— age at spawning

— mainly 2 stream
2 lake
4

Robert C. Averett[1]
and
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Distribution and Growth of Indigenous Fluvial and Adfluvial Cutthroat Trout (Salmo clarki), St. Joe River, Idaho

Cutthroat trout (*Salmo clarki*) support important sport fisheries in western North America. Anadromous cutthroat migrate from coastal streams to the sea (Sumner, 1962), while inland cutthroat either spend their entire lives in streams as fluvials (Bjornn and Mallet, 1964) or leave the stream system and migrate into lakes as adfluvials (Bjornn, 1961; Cope, 1956; Irving, 1954). Because of its moderately large size the St. Joe River in North Idaho enabled us to explore the characteristics of fluvial and adfluvial cutthroat indigenous to one river system.

We set out to differentiate between fluvial and adfluvial forms of cutthroat on the basis of scale analysis. Scales from lake-run cutthroat have circuli patterns similar to those of sea-run cutthroat described by Sumner (1962). The lake habitat causes the circuli to become heavily embossed and widely separated whereas the stream habitat results in finely textured and narrowly spaced circuli. The scales of fluvial trout lack the lake-formed circuli and appear similar to premigratory juvenile adfluvial cutthroat.

In particular, we investigated timing and duration of spawning activity, migration, distribution, length-age relationships, fry emergence, and early scale development of fluvial and adfluvial cutthroat trout.

Observations and collections of trout were made in 1961, 1962, and 1964 in the St. Joe River mainstream and in Benewah, Thorn, Trout, Mica, Gold, and Simmons Creeks, tributaries which lie near the mouth, mid-river, and headwaters of the St. Joe River. The tributaries were arbitrarily chosen according to their geographical location to the river main stem, for at inception of the study we had no prior knowledge of use of these streams, or any others, by fluvial or adfluvial cutthroats.

The Study Area

The St. Joe River originates on the west side of the Bitterroot Mountains near the Idaho-Montana border (Fig. 1), then flows west to the south end of Coeur d'Alene Lake near St. Maries, Idaho. The lowest 42 km (26 miles) of the river has relatively slight gradient and the water flows slowly because of a rise in water level of Coeur d'Alene Lake resulting from construction of Post Falls Dam in 1906. This rise in water level connects Benewah, Chatcolet, Coeur d'Alene, and Round Lakes. Above the 42-km backwater area the river drops moderately to steeply with occasional flat stretches and deep pools. The lower four study tributaries (Benewah, Thorn, Trout, and Mica Creeks) have relatively high maximum to minimum flow ratios

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Trout and Salmon Movements in Two Idaho Streams as Related to Temperature, Food, Stream Flow, Cover, and Population Density[1]

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ABSTRACT

Many juvenile salmon and trout migrated from the Lemhi River drainage each fall–winter–spring period. Seaward migration of anadromous trout and salmon normally occurred in the spring but pre-smolt anadromous and non-anadromous fishes also left the stream usually beginning in the fall. I compared data on temperature, food abundance, stream flow, cover and population density with movements and conducted field and laboratory tests to determine reasons for the two types of movements.

Smolts of the anadromous species migrated for an obvious reason but none of the factors I examined appeared to "stimulate or release" their seaward migration. Movement frequently coincided with changes in water temperature and stream flow, but I could not establish a consistent causal relationship and concluded that photoperiod and perhaps growth must initiate the physiological and behavioral changes associated with seaward migration.

Non-anadromous and pre-smolt anadromous species emigrated from the streams for different reasons than the smolts. I postulated that fish found the stream environment unsuitable during the winter. Stream temperature declined in the fall as fish began moving from the streams but I could not induce more fish to stay in test troughs with 12 C water versus troughs with 0–10 C water. Fish emigrated before abundance of drift insects declined in winter. Emigration occurred in spite of the relatively stable flows in both streams. Population density modified the basic migration pattern by regulating the number and percentage of fish that emigrated and to a limited extent time of emigration.

Movements of non-smolt trout and salmon correlated best with the amount of cover provided by large rubble substrate. Subyearling trout emigrated from Big Springs Creek which contained no rubble substrate but remained in the Lemhi River which did. In both field and laboratory tests more fish remained in troughs or stream sections with large rubble substrate than in troughs or sections with gravel substrate. Trout and salmon in many Idaho streams enter the substrate when stream temperatures declined to 4–6 C. A suitable substrate providing adequate interstices appears necessary or the fish leave.

INTRODUCTION

Both anadromous and non-anadromous salmonids migrate extensively during the fall, winter and spring season in many Idaho streams. In addition to the normal seaward movement of smolts in the spring, many pre-smolt and non-anadromous fishes move downstream during the fall, winter and spring (Chapman and Bjornn, 1969) and some return upstream in the spring and early summer (Bjornn and Mallet, 1964). I compared data on movements of fish in the Lemhi River and Big Springs Creek (1962–1969) with various environmental factors and conducted field and laboratory tests to determine which factors caused or influenced the movements.

[1] Funds for these studies provided by Idaho Fish [illegible]d Game Department through Federal Aid to Fish [illegible]toration Project F-49-R and U. S. Bureau of Sport [illegible]ries and Wildlife.

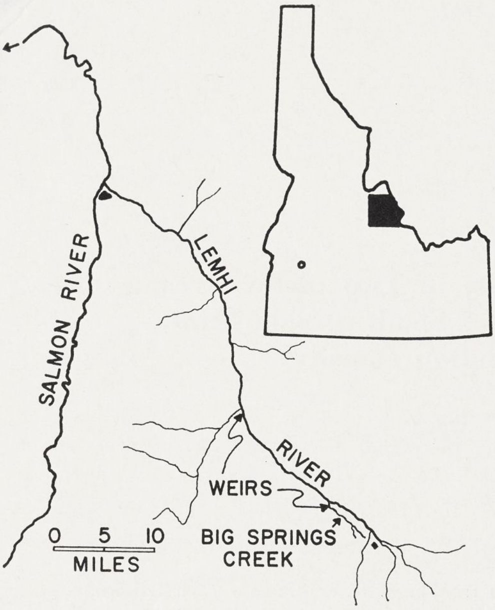


FIGURE 1.—Map of the Lemhi River drainage with location of fish weirs.

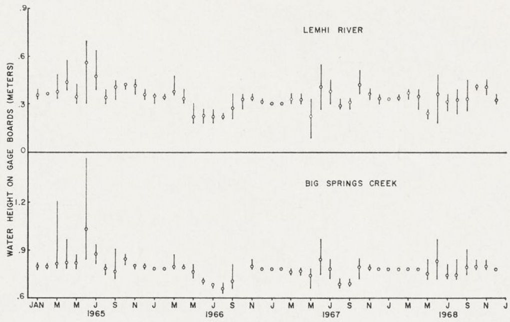


FIGURE 2.—Monthly range and mean height of water on gauge boards at Big Springs Creek and Lemhi River weir sites.

In the study streams behavior of salmonids changed from active feeding and territory occupation (or hierarchies) in the summer to "hiding or hibernation" in the winter. Few fish left the study streams during the summer but with the onset of fall, requirements of the fish apparently changed and an environment which fish found suitable in the summer became less suitable and they began to leave.

THE STUDY STREAMS

The Lemhi River (90.3 km long) flows through a broad mountain valley into the Salmon River at Salmon near the east central border of Idaho (Figure 1). Big Springs Creek (8.0 km in length) parallels and enters the Lemhi River 77 km from its junction with the Salmon River. The Lemhi River falls an average of 6.7 m/km.

I classify both streams as relatively productive on the basis of total dissolved solids (273 and 298 ppm) and bicarbonate alkalinity (134 and 160 ppm) in the water.

I found the following fish species in the study streams: non-anadromous rainbow trout (*Salmo gairdneri*), steelhead trout (anadromous rainbow trout), chinook salmon (*Oncorhynchus tshawytscha*), brook trout (*Salvelinus fontinalis*), Dolly Varden (*Salvelinus malma*), mountain whitefish (*Prosopium williamsoni*), sculpin (*Cottus* sp.), and dace (*Rhinichthys* sp.). Usually I could not distinguish between anadromous and non-anadromous rainbow trout and I used the term rainbow-steelhead trout when I believe both forms participated in the movements described.

Stream Flow

The volume of flow in the study streams usually fluctuated within a narrow range (Figure 2). The water level in Big Springs Creek fluctuated a maximum of 0.85 m during 1965–68, and that in the Lemhi River 0.61 m, but levels changed less than 0.30 m most months. Big Springs Creek discharged 0.8–1.0 m^3/sec (0.79–0.82 m on gauge board) and the Lemhi River 3.4–5.0 m^3/sec (0.30–0.37 m on gauge board) during winter. I estimated the volume at 17.0 m^3/sec in the Lemhi River at the weir during peak discharge in June, 1965. Maximum flows exceeded minimum flows by less than 10:1 in all years and 2:1 in some years. Maximum discharges of many other Idaho streams frequently exceed minimum flows by ratios of 30–100:1.

Use of Lemhi drainage water for irrigation influenced discharge patterns in the Lemhi River and Big Springs Creek more than any other factor. Peak discharge of snow-melt normally occurred in late May and early June, the same period that large scale use of water for irrigation began. Farmers withdrew water

Andrews, D.A. 1972. An ecological study of the Lost Streams of Idaho with emphasis on the Little Lost River. MS Thesis Idaho State University. Pocatello, Idaho. 57pp.

INTRODUCTION

The Rocky Mountain area of the United States is immense (1,341,000 km^2), yet its waters are limnologically poorly known (Pennak 1965). One of the most interesting groups of lotic waters in this area is the Lost Streams of Idaho. These streams all arise in the mountains of Idaho near the Continental Divide and flow to the cool desert of the Snake River Plain. There they sink into lava beds before reaching the Snake River--hence the name "Lost Streams." Russell (1902) and Stearns, Crandall, and Steward (1938) examined and described in detail the geology and hydrography of the area of the Lost Streams.

The streams are the Big Lost River, Little Lost River, Birch Creek, Medicine Lodge Creek, Beaver Creek, and Camas Creek (Fig. 1). The Lost Streams seem to have been isolated from the Snake River since the early Pleistocene (Stearns, Crandall, and Steward 1938). Hubbs and Miller (1948) explored the Lost Streams in 1944 and found the fish species of these streams to represent a partial relict of the Upper Snake River fauna as it existed prior to the lava flows. They found only three species of fish: an endemic subspecies of cutthroat trout (*Salmo clarki* Richardson), a species of sculpin (*Cottus bairdi* Girard), and the Dolly Varden Trout (*Salvelinus malma* [Walbaum]). Baily and Bond (1963) also collected sculpins from these streams, and in their revision of the species of freshwater sculpins (genus *Cottus*) from western North America, they placed those from the Lost Streams in the new species *C. confusus* Bailey and Bond.

Collections of the fish fauna of these streams were made in 1962-63 for the Idaho State University museum. Two species of sculpin (C. belldingi Eigenmann and Eigenmann and C. confusus), the mountain whitefish (Prosopium williamsoni [Girard]), and rainbow trout (Salmo gairdneri Richardson), brook trout (Salvelinus fontinalis [Mitchill]), and cutthroat trout (Salmo clarki) were collected. Two species of minnows (Rhinichthys osculus [Girard] and Richardsonius halteaus [Richardson]) were collected from Camas Creek only (Linder, personal communication).

Decosta (1966) studied the macrobenthic fauna of the Lost Streams and found very few benthic animals and a correspondingly low biomass. In general he found a very impoverished fauna, with entire groups of animals absent (e.g., Mollusca, Decapoda, Amphipoda, and Isopoda). However, Decosta identified his specimens only to order, so his findings are of limited value.

