthroat trout, Snake River, upper Missouri and upper Columbia cutthroat trout, red-banded trout, Gila and Apache trouts plus undescribed subspecies and ~~the~~ ~~identification of~~.

(insert) →

various minnows and suckers sent for identification. The information was utilized in several management projects to enhance survival of many rare forms and to draft project proposals and for program planning. When sufficient data is compiled a report is prepared on a certain fish or group of fishes. These are mimeographed and made available to the agencies. Enclosure 4 represents a presentation made in September as part of a symposium on rare and endangered wildlife. ~~El~~ Ten ~~availa~~ mimeographed reports, available from the Colo. Coop. Fish Unit, are listed on p. 5. Enclosure 5 is a list of trouts I am actively working on. This list was prepared for ~~K~~ Willis King about one year ago. Significant progress has been made this year toward a better understanding of several of these trouts. Enclosures 5A, 5B, 5C concern ~~various~~ →

~~As might~~ be It may be evident by this stage of ~~my~~ the outline that the task of documenting the status of all of the native trouts of western North America is of a magnitude and complexity that exceeds the capacity of a single person ~~to~~ for accomplish alone. Besides the ~~exe~~ assistance ~~I receive~~ I receive ~~for~~ for field collections, I encourage faculty and graduate students at other universities to study ~~the~~ certain problems in their region. Enclosure 6 ~~xxx~~ concerns a cooperative study with Dr. R.L. Wallace

→ Enclosure 3A is an example of ~~services~~ provided to Wyoming Fish and Game based on samples sent to me.

→ ~~Communications~~ with ~~the~~ Nevada Fish and Game and BLM biologists, ~~to~~ laying the groundwork for the field trips which provided the material for the description of 3 ~~new~~ subspecies of rare, desert basin trout.

on the native trouts of Idaho, a key area in understanding the origins, affinities and diversity of the trouts of the upper Columbia River basin. Enclosure 7A, 7B, 7C ~~is~~ are ~~a~~ letters to a graduate student at the University of Montana who is undertaking a biochemical study of native trouts. I eventually assisted this student in obtaining funds for his study, but it was important that he first have an understanding of what his goals would be and on the limitations of useful information that can be developed from protein comparisons. We now have an arrangement whereby the same samples are analyzed biochemically by Mr. Reinitz and morphologically by me. By the completion of Reinitz' study we should know what proteins, if any, are useful for ~~their intended~~ detecting and estimating genetic divergence in the western trouts.

II Practical applications of rare fishes.

1. A contract research project funded by B.S.F.W. on ecological evaluations of ~~t~~ various races of trouts is the only current project directly funded by the Bureau. The funds ~~are~~ support a graduate research assistant. ~~and~~ This year, projects were initiated on the Snake River cutthroat trout (propagated in the Bureau's Jackson Hatchery)

stocked in a variety of habitats ranging from mountain lakes in Wyoming (11,000+ ft. el.) to desert impoundments on Indian Reservations in New Mexico and Utah. Also a set of 5 lakes in Montana were selected for evaluation of the Montana "westslope" cutthroat trout. ~~and~~ Enclosure 8 discusses the results of sampling ~~lake~~ 2 lakes on the Jicarilla Apache Reservation in New Mexico. The striking difference in survival, (17-1) ~~over~~ in a ~~1~~ 2 year period, favoring the Snake River cutthroat over the hatchery rainbow trout, ~~(17-1)~~ is no abberation. Sampling this summer of 4 lakes on the Uinta and Ouray Indian Reservation in Utah and in a lake at the Air Force Academy, Colorado, revealed ~~this~~ essentially the same remarkable ~~dramatic~~ survival advantage of the Snake River cutthroat trout over the hatchery rainbow trout during a 2 and 3 year period in these shallow, eutrophic lakes. In the high mountain lake in Wyoming, the Snake River cutthroat trout ~~attain~~ at 5 years of age attained the same average size of 10 year old Yellowstone Lake cutthroat trout.

It is apparent that this undescribed subspecies, native to ~~a~~ a ~~small~~ limited area of the Snake River, Wyoming, has a real potential in fisheries management which ~~and~~ the Bureau should know more about. Ideas developed from this study formed the basis of a symposium presented at the

American Fisheries Society's annual meeting in September. Unfortunately, Mr. John Trojnar, the graduate research assistant conducting this study is in ill health and ~~will likely be~~ plans to vacate his position at the end of this year. I have an excellent new graduate student, Mr. Paul Sekulich, who is currently working with Mr. Trojnar, ~~and~~ I plan to have Mr. Sekulich fill the position and I expect a smooth transition without ~~m~~ any disruptions of the studies underway.

~~2~~. Another trout that appears to have desirable potentials ~~to~~ for fisheries management is ~~an~~ a fish I call the red-banded trout a complex of undescribed ~~forms~~ comprising races inhabiting ~~the~~ mainly the desert basins of southern Oregon (but extending into California and Nevada. ~~As~~ while I studying the systematics of this trout, attempting to work out its distribution, diagnostic characters and nomenclature, I compile information on its ecology. In some of the hot, arid regions inhabited by this trout, population have been observed thriving in extremely inhospitable environments. During thousands of years of adaptation in isolated areas, ~~this~~ some populations appear to be significantly more tolerant of warm water (80°+) than is any other trout.

In July, a check was made on

the only known population of red-banded trout ~~known from~~ in Nevada (representing a distinct subspecies of the complex). It was evident from the degraded condition of the stream that this population would certainly be extinct within a few years. I found this trout in several intermittant sections of the stream, apparantly thriving in water of 83°F. It was urgent matter to make an attempt to save this rare and potentially valuable gene pool. A small, barren stream a few miles away was surveyed for possible transplants. Nevada Fish and Game and the BLM cooperated in making a transplant and hopefully this unique population has ~~been~~ received a reprieve from extinction. Enclosure 9 is a letter from the BLM district manager, expressing their concern and plans for transplants and rehabilitation of the new habitat.

For propagation purposes, however, a suitable pond or lake is necessary to establish a brood stock (I would prefer to avoid developing hatchery brood stocks because of the dangers of mixing ~~and~~ selection for domesticated trait, and expenses involved). One avenue of approach might be ~~p~~ cooperative agreements between fish and game departments and landowners to use a lake for brood stock. I communicated my ideas to Dean Marraige, X

Chief Fisheries Biologist for S.C.S. western region. Enclosures 10A, 10B are the letter to Mr. Marraige, including a list of rare trouts suggested for ~~this~~ propagation, and his reply.

It is important that the genetic ~~scientific~~ basis of temperature adaptation be documented. Enclosures 11A, 11B are correspondence with Dr. Kramer of the Utah Cooperative Fishery Unit concerning the efficacy of scope for activity evaluations ~~to~~ for establishing the genetic basis of ~~the~~ physiological differences in temperature adaptations. This ~~kind of~~ type of research could be a fruitful area for the fish genetics lab to sponsor.

Enclosure 12 concerns the status of Lahontan cutthroat trout, pointing out the influence that slight genetic variation may have on the maximum size attained in Pyramid Lake.

Enclosure 13 is an outline ~~for~~ of a program for evaluating ~~Colorado Fish and Game~~ various races of trout in the fisheries management program of Colorado Division of Wildlife.

3. ~~Non-salmonid~~ fishes ~~for~~ for biological control of mosquitoes.

~~There is a~~ This type of research provides a real opportunity to utilize ichthyological knowledge and ~~at the~~ popularize the beneficial aspects possessed ~~of~~ by certain small species of fishes, many of highly restricted distribution. Basically, I'm looking for suitable alternatives ~~to~~ for the common mosquitofish, *Gambusia affinis*, ~~to~~ for mosquito control. The problem is that *Gambusia affinis* is a warm adapted species, vulnerable to predation and not suited to northern climates. Introductions in the Southwest have been responsible for the virtual elimination (and the rare ~~of so~~ or endangered status) of several native cyprinodontoid fishes such as *Poecilliopsis occidentalis*. Until now, Public Health agencies have not considered any other fish besides *Gambusia* for mosquito control. ~~I~~ In cooperation ~~have in~~ with local public health departments in Colorado, some of our native fishes ~~have been~~ are being introduced for mosquito control. It was found that *Fundulus sciadicus* and *F. kansae* completely eliminated mosquito larvae from test plots. It was also noted that ~~in~~ introduced *Gambusia* populations were eliminated in ~~all~~ ponds where predators, such as large mouth bass and green sunfish were present.

I ~~am~~ am a member ~~serving~~ on the graduate committee for ~~of~~ a Ph.D. student in entomology who will study ~~this~~ the use of fishes for mosquito control for his thesis research.

III ~~A.C.~~ Other relevant activities

1, University related. As Asc. Prof. Fisheries Biology I teach a course in ichthyology, ~~and~~ ~~serve act on~~ serve as major professor for graduate students and 25 a committee member ~~on~~ ~~other~~ on graduate student research in fisheries and related fields. ~~I view my academic association~~ The university environment ~~is~~ and ~~as~~ academic activities are essenteal in my work and in keeping abreast of the latest developments in fisheries research. I serve as major professor ~~for such~~ for such diverse research projects as the toxicity of heavy metals to aquatic invertebrates, to protein polymorphism in salmonid fishes. The interaction with graduate students is mutually beneficial.

2. ~~Editor in chief~~ Editor ~~in chief~~ for FAO synopsis on Atlantic salmon. When all of the manuscripts are completed, this synopsis ~~shou~~ will be the most ~~complete~~ comprehensive and up to date source of information on the total biology of Salmo salar. Enclosure 14 ~~ou~~ includes an outline of the subject ~~s to be~~ matter to be covered. ~~Will~~ Does the Bureau ~~to~~ have ~~interested~~ an interest in this information?