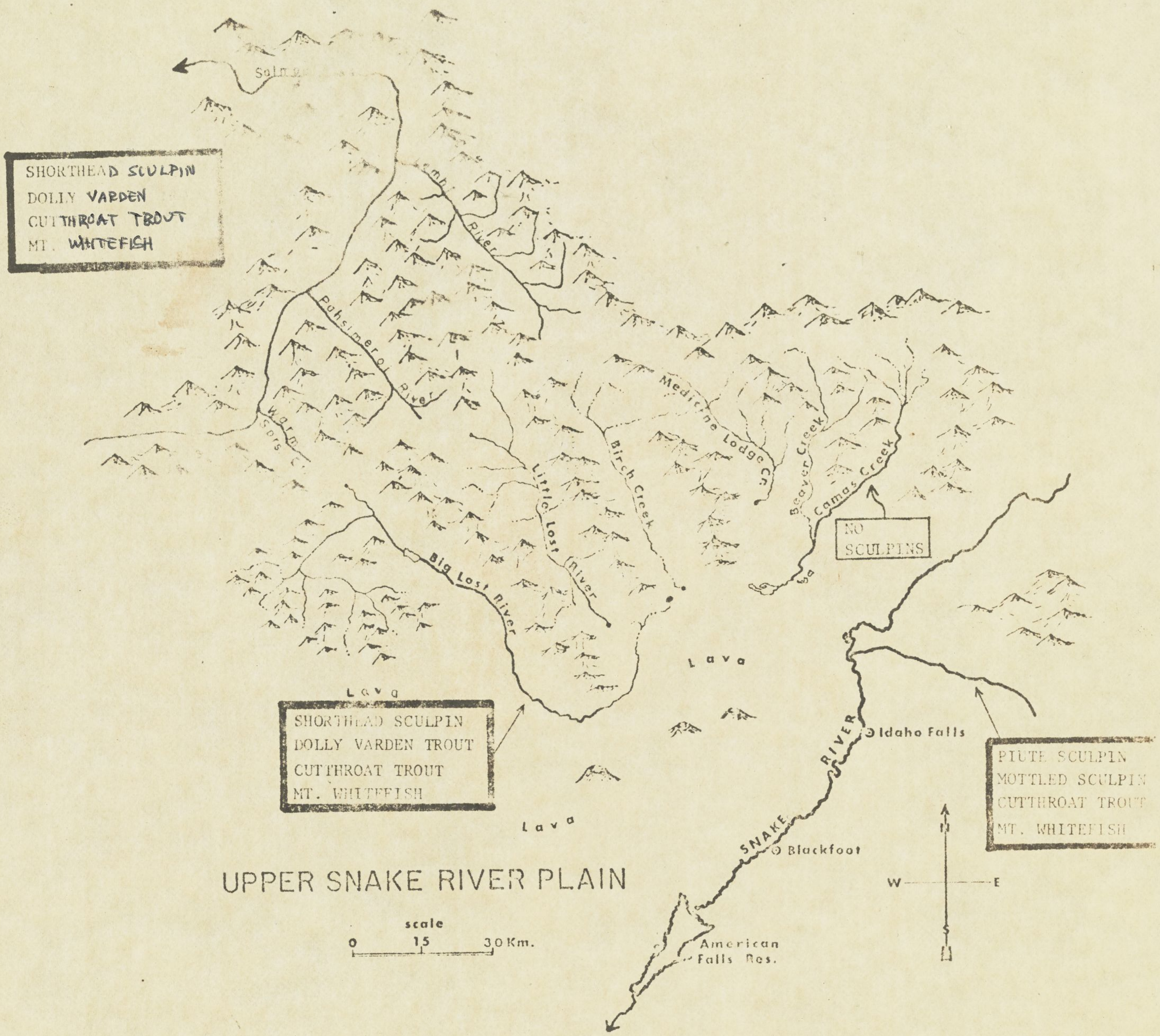
The isolation of the Lost Streams from the Snake River and from each other presents a unique opportunity for comparative studies as well as studies in zoogeography. In spite of this, there has been no intensive research on the biota of the streams, and especially of the benthic fauna. The present study was a yearlong intensive study of one of these streams, the Little Lost River, with a concurrent general study of the other streams.

The main objectives of the study were: (1) to describe the limnological conditions of the Lost Streams, including water chemistry, annual temperature range, discharge, and substrate type; (2) to determine the species richness of the benthic community and the fish fauna of the Lost Streams; (3) to determine what factors affect the distribution of the benthos and fish; and (4) to determine whether the Snake River Plain

Table 1. Limnological parameters of the Lost Streams of Idaho, 1970-71

PARAMETER			BIG LOST RIVER	LITTLE LOST RIVER	BIRCH CR.	MEDICINE LODGE CR.	BEAVER CR.	CAMAS CR.
Water Temp. °C	(15 May 1970)	SPRING	14	12	19	12	6	6
	(23 Nov 1970)	FALL	3	4	2	0	0	0
	(22 Jan 1971)	WINTER	-0.5	4	-0.5	3	ICE	2
pH		SPRING	8.2	8.1	8.2	8.0	8.1	7.3
		FALL	8.0	8.1	8.2	7.9	8.1	7.8
		WINTER	8.5	8.9	8.3	8.0	ICE	7.4
m.p. Alkalinity as $CaCO_3$-mg/1		SPRING	140	176	160	200	204	80
		FALL	122	192	144	182	234	90
		WINTER	116	190	140	214	ICE	84
Hardness as $CaCO_3$--mg/1		SPRING	142	180	128	224	224	80
		FALL	188	220	168	214	234	84
		WINTER	150	214	160	244	ICE	80
Specific Conductance--mhos/cm		SPRING	580	650	650	785	790	300
		FALL	590	820	530	660	665	275
		WINTER	570	780	580	820	ICE	280
Turbidity--J.T.U.		SPRING	30	65	54	22	51	51
		FALL	6	14	4	16	4	3
		WINTER	8	44	39	26	ICE	20
Nitrate (NO_3)--mg/1		SPRING	T	1.3	T	T	T	T
		FALL	.10	.4	.15	.10	.05	.04
		WINTER	.18	.5	.15	.18	ICE	.92
Phosphate (PO_4)--mg/1 (total)		SPRING	.48	.50	.23	.44	.44	.57
		FALL	.40	.50	.22	.40	.27	.38
		WINTER	.53	.34	.38	.45	ICE	.51
Discharge--m^3/sec		SPRING	3.194	2.659	2.605	1.603	3.220	9.426
		FALL	1.428	1.400	2.573	ICE	ICE	ICE
		WINTER	2.152	2.049	2.215	1.523	ICE	ICE

T = Trace


SHORTHEAD SCULPIN
DOLLY VARDEN
CUTTHROAT TROUT
MT. WHITEFISH
Pahsimeroi River
Little Lost River
Birch Creek
Medicine Lodge Cr.
Beaver Creek
Camas Creek
NO SCULPINS
Big Lost River
Lava
SHORTHEAD SCULPIN
DOLLY VARDEN TROUT
CUTTHROAT TROUT
MT. WHITEFISH
Lava
Lava
SNAKE RIVER
Idaho Falls
Blackfoot
American Falls Res.
PIUTE SCULPIN
MOTTLED SCULPIN
CUTTHROAT TROUT
MT. WHITEFISH
W
E
UPPER SNAKE RIVER PLAIN
scale
0 15 30 Km.

closely tied to the geomorphic history of the region. Figure 20 highlights some of the interesting facts of fish distribution in eastern Idaho. Common to the Salmon River, Lost Streams, and Upper Snake River are the cutthroat trout and mountain whitefish. Apparently their dispersal took place before the isolation of the Lost Streams. The shorthead sculpin and the Dolly Varden trout are common to the Salmon River and the Lost Streams. In the Upper Snake River there are two sculpins of the Lake Bonneville fauna--the Piute sculpin (Cottus beldingi) and the mottled sculpin (C. bairdi), and no Dolly Varden trout present (Linder, personal communication; Bailey & Bond 1963; Jeppson, personal communication).

It is believed that at one time (prior to Pleistocene) the Lemhi River and Birch Creek were one stream flowing southeast to the Snake River (Ruppel 1967), which at that time flowed down the middle of the Snake River Plain. The same drainage pattern was followed by the streams to the west. The Pahsimeroi River and Little Lost River were one stream, as were Warm Spring Creek and the Big Lost River, and the direction of their flow was also southeast to the Snake River.

Several things happened during early Pleistocene that caused the isolation of the Lost Streams, but the sequence is uncertain. The phenomena involved were: (1) downwarping of the Snake River Plain along the southern edge of the plain, (2) pushing of the Snake River southeast by lava activity to the north, (3) capturing of the upper end of the three streams by the Salmon River, and (4) uplifting and faulting causing a rise of divides (Gilmore Summit, etc.) between the three Lost Streams and the three tributaries to the Salmon River (Stern, Crandall & Steward 1938, Ruppel 1967). The barbed streams on the Lemhi River

— Westslope —

Lindsey C. C. and W. G. Franzin. 1972. New complexities in Zoogeography and taxonomy of the pygmy whitefish (*Prosopium coulteri*). J. F. R. B. C. 29(12): 1772-1775.

Waterton L. · glacial refuge areas
Waterton · postglacial → Missouri. R. 8 sp.
present in Waterton absent in Flathead
-prob. no Waterton → Col. connections (Mysis)
perhaps → Fraser - see Paetz & Nelson fishes Alberta

Carl Walter

~~462~~ 7800 ~~EXT 45~~

-Schultz, L.P. 1941. -U.S. Dept. Int. Conserv. Bull. 22: 42p.

Segerstråle, S.G. 1971 - J.F.R.B.C. 28: 1331-34.

McAllister & Ward, J.F.R.B.C. 29: 344-45

westslope — eastslope
native

Salvelinus malma

+ — —

Thymallus arcticus

— — +

Prosopium williamsoni

— (?) +

Prosop. coulteri

— + (?) —

S. gairdneri

+ — —

O. nerka (+) — — —

Ptychocheilus

+ —

(cyprinidae) +

+

Catostomidae

Catost. + +

Pantost. + +

Cottidae

+ +

Introduced

S. gaird. — namaycush

S. trutta — nerka

Sal. fontinal. Corego clup.

agassimita

Percidae

Centrarch.

1345

1850
750
2600

COLORADO COOPERATIVE FISHERY UNIT

2600
1345
1255

312
4 (1255

CAT. NO. ____________________ ____________________
NO. SPECIMENS

SPECIES ____________________

LOCALITY ____________________

____

COLL. ____________________ DATE ____________________

(Fig. 20) are evidence of a drainage reversal having taken place.

The fish distribution seems to confirm the geological evidence of drainage reversal and places the sequence of geological happenings in the order already mentioned. Thus, the cutthroat trout and mountain whitefish were present throughout the area. The Snake River was pushed southeast by lava isolating the streams. Next, the Dolly Varden trout and the shorthead sculpin entered the streams when the Salmon River captured their headwaters. Following this, the divides rose and separated the streams into two groups, one flowing northwest into the Salmon River, and the other group becoming the Lost Streams.

Some time after the isolation of the Lost Streams took place (middle Pleistocene?), the immense inland Pluvial sea, Lake Bonneville (of which Great Salt Lake is a remnant) had risen high enough so that its waters found an outlet into the Upper Snake River (Gilbert 1890, Morrison 1965). During this short period of overflow, several elements of the Lake Bonneville fish fauna, including the Piute sculpin (*Cottus beldingi*) and mottled sculpin (*C. bairdi*), entered the Upper Snake River (Hubbs & Miller 1948), resulting in the present-day distribution of fish in eastern Idaho (Fig. 20).

The water chemistry in the Lost Streams (Table 1) is almost identical, except for Camas Creek. Also of interest is the apparent lack of sculpins in Camas Creek. All the collecting records available have shown that sculpins have not been collected in this stream (Linder, personal communication; Bailey & Bond 1963; Jeppson, personal communication). If this is so, perhaps it is because of a physiological problem caused by the low chemical content of Camas Creek.

Dr. Behnke,

Thanks for your assistance in making a positive identification on these fish. I am enclosing specimens, a map of the drainage, and photographs.

We are encountering fish showing three distinct forms of coloration and spotting patterns. One form is similar in appearance to the Upper Klamath redband trout illustrated on plate 5 of your book Native Trout of Western North America. Based on spotting patterns and coloration the other two appear to be a cutthroat or cutthroat/rainbow hybrid. However, these fish, in almost all cases, lack any form of a cutthroat marking ("slash") on the lower jaw. The one form has large round spots covering the majority of the body. The other has has large round spots, but they are generally confined to above the lateral and the caudal area. This form also has parr marks in the adults. The difference in color and spotting patterns between these three forms of fish is shown in the photographs.

The specimens I am sending were collected on North Fork Deer Creek, South Fork Deer Creek, and Badger Creek, all tributaries to the Little Lost River. Water temperatures at the time of collection were 14, 16, and 7 degrees Celsius respectively. All the streams are relatively small ranging from 1.2 meters to 1.7 meters in width and .15 to .05 meters in depth.

Again, thanks for your help. If I can be of any help please contact me at (208) 588-2224 or Lost River Ranger District, P.O. Box 507, Mackay, ID 83251.

Sincerely,

Bart L. Gamett

RR 1
Box 904
Moore, ID 83255

saw a chance to make a big profit and asked too much for their land; so the railroad company started a town of their own, calling it Leadore.

The Lemhi *Herald* of July 3, 1901, reported—

> In June, two carloads of lead concentrate have been shipped from the old Viola mine at Nicholia. It is learned that the bulk of the carbonates rounded out of the old works have been gathered in and a further shipment from that depository will be deferred till explorers for another "pillar" [have completed their work]. In the closing days of the old Viola Company's operations, a cortex of wiseacres made the disclosure that an agent or boss, for certain sinister reasons, left a supporting "pillar" of first class sand carbonate, estimated at 100 tons, veiled in some mysterious shape for his own personal exploitation, after the work should be abandoned. The operation thereon for the years 1894–96 were chiefly directed toward uncovering the hidden treasure. In skimming through various workings, lessees of the property, have been successful in mining or jigging sands that have paid well for the labor, the product amounting to 200 tons.
>
> Across the valley, twelve miles distant, lies Spring Mountain District. Through the winter miners have been busy developing the property and piling up ores for shipment. The camp is in full blossom and the population daily increasing.

Wages paid were $3.50 per ten-hour day, with $1.00 a day for board.[24]

21. The fish in Birch Creek

Thomas Kane, an uncle of Mrs. Elizabeth Reed of Salmon, told her about how the fish were started in Birch Creek. Because the stream started in the springs and snow runoff and ended in the sinks, there were no fish. Marmaduke Hewitson was doing blacksmithing for the Viola Mining Company at the time. He and one of the miners thought that fish could be transported from Clear Creek to Birch Creek. They sewed two long wool sacks together, fastened one end closed and wired the other open. Next they built a sort of runway or chute of rocks in Clear Creek. At the end of the runway they placed the open end of the sacks, which, being submerged, the running water kept open. Going upstream, they used handfuls of brush to drive the fish down where many of them went into the long sack. The fish were taken in two barrels of water to Birch Creek and turned loose. Two barrels were used so the water could circulate and keep the fish alive. This was in 1885 while Nicholia was still operating.

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42*h–j*.—CRAB CREEK BASIN AND OTHER WATERS ON CHANNELLED SCABLAND.—Crab creek (Russell, 1893; Calkins, 1905; Schwennesen and Meinzer, 1918) is a disrupted tributary (no. 42*h*) of the Columbia in eastern Washington. The upper part contains a number of undifferentiated Columbia River types, including *Catostomus syncheilus* Hubbs and Schultz (1932*b*). Formerly, at least, it also contained a cutthroat trout, which Evermann and Nichols (1909) described as an endemic species, but which we would treat as a subspecies (*Salmo clarkii eremogenes*). This part of the creek occasionally flows into Moses Lake (no. 42*i*) in Grand Coulee. The U. S. Geological Survey state base map erroneously shows Crab Creek as a tributary first to Soap Lake, a highly saline lake in Grand Coulee, north of Moses Lake. These are but two of numerous more or less isolated lakes (no. 42*j*) on the "Channelled Scablands" of eastern Washington (Russell, 1893; Bretz, 1923, etc.; Flint, 1938). Except for Moses Lake, none of these waters have been explored by ichthyologists. Moses Lake, containing an isolated endemic subspecies of *Siphateles obesus* (a species mostly confined to the Great Basin), had no surface outlet, for it is blocked by the sand dunes by which it was formed (Calkins, 1905; Schwennesen and Meinzer, 1918). Seepage from the lake forms the lower Crab Creek, which still flows into the Columbia. A race of *Siphateles obesus* distinct from that of Moses Lake, and less modified for lacustrine life, occurs in the lower creek.

42*k–n*.—ISOLATED STREAMS OF THE SNAKE RIVER LAVA PLAIN.—North of the Snake River, Idaho, is a large area where streams from the mountains feed into Mud Lake or into usually dry sinks to the westward. Physiographers have not regarded this area of the Snake River Lava Plain as one of interior drainage, because the waters percolate through the Pleistocene lava to emerge as large springs along Snake River. From a zoological standpoint, however, the drainage is to be treated as interior—at least isolated—for the underground flow can have little if any effect on the distribution of fishes and other animals. The geology and hydrography of the region has been described in detail by Russell (1902) and by Stearns, Crandall and Steward (1938). The fish fauna of the Mud Lake–Lost River group of streams (42*k*) has not been published on, but we have explored the area. In the several streams (Camas, Medicine Lodge and Birch creeks, and Little Lost and Lost rivers) we found 3 species: an endemic subspecies of cutthroat trout; the Dolly Varden trout (probably a Glacial relict, rather than an introduced fish); and 5 highly localized, endemic subspecies or races in the genus *Cottus*. None of these species are Bonneville types, despite the fact that the stream complex lies in the upper part of the Snake River system, which in general has a Bonneville fauna. As mentioned on page 31 these fishes seem to be relicts of the old Snake River fauna, as it existed prior to the time of the destructive lava flows and of the Lake Bonneville discharge. Some Bonneville species do occur in Mud Lake, but definite evidence was obtained to indicate that they were introduced by a bait fisherman.

The Wood River group of streams, just west of Lost River and the Craters of the Moon lava beds in Idaho, exhibits partial isolation and disruption, coupled with faunal peculiarities. According to earlier maps and local usage the Wood River system comprises Big Wood River and Little Wood River, which unite to form Malade River, but the U. S. Board on Geographic Names [illegible]

system through Fish Creek, but it is now definitely cut o
of 1934 the bed of Lava Lake was dry and the inlet, wholl
gation, apparently contained no fish. Fish Creek (42*m*)
sump separated from Little Wood River by a slight allu
water was first used for irrigation there is said to have
between Fish Creek and Little Wood River, and local testi
ment as to a former linkage. That such a connection onc
vocally shown by the ichthyological data, for Fish Cree
River fauna, including *Cottus leiopomus*. The Wood river
tain a fish fauna that is in part very peculiar. *Salmo clar*
cheilus (local subspecies?), *Rhinichthys osculus* and *R. cat*
present the old Upper Snake fauna (prior to the lava flo
species are noteworthy. One is a local form of *Snyderich*
ville species that also is known, very locally, from the U
1942, as *Gila copei*). The occurrence of this Bonnevill
main falls, in an area occupied by the true Columbia Ri
what anomalous. Its introduction through the Twin Fa
might be offered as an explanation, were it not for the f
was recorded from Little Wood River in 1894, whereas
completed until 1907 (Youngs, Trail and Young, 1933). T
has probably been isolated for a long time, for it shows
tures (Miller, 1945*a*). The other notable species is a w
Cottus leiopomus. The distinctiveness of this sculpin is
tion of the Wood River fauna. The rush of water in the
Canyon (due to huge springs discharging water from th
Plain) forms rapids and falls that are impassable for
this flow the system for a considerable distance is dry
physiographic relations involved have been treated by R
Stearns, Crandall and Stewart (1938); the ichthyological
Evermann (1894). We have also studied the area and th

There are several other disrupted portions of the Col
but they have not been explored ichthyologically. Hubbs
thought that *Cottus tubulatus* is confined to the generall
waters of the North Fork of Clearwater River in Idaho
determined that the same or a very similar type occurs
streams in the Columbia River system.

DEATH VALLEY SYSTEM

Ranking third in area and in faunal diversity among
basins is the Pleistocene Death Valley System, now g
occupying several isolated valleys and basins in the des
California and adjoining parts of Nevada (Miller, 194
The late physiographic history of the rivers and lakes in
into at least two stages, which have been correlated
welder (1931: 918) with the Tahoe and Tioga stages of g
by Sierra Nevada Range. These stages, in turn, are beli
proximately contemporaneous with the earliest and late
consin or last continental glaciation in eastern North A
1933: 464–471: 1936: 311). Still earlier phases are also

...ng U.S. fisheries

vaca- ... to a ... om ... s ... ree on, ... nd de- ... ng limits ... 200 miles. ... ent would li- ... fishermen, ... h and punish

violators — in short, set up a sensible conservation program.

If anyone doubts such a program is needed, he should talk to New England fishermen. They have seen such valuable fish as the cod, haddock and yellow-tail flounder virtually disappear in the decade since the first Soviet factory ships appeared off our coast.

Joined by equally super-efficient trawlers from East and West Germany, Poland and Japan, the Russian fleet has recklessly overfished U.S. waters and refused to join in international conservation agreements.

Some 30 other countries have already adopted 200-mile fishing limits or are considering it, but the United States has hung back.

The State Department has feared that such U.S. action would undermine the United Nations Law of the Sea Conference, which has been stuttering on for many years without notable progress.

And the Defense Department has worried that a unilateral American move might cause other countries to close international straits and territorial waters to U.S. naval vessels and aircraft.

The bill before the House has been carefully drawn to avoid such pitfalls. It affects only fish conservation, not questions of territorial limits, free passage, deep-sea mining and others that are before the U.N. conference.

We have two choices. One is to proceed now to protect coastal resources for this generation and future ones. The other is to wait until the United Nations ties up the matter, if it ever does, in one neat world treaty. Of course by then the fish will be gone.

...es?

...rter com- ... the argu- ... ement. He ... distasteful ... be unable ... competent

...ent frustrat- ... ente, Bezoff ... operation is ... nsideration, ... er on anything." ... n offer his residen- ... he mayor's charter ... deliberations in a few ... w if the proposal will ... year's, but ... dn't apply

... an em- ... pleases is not ... must demon- ... nent serves ... gh to justi-

...one — that ... suburbs up- ... to the city ... al. ... t applicable ... consideration. ... mmittee should ... it at least can be ... City Council and

...employees would be ... ter job were they ... the consequence of ... ns are directly felt.