3. Senior ~~&~~ Translation Editor for ~~Problems~~ Journal of Ichthyology and Hydrobiology Journal. (Translated from Russian by Am. Fish. Soc.). These journals cover a wide range of topics on fisheries management, fish culture, limnology, taxonomy, pollution biology, etc. I can supply pre publication copies of papers on specific topics for interested persons. The translated titles of each issue are included in the list of foreign journals published each month by NMFS. ~~of NOA~~

4. Enclosure 15 is a reprint ~~that~~ which ~~prov~~ documents the practical value of preserving genetic diversity in fish species and ~~the~~ concerns the application of principles of ichthyology to fisheries management. It represents the culmination of several years of research.

reprint –

The most recent issue of Systematic Zoology has an article, ~~I~~ coauthored with 2 graduate students, ~~with~~ presenting the results of analyzing ~~the~~ data from over 700 specimens ~~with~~ using 2 different computer programs, to evaluate cluster analysis techniques.

Stock	N	Gillrakers	Pyloric Caeca	Basibranchial teeth	Scales, above ~~lat.~~ ser l.l. and lat. series	Ver
McBride L. raised at (Big Timber Hatchery)	15	17-20 (19.0)	40-49 (45.3)	13-33 (18.2)	37-43 (38.2) 168-205 (184.6)	
Yellowstone L. (brood stock held at Big Timber Hatchery)	15	18-22 (20.5)	30-42 (36.6)	15-30 (21.3)	37-42 (39.3) 156-180 (164.7)	
Yellowstone L.	N= 40	18-23 (20.6)	31-51 (41.2	10-46 (22.3	149-202 (174)	

- spots on belly
- post. rakers
vert. - basibranch teeth
Caeca
* raker
Scales

Yellowstone & trib. (mostly 1967)

N	60	61	62	63	
42	4	15	19	4	61.5
1954 30	4	10	13	3	61.5

Caeca N=15 33-45 39.4 - students
N=16 31-51 ~~41.2~~ 43.0 - my counts

N = 31 31-51 41.2

teeth

stained heads
N=16 10-46 22.3

29 w/o staining 1-~~27~~ 13.7 + Buckley

rakers. 17

	18	19	20	21	22	
	~~3~~	~~4~~	~~5~~	~~3~~	~~2~~ (?)	20.8
	1	4	2	5	3	20.3

post. usally 3-6

1954

19	20	21	22	23	
4	13	~~7~~	~~3~~	~~3~~	20.6

Scales: 37-46 (40-41) students
161-187 (178) student.

Bren. 10.6 10.7

30 36-48 41.8 } Frank Reid
30 149-202 170.3

	18	19	20	21	22	23	
~~1967~~	~~1~~	~~4~~	~~2~~	~~5~~	~~3~~		~~20.3~~
1967		3	4	5	3	2	20.8
1954		4	13	7	3	3	20.6
N 61	1	11	18	17	9	5	

13 50 37 18 15 17 31 24 36 47 16

72)1380
38/72
64/150

Douglas Crk.

61	62	63
10	20	11

62.0

rakers

18	19	20	21
1	8	4	1

19.4

Caeca

14 31-42 37.1

Bran. 9.9
10.0

scales 38-44 41.4
159-197 178.6

3 of 14 w/o teeth others 1-13 x̄ ca 5

Home Crk. 5 of 8 w/o teeth

N=8 31-42 38.0
148-187 168.6

31-42 (36.5)

rakers

19	20	21
5	1	2

19.6

vert.

61	62	63
2	3	2

62.0

Bran. 10.1
10.3

L. Victor

60	61	62	63
1	7	4	3

61.6

rakers

19	20	21	22	23	24
3	6	5	0	0	1

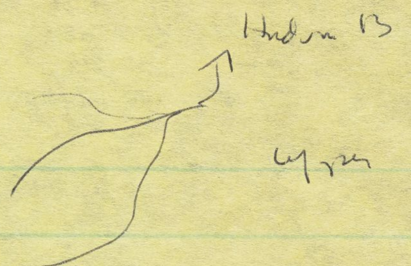
20.4

caeca 31-46 39.9

scales 163-204 181.3
41-47 44.2

teeth 4-19 11.8

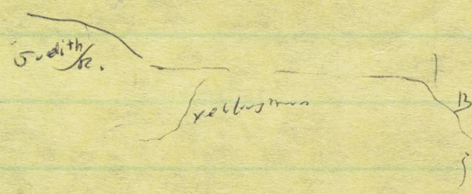
10.7
Bran. 11.4



50,000 yrs BP — upper Missouri drained

Hudson Bay - Hiodon alosoides, P. gracilis.
remnant of fauna - Cutt. ?? - grayling [illegible]?
Dolly Varden - Col. refug. P. williamsoni - or
all from Col. - ice front ↓ → - then
re-invade? ↗ Snake ↓ Col. - S. Saskatchewan?
(where from?) . Dolly varden -
- How many invasion routes - Timing? - differentiation
- Pre glacial - cutts?

coulteri
[illegible]
williamsoni



cold glacial pond often in changed course of R.