Benchmarks

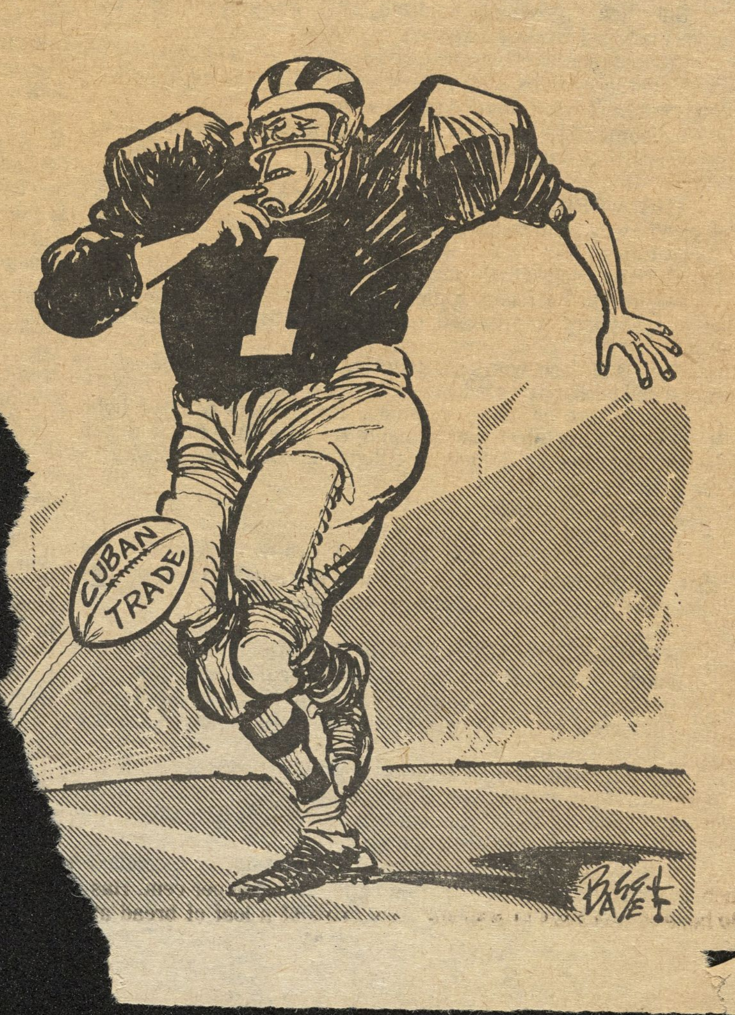
"THE QUESTION is this: Is man an ape or an angel? I am on the side of the angels. I repudiate with indignation and abhorrence these new-fangled theories."

—Benjamin Disraeli
Speech, Nov. 25, 1864

"MIDDLE AGE is when you've met so many people that every new person reminds you of someone else."

— Ogden Nash, *Versus*

...t may be a trick!'



Out Back
By Bill Logan

How it used to be

We were on our way to fish on Sunday when somewhere in the conversation it was brought up that old Edward R. Hewitt said he probably was the first non-Indian to flyfish for trout in what is now Yellowstone National Park.


Logan

So I have looked it up in the fine fishing book the late Edward Hewitt wrote. If a trout fisherman who liked to read about trout fishing were ever stuck on a desert island with only one fishing book, and especially if he liked salmon fishing too, by all means that is the book he should have. It is Hewitt's "A Trout and Salmon Fisherman for Seventy-five Years."

There is more information of real substance in one page of Hewitt than there is in almost any angling literature you can name. Hewitt was born June 20, 1866, and when he was 15, which was probably the summer of 1881, he, his father, the U.S. interior secretary and others went westward in a private railroad car to the end of the Northern Pacific near Billings, Mont.

Some of the party, escorted by troops under the command of Gen. Phil Sheridan went an additional 300 miles by horseback to Yellowstone, which then apparently had been designated for special preservation but of course was still wild country and not developed.

CATCHING AND SMOKING TROUT

Indians in that territory were catching and smoking trout, and Hewitt gives an account of fishing for them. The Indians provided the horses and men to load them with fish that Hewitt caught.

As to the Yellowstone River, Hewitt said the largest trout he took weighed 4½ pounds, which is not really a very big trout compared to some taken today. He made the point that the trout which were in the Yellowstone, which were cutthroats, for browns and rainbows had not been introduced at that time, ranged from two to four pounds.

He saw none larger than the 4½-pounder and noted that there was an absence of small trout.

I think it is always interesting to see an account of fishing in the West of those days. And while we are on the subject, it seems to me that more or less lost or at least apparently unknown to the general public is quite a lot of fine writing which may have been popular and well known at one time but which has slipped into oblivion.

FISHING WITH CROOK

In further pursuit of some of the conversation on our way fishing, I have turned to a book entitled "On the Border With Crook," which was an account of the campaigns of Gen. George Crook, the prominent horse soldier who often rode a mule in the Indian campaigns in the Southwest, on the Great Plains and up into Montana.

The copy I have was reprinted by the University of Nebraska Press. The book was written by Capt. John G. Bourke. Unfortunately for Ernest Hemingway, a bit of which I looked at for a few minutes before looking at Bourke, it was then I realized that much good writing has been set out but has not become popular with the public of the current time.

The first sentence I came upon by Bourke, after opening his work and trying to find some of what he said about the trout fishing engaged in by horse soldiers, who seemed to have done a lot of fishing during their expeditions, was this:

"June 18, 1876, we were turned out of our blankets at three o'clock in the morning, and sat down to eat on the ground a breakfast of hard-tack, coffee and fried bacon. The sky was an immaculate blue, and the ground was covered with a hard frost, which made every one shiver."

Frost in June. A horse outfit being rousted up, one week before the Custer massacre, up in the same vicinity, for Crook engaged the same Indians that one week later massacred Custer's Seventh Cavalry.

CAN'T STOP

So it is impossible to stop at one sentence even when trying to find where Bourke was writing about trout fishing on cavalry expeditions. Do not fear, we will go further into Bourke and where he estimates the troops caught many more than 15,000 trout in a three-week period, with the author noting the 15,000 figure is "far below the truth."

Back to the the early morning when the outfit was awakened:

"The animals had rested, and the wounded were reported by Surgeon Hartsuff to be doing as well 'as could be expected.'

" 'Travois' were constructed of cottonwood and willow branches, held together by ropes and rawhide, and to care for each of these six men were detailed. As we were moving off, our scouts discerned three or four Sioux riding down to the battlefield, upon reaching which they dismounted, sat down, and bowed their heads; we could not tell through glasses what they were doing, but the Shoshones and Crows said that they were weeping for their dead. They were not fired upon or molested in any way."

Custer's problem was that he did not follow the plan, and during the same days on the nearby Tongue River Crook's outfit was doing a lot of fishing. This will be brought into focus on Wednesday.

Fe...

SA... Jo... me... star a... year. Gree... News-Se... papers al... the Derby... talk of sy... stage," C... The p... cation w... few d... Greer... world-... owned... GREE... had bee... sons wa...

TU...
A R...
2...

League boxes

GIANTS TOP A EXPOS

San Francisco	ab	r	h	bi	Montreal	ab	r	h	bi
Joshua cf	3	0	0	0	Mangual cf	5	0	0	0
Thomassn cf	3	1	0	0	Dwyer lf	4	0	1	0
Thomas 2b	6	2	3	0	Jorgensn 1b	2	1	1	0
Murcer rf	4	2	1	1	Biittner rf	4	0	1	0
Matthews lf	4	1	2	1	Parrish 3b	4	0	1	1
Montanez 1b	3	1	1	0	Mackanin 2b	4	1	1	0
Speier ss	5	1	3	3	Foli ss	4	0	1	0
Rader c	5	1	1	1	Foote c	4	0	1	1
Ontiveros 3b	3	0	1	0	Rogers p	0	0	0	0
Halicki p	3	0	1	2	Bailey ph	1	0	0	0
Adams ph	1	0	0	0	DeMola p	0	0	0	0
Moffitt p	0	0	0	0	Lyttle ph	1	0	0	0
					Taylor p	0	0	0	0
					Morales ph	1	0	0	0
Totals	40	9	13	8	Totals	34	2	7	2

San Francisco 203 003 100—9
Montreal 100 001 000—2

E-Mackanin, Dwyer. LOB-San Francisco 12, Montreal 11.
2B-Speier, Foli, Matthews, Mackanin. 3B-Murcer. SB-Montanez, Dwyer. S-Halicki.

	ip	h	r	er	bb	so
Halicki W 6-9	7	7	2	2	4	12
Moffitt	2	0	0	0	2	2
Rogers L 8-9	4	8	5	5	5	4
DeMola	2	4	3	3	1	0
Taylor	3	1	1	0	0	1

HBP-by Taylor (Montanez).
WP-Moffitt.
T-2:45. A-14,614.

ASTROS DECK CARDS

St. Louis	ab	r	h	bi	Houston	ab	r	h	bi
Brock lf	3	0	0	0	Howard lf	5	1	0	0
McBride cf	4	0	1	0	Gross rf	4	1	0	0
Fairly 1b	4	0	0	0	Cedeno lf	4	2	3	1
Simmons c	4	1	4	0	Johnson 1b	4	1	4	2
Smith rf	4	1	2	0	Rader 3b	2	0	0	0
Sizemore 2b	4	0	0	0	Helms 2b	4	0	0	0
Reitz 3b	4	0	1	0	Jutze c	4	1	2	0
Tyson ss	4	0	2	2	DaVanon ss	4	1	3	3
Curtis p	1	0	0	0	Dierker p	3	0	0	0
Bradford ph	1	0	0	0					
Parker p	0	0	0	0					
Melendez ph	0	0	0	0					
Rasmussn p	0	0	0	0					
Reynolds p	0	0	0	0					
Rudolph ph	1	0	0	0					
Totals	34	2	10	2	Totals	34	7	12	6

St. Louis 000 000 200—2
Houston 300 003 10x—7

E-Sizemore, Simmons. DP-St. Louis 1, Houston 3. LOB-St. Louis 7, Houston 7.
2B-Simmons, Cedeno, Johnson, Jutze. HR-DaVanon (1). SB-Cedeno, DaVanon, Brock. S-Dierker.

	ip	h	r	er	bb	so
Curtis L 8-9	5	5	3	2	2	1
Parker	1	3	3	3	0	1
Rasmussen	1	2	1	1	1	1
Reynolds	1	2	0	0	0	0
Dierker W 10-12	9	10	2	2	2	3

WP-Dierker 3.
T-2:19. A-10,550.

NFL transactions

Monday's Pro Football Transactions
By The Associated Press
National Football League

WASHINGTON REDSKINS — Veterans cut: runnng back Doug Cunningham. Free agents cut: defensive end Allen Aldridge, guard-tackle Carl Johnson, tackle Craig Robinson. Rookies cut: linebacker Dave Benson, Weber State; guard Dennis Pavelka, Nebraska; kicker Russ Brown, William & Mary; quarterback Alan Chadwickk, East Tennessee State; guard Jerome Hodges, Kansa; wide receiver Tim Paulus, Kansas State; linebacker Brad Watson, Western Kentucky.

PHILADELPHIA EAGLES — Rookies cut: defensive back Ken Schroy, Maryland; defensive back Mike Gambrell, Sam Houston; place-kicker Terry O'Brien, Towson State.

GREEN BAY PACKERS — Rookies: guard Nick Bastaja, Sim Fraser; guard Bill Kairit, Brown; linebacker Donn Pierce, St. Norbert, defensive tackle Jerry Lawrence, South Dakota State, all cut.

SAN DIEGO CHARGERS — Rookies: defensive tackle Von Boatwright, cornerback Vince Phason and linebacker Jerry Dahl, all waived.

DALLAS COWBOYS — Rookies: defensive back Ed S. Jones, Rutgers; center Greg Krpalek, Oregon State; running backs Willie Hamilton, Arizona State, and Pete Clarke, Colorado State; quarterback Leo Gasienieca, Rutgers; defensive tackle Dan Fish, Catawba; receiver Wayne Johnson, Houston; and back Walter James, Florida A&M, all cut.

NEW ORLEANS SAINTS — Veterans: linebacker Charles Hunt and wide receiver Jack Phillips, both cut. Rookies: linebackr Bill Malcolm, Eastern Michigan; tackle Pat Tumpane, Michigan; linebacker Mike McDonald, Catawba; punter Dale Lybecker, North Carolina; cornerback Tony Pawlik, Rutgers, all cut.

Muny softball

RUBY HILL PARK HAYNES—University Hills 3, Christian Indian 2. Tire Shoppe 6, Save & Dars 1. Calvary Indian 9, 1st Reform 2.

CROW FIELD—Dee-John Up. 10, Holiday Trailer 9. Paddock & Take 6, Data Planning 2. Harry Post 6, Alameda Tavern 0.

GARLAND PARK—Gates All Stars 9, Yellow Cab 5. Speaker Reconing 7, Rock Tower 1. Queen Motors 7, Nolte Bros. 6.

RUBY HILL PARK 2—Ralston Purina 9, Denver Water Dept. 4. Stearns Roger 8, United Bank 4. Bull Ring 8, American Family 2.

BARNUM 1—Parks & Rec. 21, Eaton Metal 2. Koppers 7, Hoerner Waldorf 0. Mile High Express 13, Blair Elec. 12.

BARNUM 2—Champion Inter. 12, Stearns Roger 3. Stearns Roger Red 15, Grubbers 5. Undertakers 11, Stearns Roger Blue 9.

Columbine tennis doubles results

RESULTS MONDAY

GIRLS 14: Traub-Schoelzel def. Evans-Janssen 6-4, 7-5. Tepper-Miller def. Pepper-Fuller, 6-2, 6-4. Epstein-Waldbaum def. Shea-McLish, 6-3, 7-6. Wolf-Wolf def. Marks-Petty, 6-0, 6-3. Fowler-Griffith def. Satriano-Ruehr, 6-4, 6-7, (5-3), 7-6 (5-3). Shaddock-Roder def. Kettering-Long 6-4, 6-2.

BOYS 18: Christenson-Romero def. Wolinsky-Wolinsky 6-1, 6-2. Donato-Gerden def. Sibrill-Go 6-3, 6-4. Thompson-Kellog def. Tweeten-Hannon 6-0, 6-2. Wilkins-McCardell def. Milner-Lecin 6-1, 6-2. Hogue-Sevier def. Thiesen-Thiesen 6-4, 6-4. Kellog-Lundin def. Friedman-Melnick 6-3, 6-4. Gottschalk-VanSkike def. Lange-Woodard 6-1, 6-2. Lacontare-Mahoney def. Mares-Young 6-3, 6-3.

MIXED 18: Aguilera-McGinley def. Miller-Bradley 6-1, 6-2. Yamamoto-Holderby def. Bodine-Elliot default. McNamara-Seelinger def. Gardmer-Wagner 7-6, 6-4.

BOYS 14: Levine-Friedman def. Seibert-Meyers 6-2, 6-1. Gillach-Phillips def. Turley-Wilking 6-1, 6-2. Harmon-Reed def. Eber-Sanchez 6-0, 6-2. Goodman-Rottman def. Leibold-McMurria 4-6, 6-4, 6-4. Gordon-Hagen def. Kovar-Kishiyama 6-3, 6-1. Weber-Jones def. Head-Frank 6-7 (5-3) 7-5, 6-2. Vandenbergh-Hoeven def. LaFonte-Dennen 6-1, 6-0. Capra-Robinson def. Magill-Gaudio 6-1, 6-3. Snyder-Hoeven def. Mimmack-Hammond 6-3, 6-3. Ryan-Ratterman def. Lund-Marcus 6-2, 6-0. Dulaney-List def. Freeman-Washburne 6-3, 6-4. Bendfeldt-Pattridge def. Jeavons-Froyd 6-3, 6-2. Meyer-Fiske def. Unger-Rink 6-2, 6-1. Seracuse-Chow def. Johnson-Cammozzi 6-2, 6-1.

GIRLS 16: Akin-Isbill def. Feiner-Altberger 6-3, 6-1. Johnson-Miler def. Kenney-Miller 6-2, 6-0. Parsons def. Balstad-McGehee 7-6 (5-4), 6-7 (4-5), 6-3. Gillach-Hollenbeck def. Stewart-Hazuka 6-0, 6-0. Thompson-Rudy def. DeLaney-Rink 6-2, 6-2. Danos-Head def. Snyder-Pepper 6-1, 7-6, 7-6. Jacobson-Grant def. Deeds-Diefendorf 3-6, 6-2, 6-2. Houser-Bloom def. Boatright-Schaefer 6-3, 6-1. Levin-Hoffman def. Jones-Richardson 6-3, 6-3. Fiske-Langstaff def. Frisbie-Evans 7-5, 6-2. Bushey-Gemmill def. Traub-Malnati 6-2, 6-1. Augustine-Athens def. Maloney-James 6-2, 6-2.

MIXED 16: Gray-Levin def. MacNeill-Akin 7-5, 6-3. Riccardi-Murphy def. Onedera-Chiu 6-2, 6-2. Bartlett-Maloney def. Eggert-Lafonte 5-7, 6-1, 6-4.

MIXED 14: Reed-Reide def. Camozzi-Ferry 6-0, 6-1. Wright-Jacobs def. Seibert-O'Donnell 6-2, 6-3. Kressin-Wilson def. Ross-Epstein 6-4, 6-1. McGowan-Craddock def. Rumsey-Fuller 7-5, 6-4. Everhardt-Voss def. Weisbart-Weisbart 6-2, 6-0. Gordon-Price def. Bensfeldt-Schoelzel 6-0, 6-0. Snyder-Roder def. Hoeven-Shaddock 6-1, 6-3. List Kettering def. Card-Baker 6-0, 6-1. Friedman-Tepper def. Higbie-Griffith 6-0, 6-1. Levine-Long def. Sevier-Peters 6-1, 6-0.

BOYS 16: McGinley-Pritz def. Coren-Miller 6-0, 6-1. Harris-Turner def. Galey-Savage, 6-3, 6-1. Grant-Adams def. Sarlo-Bodek 6-0, 5-7, 6-2. Roth-Pearson def. Johnson-Henry 6-4, 7-6. Smith-Wicklund def. Boggess-Sulmeisters 6-3, 6-2. Riccardi-Goldman def. Eberhardt-Rickert 6-1, 7-6. Jacob-Miller def. Kelly-Fleck 4-6, 6-0, 7-6. Delaney-Delaney def. Harrison-Klinger 3-6, 6-2, 6-1. Gray-Averch def. Anderson-Oettli 6-2, 6-4. Hayne-Pelling def. Blanc-Eby 6-4, 6-4. McLaughlin-Brase def. McNeil-Mankoff 6-0, 6-0. Sevier-Gotaas def. Mares-Hulbert 6-4, 7-5. Retherford-Pearson def. Woodard-Lange default. Dannenberg-Beckwitt def. Mayer-James 6-4, 6-4. List-Murray def. Mimmack-Kuhn 6-0, 6-2. Mease-Poitras def. Langstaff-Mitchell 6-3, 4-6, 6-0.

BOYS 12: Madsen-Reed def. Cassidy-Harrison 6-2, 6-4. Sigman-Malek def. Meyer-Gallagher 6-3, 6-2.

SCHEDULE TUESDAY
AT COLUMBINE COUNTRY CLUB
ALL DOUBLES

GIRLS 18, 10 a.m.—V. Aldea-S. Aguilera vs. D. Bevan-M. Seeliger; K. McPhail-A. Flynn vs. J. Bradley-B. Melani; 4 p.m.—S. Guggenheim-B. Hall vs. M. Kolhagen-J. Finley; 11 a.m.—C. Linden-L. Moyer vs. M. Chiu-M. Denny; S. Fleck-L. Verkutis vs. B. Schneider-L. Oberg; 6 p.m.—K. Philpott-E. Brown vs. F. Haskel-A. Griffith; Noon—M. Nuccio-M. Hanson vs. A. Shepard-T. Shaffer.

BOYS 18: 8 a.m.—P. Miller-G. Mares vs. R. Ponds-B. Bowen; C. Doolittle-M. Pattridge vs. C. Curtis-M. McNeil; 9 a.m.—w/o previous match vs. K. Gottschalk-R. Van Skike; B. Lozow-K. Toltzus. M. Phelps-M. Luna; T. Yamamoto-D. Metzger vs. K. Mason-N. Smith.

MIXED 18: 2 p.m.—M. Phelps-V. Aldea vs. R. Augustine-R. Robinson; K. Gottschalk-L. Oberg vs. E. Weld-J. Johnson; 4 p.m.—R. McNamara-M. Seeliger vs. M. Pattridge-Mary Gillach; 11 a.m.—Philpot-Dannenberg vs. Lacouture-Burrus.

MIXED 12: 4 p.m.—G. Oakley-S. Connelly vs. R. Kornfeld-J. Ross; J. Hoskins-A. Frederickson vs. L. Gugenheim-A. Rosenberg; C. Mease-K. Imber vs. w/o previous match; 6 p.m.—w/o previous match vs. C. Hoeven-K. Colglazier; B. Kreidle-K. Ellington vs. J. O'Connell-M. Berger; V. Connelly-L. Donahue vs. Vandenberg-L. Rose.

AT GREEN GABLES

BOYS 12: 10 a.m.—Koza-Drose vs. McLish-Marshell; Noon—Nelowet-Chambers vs. Card-Hoskins; Sanders-Markove vs. Sherman-Heppenstall; O'Connell-Seibert vs. Oakley-Wright; Monneyham-Halley vs. Paul-Kornfeld; 3 p.m.—Bierekoven-Grossman vs. Sherrard-Henson; Mease-Sevier vs. Creidle-McNamara; Danner-Rink vs. Cohen-Titsch; Zimmerman-Merriman vs. Malcove-Friedauer; Evans-Parsons vs. w/o previous match; 2 p.m.—w/o previous match vs. Connelly-Connelly; Hutchen-Piltz vs. Zwaanstra-Morr; Mimmack-Dilack vs. Hollenbeck-Moore; Cohen-Shole vs. Thompson-Swearigen; Rosen-Scheer vs. Gugenheim-Spiska; Aguilera-Hagen vs. Shaddock-Mattson.

GIRLS 12: 10 a.m.—Ellefson-Langlett vs. Berenbaum-Ross; 3 p.m.—Robbins-Chase vs. Langstaff-Wallbank; Halsell-Ludwig vs. Colglazier-Hoeven; Danos-Irwin vs. Ezzard-Ezzard; Koza-Warosh vs. Berger-Rose; Heffner-Savage vs. Zinke-Perry; Roth-Roth vs. Chase-Robbins; 8 a.m.—Heitler-Marcus vs. Ludwig-Ellington; 1 p.m.—w/o previous match vs. Imber-Colglazier.

BIRLS 14: 8 a.m.—Jordan-Sigman vs. Frederickson-Fuller; Chapin-Johnson vs. Baker-Loeffler; Payne-Vincent vs. Bushey-Langstaff; S. Reide-A. Wagner vs. w/o previous match.

GIRLS 16: Noon—C. Sigman-S. Rose vs. w/o previous match; w/o previous match vs. N. Pattridge-J. Rumstetter.

MIXED 16: 9 a.m.—M. Smith-S. Rose vs. L. Hayne-A. Bye; R. Nelson-B. Curtis vs. P. Cavanaugh-M. McHugh; P. Sarlo-C. Sarlo vs. C. Averch-E. Sigman; P. Pritz-S. Eggleston vs. B. Johansen-J. Vincent; T. Headlee-K. Grant vs. P. Trifunal-A. Diefendorf; 10 a.m.—B. Boggess-J. Ramstetter vs. M. Delaney-B. Bushey; H. Langstaff-L. Fiske vs. J. Oettli-P. Miller; E. Gotaas-S. Jones vs. B. Brown-C. White; 11 a.m.—J. Klingler-N. Payne vs. D. Jacob-S. Sloan; J. Wicklund-J. Jacobsohn vs. J. Mease-C. Pepper; R. O'Donnell-L. McNutt vs. V. Stanley-S. Reed; T. Galey-J. Nelson vs. S. List-L. Langstaff; D. Petterson-C. Sigman vs. C. Norgren-P. Hollenbeck; W. Sulmeisters-L. Stutheit vs. D. Kelly-S. Riely.

Co

The lemming marc

By HARRIET VAN HORNE

ARE UNION LEADERS THE LEMMINGS of the hard-hi Seventies? Are they on a death march, step by step, into a churning sea of inflation, taking millions of union members with them?

A decade ago only an American Gothic reactionary, a fiscal conservative of the Silas Marner mold, coul have asked such a question.

Van Horne

Today the inflexibility of trade unionists causing shudders in big cities across the lan Unless New York City takes a firm stand, a re grettable pattern of capitulation will be set. It a pattern that could lead to municipal bankrup cies from coast to coast. And suicide for the lemmings.

When I suggested recently that city workers, in time of financial crisis, ought to modify their demands, every third city worker — or so it seemed — sat down and wrote me an outraged letter.

Most were unsigned, which is considerate because it frees me from the obligation of sending back the letter that begins, "I am sorry we do not see eye to eye in the matter of . . . ."

AND I TRULY AM SORRY. While there's an outraged working class, I'm in it. But there are legitimate grievances and honorable demands — and then there's extortion. And there's greed.

"I am an employe of New York City, and I am tired of always being blamed for the city's troubles," begins a typical letter. "We are not the highest paid civil servants in the nation . . . we rank fourth."

I'd be interested to know which three cities pay m money, in salaries and pensions, than New York, but this c spondent does not enlighten me. He goes on — with perfect jus

Murk added to fog

By TOM FESPERMAN

I DON'T APPLAUD the daytime soapies on the telly.

I also don't defend those quiz shows wherein wigged women win washer-dryers for naming the brothers who invented the aeroplane.

I simply say these are not the worst tube products.

Fesperman

The worst are the likes of Face the Nation and Meet the Press, and Issues and Answers.

I reckon I've gone through the change. I used to think such programs were essential to the improvement of life.

Not long ago, wrapped in the world's cares, I always tuned them in. I went into studious silence. I wouldn't even light a cigarette, lest falling ashes disrupt wisdom.

Here sat our leaders, the insiders. They could take us by the hand, get us out of the swamp.

But then I gradually realized what was happening: The more I listened, the less I learned.

Cabinet members hemmed, and party generals hawed.

Undersecretaries lost themselves in thickets of theories. Congressional chieftains dodged questions.

Subcommittee chairmen expanded answers into elongated espousals of incomprehensible ideas.

THE WORDS WERE TINY BUBBLES of air, vaporous, floating away from microwave relay towers to join the pollution of platitudes.

Murk was added to the fog around us.

Replies to questions spilled out like overturned spaghetti, sauced, slippery, intertwined, curled to hide beginnings and endings.

Panels of questioners sat suffering silently in unsatisfaction, pressured perhaps by producers into phony politeness.

There were no new revelations. No answers beamed light into our picture tubes, and slapping the sets on the side didn't help. The networks' efforts at enlightenment added density to the darkness.

I switched channels.

And thought of my own newspaper interviewing.

There was a difference. Editing. I'd come back from a big shot, and the boss would ask what was new, and I'd reel off this gunk, and he'd decide what two per cent was worthy.

HIS PENCIL WAS THE ANTIDOTE to swollen statements.

I hope the networks will drop their political game shows.

Out here where we live on The Edge of Night, in our Search for Tomorrow as The World Turns, we need clarity, kids, not compounded confusion.

We get more straight answers from Hollywood Squares. We get more sober thought from Foster Brooks.

We need big shots who can talk out of only one side of the mouth, the way Buddy Hackett does.

The nets would serve better if they produced specials on boat safety, because we're heading for the lakes, to try to co it, and we're hoping somehow to stay afloat.

An

Out Back

By Bill Logan

Fishing in the cavalry

It may seem strange that the forces of Gen. George Crook, the respected leader of cavalry during the Indian wars, were doing a lot of trout fishing not far away when Custer and his outfit rode to slaughter.

A week before Custer's forces fell on the Little Bighorn River, Crook's command had a one-day battle with the same Indian forces Custer attacked.


Logan

Crazy Horse, the Sioux war chieftain, later said he had 6,500 mounted warriors. He set a trap for Crook. He sent in 1,500 warriors, hoping that Crook would be drawn into an ambush manned by 4,000.

Crook didn't take the bait. Both sides withdrew. Crook moved from the Rosebud River, where the battle occurred, to the nearby Tongue River. For some days he was forced to await the arrival of supply wagons.

There were other military units in the region and an overall plan of movement, but Custer on June 25, 1876, on the Little Bighorn River only a few miles to the west, attacked the largest and most powerful concentration of Indian strength ever assembled in the history of plains warfare.

NEWS TRAVELS SLOWLY

It was a number of days before Crook's command learned of the Custer massacre, and many of Crook's men were catching a lot of trout from the Tongue River and its tributaries.

The problem with western movies is that you do not see casts of thousands any more. Crook's command had 2,000 horses and mules, and it was noted the fishing was good, except for the animals interferring.

Capt. John G. Bourke who for 16 years was on Crook's staff during Indian campaigns in the Southwest, plains and up into Montana, shows us that the horse soldiers were notorious anglers.

It didn't take the troops long to discover the Tongue River and its tributaries were great trout streams, as Bourke's book, "On the Border With Crook," pointed out.

"My notebooks about this time seem to be almost the chronicle of a sporting club, so filled are they with the numbers of trout brought by different fishermen into camp," Bourke wrote.

" . . . Under the influence of the warm weather the fish had begun to bite voraciously, in spite of the fact that there were always squads of men bathing in the limpid waters, or mules slaking their thirst.

500 ON ONE DAY

" . . . Mills started in with a record of over 100 caught by himself and two soldiers in one short afternoon. On the 28th of June, the party has another record of 146. On the 29th of the same month Bubb is credited with 55 during the afternoon, while the total brought into camp during the 28th ran over 500."

Bourke himself claims to have taken the largest trout brought into camp in a week. It was a three-pounder. One day Crook had bad luck, and members of his staff decided to say nothing about it to him.

This is the way Bourke put it: "Gen. Crook started out to catch a mess, but met with poor luck. He saw bear tracks and followed them, bringing in a good-sized 'cinnamon,' so it was agreed not to refer to his small number of trout. Buffalo and elk meat were both plenty, and with the trout kept the men well fed."

The captain said it would tax the credulity of the reader if he set out his record of catches of trout from the Tongue and tributaries.

The fishing began with men trying to get 15 or 30, for a good meal for themselves and messmates. Some got carried away. Then there was a rush to compete against fishermen in the outfit who were thought to be good anglers.

Crook insisted that all the fish either be eaten or dried for use later, according to Bourke. One afternoon Crook took 70 trout. A Maj. Dewees caught 68, another, Bubb, 80. The outfit's packers, true to form, came in with reports there were fine, deep pools farther up in the mountains, where the fish were much bigger.

WILLOWS PUT TO WORK

For the fishing, willow poles were cut. Grasshoppers were baited on hooks and worked the best, Bourke said. But some on the expedition had flies that had been tied in England.

"Maj. Noyes, one of our most earnest fishermen, did not return from one of his trips, and, on account of the very severe storm assailing us that afternoon, it was feared that some accident had befallen him; that he had been attacked by a bear or other wild animal, had fallen over some ledge of rocks, been carried away in the current of the stream, or in some other manner met with disaster," Bourke wrote.

". . . Noyes was found fast asleep under a tree, completely exhausted by his hard work; he was afoot and unable to reach camp with his great haul of fish, over 110 in number . . .

" . . . There must have been at least 15,000 trout captured in streams upon which we had been encamped during that period of three weeks."

He said the whole command of hundreds of soldiers and packers was living off trout and "every man had all he could possibly eat for days and days."

...y game

...es.

...k the game is going to be very ...ing. It will be played under ...e game conditions."

... the "game conditions" could be ...er test as several players have ...ioned noticing a difference in ...king in the altitude during prac...ces which began Monday.

...vance tickets are available at the ...et box office, Select-a-Seat outlets ...ay D&F, and will sell for $3 ... and loge and $2 balcony at ...s Wednesday night.

Rookie lineups

WHITE

No.	Player	Pos.	Ht.	College
11	G. Zumbro	F	6-6	Denver
12	Matt Gantt	F	6-5	St. Bnvntr
15	D. Thompson	F	6-4	N.Carolina St.
20	Monte Towe	G	5-7	N.Carolina St.
22	Jimmy Foster	G	6-1	Connecticut
23	Greg Popovich	G	6-1	Air Force
32	Roger Brown	C	6-11	Kansas

BLUE

No.	Player	Pos.	Ht.	College
11	Rudy Carey	G	6-0	Colorado St.
12	C. Russell	F	6-6	Alabama
13	Tony Byers	G	6-3	Wake Forest
15	B. Ashbaugh	C	6-8	Northwestern
20	Mo Rivers	G	6-1	N.Carolina St.
23	Tommy Smith	F	6-4	Kansas
32	Mike Odemns	F	6-5	W.Kentucky

Dr. Behnke,

I came by today. I'll get in touch Friday if you need help.

— Eiseiman $500 request — moved coll. — habitat cons biblig. —

— Intent of Wyo pub. - I & E, mgt.

— Denver Lib — illustrations

— Any more spec. this yr. (?)
— Enough to write sep as is — Jay

Binns — co-author

discuss actual projects

— handbook for native trout restoration —

Summarize

Wyo Tables

date

area

N

coll.

San
* Urban
Trout
fish.

- Jester - look at Paddy Crk. ↓ San Francisco
- put in $ / ...

Lead vs. Gold

L. Erie - white bass, white perch, drum, smelt, ... carp, sucker, - vs. lake trout, whitefish -

- Muskelunge - 1-2 lb/acre - .

- Larry Marshall - values - for cost/benefit for rehabilitation, grazing - alternate use -

Rept. II
for purity of S. c. , S. c. ...

- 18 samples (16 Green R. S. c. plus 2 Bear R. ... S. c. ...) -
of 177 specimens (excluding those about 35 less than 100 ... to

- Burns -
Recom.
3 types -

Native Trout fish. - 1 aura of mystique -
- natural surroundings of wilderness or primitive area -
2 Values: 1 Catchable trout fish 2. fingerling plants for 3 wild trout (not natives) based on natural reprod. 4 Native fishes
Yellowstone Park - Idaho -
Levels of exploitation - food supply, growing season
cutthroat have potential for rapid growth ...
(1) greater longevity over hatchery rainbow ... fish -
(2) Vulnerability to angling.
-

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This is the final paper in a set of five on Population Dynamics, originally presented at the New Zealand Science Congress in 1960. *Others papers appeared in issues* 1 *and* 2 *for* 1962 *of New Zealand Science Review.*

THE NATURAL REGULATION OF POPULATION IN THE SALMONIDAE

By K. RADWAY ALLEN, *Fisheries Laboratory, Marine Department*

Introduction

IN any discussion of the natural regulation of population in a group of animals, one of the first points which has to be considered is whether the group as a whole has any particular characteristics which influence the regulation of populations within it. Fish have one characteristic that is common to many species and has a considerable effect on their populations but which is rarely found to the same degree in other groups of animals. This is an extreme plasticity in their growth-rate and reproductive potential. The variations which can occur in these features interact not only with each other but also with population size and density and, as a result, the relatively simple techniques of analysis which are satisfactory for the study of many other animals are not adequate for fish and more elaborate methods have had to be developed.

The Salmonidae are well adapted for the study of this problem since they show plasticity to an extreme degree and also, being largely freshwater, they tend to form discrete populations which are susceptible to quantitative study. This paper will not, however, attempt to construct a comprehensive model of the mechanism of population-regulation in the group, but merely to outline some of the factors which may affect population size and structure and particularly to consider the effects of the interaction between population-density, growth-rate, and reproduction.

The Basic Factors

The principal interaction is between two opposing effects: the tendency for increasing population to reduce growth-rate through the influence of competition for food, and the tendency for reduced growth-rate to reduce numbers in the next generation by causing the fish to mature later and at a smaller size and so reducing egg production. Balance between these two effects will tend to stabilize population size and structure in a given set of environmental conditions, while changes in the two controlling factors, food supply and cause of mortality, will produce entirely different effects on the population. For a given food supply, increase in mortality rate will reduce the number of fish of any age resulting from a given egg production; this will reduce the competition for food and so increase the growth rate, thus bringing maturity earlier and at a larger size, and so leading to a larger egg production to start the next generation. Stability will ultimately be reached with a population consisting of fewer but larger fish than before. On the other hand, if the food supply is increased while mortality rates remain constant, growth rates will increase correspondingly and fish will be larger at each stage of their lives; the associated reduced age and large size at maturity will lead to increased egg production and hence more fish in the next generation. This will tend to reduce growth-rate towards the original level, but stability will tend to be reached with fish both larger and more numerous than before. The effect of food supply is therefore directed towards determining the total quantity of fish in the population, considered as a function of both number and individual size. In contrast, mortality rates affect the structure of the population, that is, whether it consists of few large fish or many small fish.

While this is, of course, an oversimplification, it is believed to be essentially true, and the remainder of this paper will be devoted to considering some of the evidence for the basic assumption and to examining a few of the complicating factors which are known to occur.

Growth and Food Supply

The effect of the number of fish inhabiting a limited area of water upon their growth-rate has been repeatedly demonstrated. A simple example is provided by recent work at Lake Ngapouri in the Rotorua district. The population, which was originally derived solely from natural reproduction, is being gradually increased by annual liberations of hatchery-produced fingerlings and as a result the growth-rate of successive year-classes of fingerlings has diminished, as Fig. 1 shows. The effect of natural fluctuations in number on growth-rate was studied by Foerster (1944), who found that the weight and number of sockeye salmon yearlings leaving Cultus Lake varied in opposite directions with a resulting well-marked tendency for the total weight of the migrants to remain constant.

The factors controlling growth-rate are not, however, always as simple in their action as the above examples might seem to imply. In particular, the rate of growth at successive stages of the life-cycle may vary in a different manner in different waters. At one extreme growth in length may continue at a fairly uniform rate throughout life, while at the other extreme it may stop

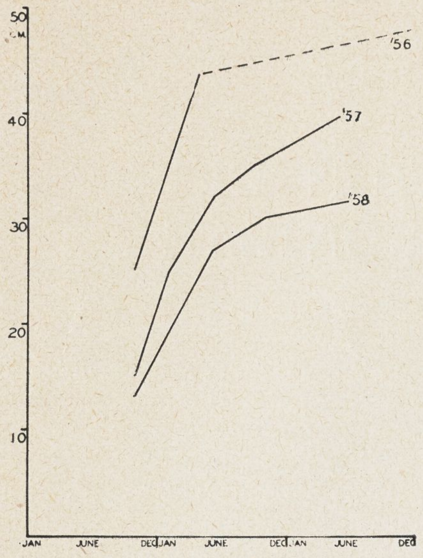

FIG. 1: The growth curves of fingerling rainbow trout liberated in L. Ngapouri in the three successive years, 1956 to 1958, showing the reduction in growth rate as the population is built up.

almost completely at the end of an initial growth period which is commonly about two to three years. The completeness of the cessation of growth and the age at which it occurs bear no clear relation to the initial growth-rate, and some fish which grow steadily throughout their lives and finally reaches a large size may grow more slowly at first than others of the same species which cease to grow while quite young and of small size. Figure 2 shows a number of growth curves of brown trout, derived from various sources, and illustrates this diversity in the shape of growth curves In some circumstances, rainbow trout may show an even more sudden and complete cessation of growth than any of these brown trout examples (Smith, 1959).

Various explanations of the check in growth at a certain point have been put forward. Food supply may sometimes be the controlling factor; a steady growth would then occur only if the fish could continue to obtain an abundant intake of food without an excessive output of energy even when they were large. This would require either a sufficient supply of large food animals, e.g., small fish, or else a really abundant supply of smaller food. If large food or abundant small food is not available, the energy expenditure involved in catching food may be so large as to prevent sufficient being obtained to provide for growth beyond a certain size. Effects of this kind have been demonstrated by various experiments in which fish nearing the normal maximum size have been taken from waters in which growth is checked and have resumed rapid growth when placed in other waters where fish normally reach a larger size. Sexual maturation itself may also be a contributing factor, since it frequently happens that growth ceases at about the time fish first become mature (Smith, 1959). The existence of populations in which growth continues past maturation shows, however, that other factors must determine whether or not the growth-retarding effects of maturation can become operative.

Growth and Egg Production

The effect of growth-rate upon egg production is itself the resultant of two other relationships, those between growth-rate and size at maturity and between size of fish and number of eggs produced. Of these, the latter is the simpler and more precise, and some linear relation between the two is usually accurate enough for most practical purposes.

The relationship between growth-rate and size at maturity is more complex since growth-rate affects age at maturity as well as size at a given age. Much data on this problem has recently been examined by Alm (1959), who has shown for a variety of species that, for any particular race, the age at first maturity tends to decrease as growth-rate increases. The effect is to keep the size at first maturity roughly constant over a wide range of growth-rates. It tends, however, to diminish at very slow growth-rates, while it rises in populations having very rapid growth, since once the age at maturity has been brought down to the minimum normally possible for the species, size at maturity inevitably varies with growth-rate.

Thus, over the whole range, decreasing growth-rate will be associated with increasing age and decreasing size at maturity. At the two ends of the range the change in size is probably more significant, while in the middle range the change is mainly in age. Both effects will, however, tend towards a decrease in egg production with decreasing growth-rate and thus provide a basis for the hypothesis outlined earlier.

Mortality Rates

While the size of a population will depend on the overall mortality rate, its detailed structure will reflect the influence of different causes of mortality operating at different stages of the life-history. Although it is rash to attempt any generalization, it is probably safe to say that a great many salmonid populations show three distinct phases in the life-cycle with characteristically different mortality rates. The egg stage, which generally lasts two to three months, has usually a low mortality rate, under good conditions often less than 10 per cent. for the period; the first few

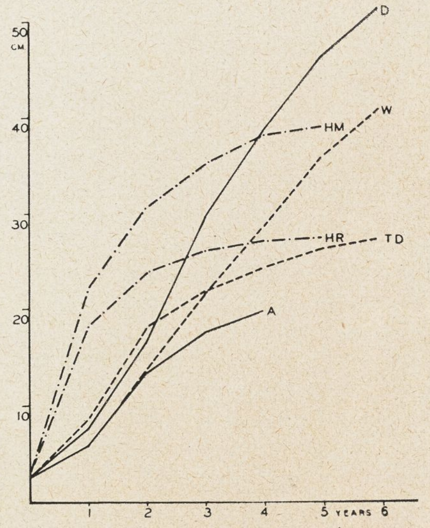

FIG. 2: Growth curves of brown trout from various waters showing the diversity of form—England; W, Windermere; TD, Three Dubs Tarn, (Frost and Smyly, 1952)—Ireland; D, L. Derg; A, L. Atorick (Southern, 1935)—New Zealand; HM Horokiwi Main Water; HR, Horokiwi Road Branch (Allen, 1951).

months of independent life have a very high mortality, often considerably more than 90 per cent. for the first six months or so; after this stage mortality is much lower, being commonly between 60 per cent. and 85 per cent. per annum. A fourth phase, that of post-maturity, could perhaps be distinguished, but a great diversity occurs between species in mortality rates at this stage; at one extreme, the Pacific salmons, *Oncho-rhynchus,* all die immediately after spawning, while at the other the brown trout often appears to be subject to little or no increase in mortality rate after reaching maturity.

In the time available only two sources of mortality can be discussed. Those chosen operate at different stages of the life-cycle, but they both may have a considerable effect on the nature of the population. They are quality and extent of spawning grounds, and predation.

Spawning Grounds

The spawning requirements of the Salmonidae are rigid and far from universally met. These fish require a bed of stable, permeable, well-graded coarse gravel in which the eggs can be buried to undergo development. Where such gravels are entirely absent, the group cannot occur naturally at all, while in streams with larger areas of such gravel mortality rates in the egg stage may be negligible. Where suitable gravel exists, but in limited extent, a definite regulatory effect on the population may occur, as Hobbs (1940) has pointed out. The earliest spawners find sufficient unused gravel and are able to spawn normally. Later spawners, however, have to spawn in places already occupied; they deposit their own eggs successfully, but in making their excavations they frequently disturb the eggs of their predecessors which may drift away and be eaten by predators or lodge in places where they cannot develop. As a result, in some localities where spawning areas are of restricted extent, the quantity of eggs which can be deposited and hatched successfully may be virtually limited, and so may determine the maximum number of young fish which can be produced to start each year-class.

Where spawning gravels occur extensively but are of poor quality, generally due to insufficient permeability, different effects will occur. Mortality rates may be quite high, usually as a result of inadequate oxygen supply (Wickett, 1954), but they will be independent of population density, and while they may affect population structure they will have no regulating effect on its size.

Predation

The principal predators on freshwater fish are birds and fish of the same and other species. Observations on the effect of bird predators on salmon and trout populations in Canada have been reported by White (1939) and Smith (1955) respectively. In the former, an increase in the number of salmon smolts migrating out of the North-east Margaree River from 1,844 in one year to 4,065 in the following year was associated with the removal of mergansers from the river. In the latter, reduction in bird predators of various species on Crecy Lake raised the percentage return to anglers of liberated fingerlings from an average of 6.8 per cent. in the five preceding years to an average of 62.4 per cent. in four years of bird removal.

In a somewhat similar experiment on the effect of the removal of predatory fish, Foerster and Ricker (1941) found that the mean survival of sockeye salmon to the migrating smolt stage in Cultus Lake averaged three and one-third times as great in three years of predation control as in previous years.

It is thus evident that predation by other species can have an important effect on survival and the numerical size of populations. It is unfortunate that none of these experiments were conducted on natural populations for a long enough period to determine how the new level at which the population stabilized would compare with the old. Ricker (1952) has shown that various types of predator-prey relationships are theoretically possible and would have very different effects on the prey population.

Evidence has been accumulating in recent years to show that intraspecific predation may be significant in some salmonid populations. Where it occurs it may have an important effect on population regulation, since there will be interaction between the number of fish in the larger predator phase and the number in the smaller prey phase. In a continuation of the Crecy Lake experiment (Smith, 1956), removal of the larger trout produced a further marked increase in the proportion of fingerling trout surviving to be taken by anglers. Intraspecific predation may also tend to produce cyclical effects in populations under natural conditions, since a strong year-class may suppress those which follow it for several years until it is so reduced that another strong class is allowed to develop. Burnet (1959) has suggested that this may be the cause of the four-year cycle which he has found in the brown trout populations of several New Zealand streams. It must be admitted that competition for food, cover, etc., might also affect mortality and so produce interaction between larger and smaller size groups. In the examples quoted, however, there seems to be good reason to consider predation as an important factor in the process.

In conclusion, this paper does not purport to be an exhaustive analysis of the process of population regulation in the Salmonidae as a representative group of fish. It is an attempt only to show that food supply and direct causes of mortality can both play an important part although they produce different effects on the population size and structure, and to indicate how such different causes of mortality as, on one hand, extent and nature of spawning grounds, and, on the other, predation both within the species itself and by other species can also have important effects, each of them in several different ways.

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JOB PERFORMANCE REPORT

State of Idaho

Name: SALMON AND STEELHEAD INVESTIGATIONS

Project No. F-49-R-13

Title: Evaluation of Survival of Hatchery Reared Salmonids

Job No. V-a

Period Covered: 1 March 1974 to 28 February 1975

Between 25 June and 19 September 1974, fisheries personnel snorkeled a total of 241 transects on 32 different days in Lolo, Newsome, Crooked Fork, Papoose, Squaw, Post Office, Moose and Bear creeks as well as Red, Lochsa and Selway rivers. For the second consecutive year, we counted juvenile steelhead, juvenile chinook, adult chinook, cutthroat trout, Dolly Varden, and brook trout in these streams.

Lolo Creek was the only Clearwater River tributary to receive a plant of smolt-size steelhead during 1974 (102,000). The result was an increase in juvenile steelhead from 13.0 per transect in 1973 to 21.3 in 1974. Newsome Creek and Red River received no fingerling steelhead in 1974, after having been stocked with 390,000 and 325,000 fingerlings, respectively, in 1973. Our juvenile steelhead count declined in Newsome Creek from 95.2 per transect in 1973, to 12.1 in 1974 and in Red River from 23.3 to 13.9. Numbers of juvenile steelhead declined in the Lochsa and tributaries in 1974, but increased in Bear Creek and Moose Creek on the Selway. Neither of these drainages received any fingerling steelhead in either 1973 or 1974.

Newsome Creek and Red River showed the greatest increases in juvenile chinook in 1974, increasing from 2.3 to 11.2 and 4.4 to 15.2 per transect, respectively. Bear Creek and Moose Creek in the Selway drainage both had significant increases in juvenile chinook; however, Crooked Fork Creek in the Lochsa drainage declined by 52%.

From 9-16 May 1974, a total of 1,904 unspawned adult steelhead were trucked from Dworshak National Fish Hatchery to various locations in Lolo Creek, Newsome Creek, Red River and selected Lochsa River tributaries. They survived trucking quite well, but were vulnerable to snagging by Indians and poachers once released. The snagging problem was apparently greatest in Lolo Creek.

We conducted aerial spawning ground surveys for steelhead and chinook in the Lochsa and Selway drainages. Steelhead redd counts declined in all areas of the Lochsa and Selway with the greatest decrease of 51% in Crooked Fork Creek on the Lochsa. Chinook redd counts were down 72% in the Selway and 65% in the Lochsa compared to those of 1973.

Author:

Ronald L. Lindland
Senior Fishery Research Biologist

McFadden, J.T., G.R. Alexander, D.S. Shetter

1967 - JFRBC - Numerical changes brook trout

14 yrs.

x̄ 132,000 eggs spawned in study area

x̄ 4,813 fish survive one yr. (O-I)

x̄ 1,966 " 2nd I-II

→ x̄ 356 " II-III

29 III-IV

0.6 IV-V

Hunt Crk., Mich.

x̄ size each age group in inches

	I	II	III	IV
1951 - 1962	7.2-7.4	7.4-7.8	7.9-8.5	8.8-10.2

fishery mortality

1.7% of total mortality O-I

23.6% I-II

35% II-III

3.6 / 20 | 20⟌360 (1.8)

II-III 82% nat

65 nat.
35% fish.

fall
1957 pop. est.

age	
O	6703
I	1796
II	309
III	53
IV	1
	8842

sizes

2-2.9	2624
3-3.9	4047
4-4.9	727
5-5.9	720
6-6.9	519
7-7.9	140
8-8.9	25
9-9.9	20
10-10.9	15
11-11.9	5
65	8842

8842⟌65000 (.74)
61754
3250

< 1% 8-12 in.

SFI bulletin

SPORT FISHING INSTITUTE

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No. 268 *"The Quality of Fishing Reflects the Quality of Living"* September, 1975

SPECIALIZED USE OF RECREATIONAL FISHERIES RESOURCES*

Excepting only swimming, **fishing** is the most popular of all the traditionally-recognized participative forms of outdoor recreation in terms of percentage of population involved.[19]

WHY DO PEOPLE FISH? The reasons why angling is so popular with Americans remain imperfectly analyzed and understood. The activity has roots in antiquity as a means of personal survival. However, individual fishing has not been a life-sustaining necessity on the part of the American public since colonial times. Sir Henry Wooton, mid-17th-century Provost of Eton College, said of angling:[20] "Tis an employment for my idle time which is then not idly spent."

Izaak Walton[20] described fishing as "The Contemplative Man's Recreation."

Herbert Hoover[7] asserted that, "The reason for it all is that fishing is fun and good for the soul of man."

William D. Ruckelshaus[14], Keynoting the recent National Bass Symposium, asserted that, "People fish to catch fish, not necessarily to keep them, but to catch them."

A 1973 survey of 524 sport salmon anglers on Vancouver Island revealed[2] that the two most important motivations for their fishing trips were, "to take it easy" and "to be outdoors." Closely following were, "to eat fresh fish" and, "the experience of the catch." The investigator concluded that, "sport fishing represents an ideal outlet for the frustrations of modern living in that it produces multiple benefits with few social costs."

A poll of anglers in the national capitol area,[4] in 1958, revealed that their chief reason for going fishing was to **relax**. The second and third reasons given were to enjoy **companionship** and **pleasant surroundings.**

Further insight comes from a recent behavorial study of 1,436 canoeists and fishermen on the Au Sable River, Michigan.[5] The need to escape temporarily "from stressful conditions in the non-leisure environment" was a major motivation for those activities. It was found to rank particularly high among those who fished.

MOST FISHING IS FOR FUN. We hear and see much aggresive promotion these days for something glibly called "Fishing-For-Fun"—just as if this were something unique and revolutionary. Actually, it is both nothing of the kind and a possibly harmful misnomer.

The deliberate implication—by some—that all but a select few have been 'Fishing-For-Meat' is a disservice to this great outdoor tradition. It is at considerable variance with the established facts, as well. It is widely documented, for example, that at least two-thirds of America's currently-estimated 34 million habitual anglers take less than one-third of all fish caught, and that half of these anglers probably catch no fish whatever! Of the remaining one-third of the habitual anglers, who catch some two-thirds of all fish taken, at least half of them catch only a few fish each time out. Thus, about 80% of anglers are obviously *Fishing-Mostly-For-The-Fun-Of-It!*

CATCH-AND-RELEASE-TROUT-FISHING. More than 20 years ago, an experimental project for catching and releasing trout was devised to permit catching them more than once. It was the inspiration of fisheries biologists in Michigan, where it was seen as one possible approach to trout management that might diminish the need for expensive trout stocking. After several years of testing, the so-called Hazzard Plan was shown to have modest benefits when applied to high-quality trout streams with good natural trout populations.[3,8]

The method depended upon use of artificial lures—including "hardware," as well as flies—to the exclusion of natural bait. Negligible mortality occurred among released fish due to hooking on artificials,[8,9,16] whereas hooking mortality was significant among released trout caught on natural bait. The plan also involves the release of all trout caught—except the largest individuals. In essence, it is scarcely more nor less than artificial-lure fishing coupled with a high minimum length. As such it ought more properly to be called **Catch-And-Release-Fishing.**

Despite contrary claims by many anglers and some allied **amateur** ecologists, prohibiting harvest does not result in a stock-piling of fish into subsequent years. As **professional** ecologists recognize, Nature steps in during the winter season, in such circumstances, and removes the surplus fish that anglers have left in the water. It's an inexorable rule—'If the Anglers don't get 'em. Mother Nature will.' Put another way, "It isn't nice to fool Mother Nature!"

In Catch-And-Release-Fishing, the anglers elect to increase the **catching** and drastically reduce the **take-home** of

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*Summary of invitational remarks by R.H. Stroud, Executive Vice President, Sport Fishing Institute, at Annual Conference of the Western Association of State Game and Fish Commissioners, July 13-16, 1975, Seattle, Washington. Full details will be available as part of the Proceedings of the Conference when published by the Association.

any proof of their angling prowess. Undoubtedly, however, the latter will long remain an essential element of the fishing trip for the vast majority.

A catch-and-release ("fish-for-fun") program conducted in 1962, on Virginia's Rapidan and Staunton rivers, serviced fewer than 5 percent of an estimated 75,000 trout anglers statewide.[11] The state's fish chief emphasized that the vast majority of Virginia trout anglers at that time—about 97%—preferred to use natural baits, and fish they could keep.

Similarly-low fishing participation under catch-and-release regulations was noted in a 1962 study of Colorado's heavily-fished Cache la Poudre River. When bait fishing and catchable-trout stocking were eliminated, and a 12-inch minimum "keeper" length was enforced on rainbow trout, use by fishermen dropped significantly.[10]

BASS FISHING TOURNAMENTS. Several years ago, there developed in the Southern states an ingenious commercial enterprise based on the organization of bass fishermen into clubs for the purpose of promoting professional bass-fishing tournaments. Club membership was rewarded with an annual subscription to a specialized bass angling magazine, identification patches, cut-rate group insurance, and discount-purchase of fishing equipment and supplies. For additional fees, club members could enter and compete for cash prizes in a series of professional bass-fishing tournaments on selected waters—in practice, mostly large southern reservoirs. The deliberate design is to stimulate competition among bass anglers and to determine their professional ranking.

The time-honored view has been that fishing permits practicipants to get away from the stressful competition with other people that increasingly characterizes modern life. Most people have long held the view that the only competition out fishing should be between the angler and the fish.

It is a reasonably-well established medical fact that many functional and organic human illnesses are psychosomatic in origin. More than a decade ago, the American Medical Association noted that fishing on a lake or stream offers peace and freedom from stress.[6] Somewhat later, an American Medical Association news release[1] stated: "Fishing is highly recommended by your doctor as a healthy, relaxing sport that will get you out of doors into fresh air and sunshine, and help to clear those mental cobwebs left over from home and office worries."

The traditional values of fishing, as a re-creator of the psyche, are increasingly needed for relaxation from the tensions of a more and more stressful society. In this context, the deliberate promotion of competition among anglers is evidently a destructive influence upon the fundamental value to society of recreational fishing. Taking these matters into thoughtful account, and having additional concerns for the ecological impact of artificially-intensified exploitation by expert anglers of the critically important predator fishes, the Board of Directors of the Sport Fishing Institute, in May, 1973, adopted the following resolution:

REAFFIRMING THE CONTEMPLATIVE NATURE OF FISHING

WHEREAS, many highly competitive commercialized fishing tournaments are being widely and increasingly organized and promoted, specifically aimed at the relatively limited supplies of the predator game fishes such as largemouth bass that play an essential natural role in helping to control the excessive production and stunting of bluegills and other prey panfishes, which in turn support the vast majority of recreational fishing nationwide, including the vitally-significant family fishing activity; and

WHEREAS, for many centuries angling has been regarded as the "gentle art," while serving usefully during many recent decades as the foremost form of contemplative outdoor recreation, widely recommended by health authorities as a tension-relaxer for rejuvenating the spirit of man; and

WHEREAS, despite an encouraging trend toward voluntary release of tournament-caught fish, the philosophy of highly organized competitive tournament angling for the benefit of the few remains in significant conflict with the contemplative philosophy of recreational fishing for the benefit of the general public, and uncontrolled tournament angling may well prove inimical to the broad public interest through curtailment of contemplative recreational fishing opportunities for the general public;

NOW, THEREFORE, BE IT RESOLVED, that the Directors of the Sport Fishing Institute, assembled in regular Annual Session at Montreal, Quebec, on May 15, 1973, do herewith declare their active concern with respect to possible harm to public fishing that may result from the rapid, largely unregulated growth of the highly competitive commercialized fishing tournaments, and

BE IT FURTHER RESOLVED, that the Directors of the Sport Fishing Institute do herewith urge the State and Federal fish conservation agencies, as may be appropriate in various circumstances, to closely monitor and evaluate all such tournaments and conduct related research in order to develop biologically-sound regulations designed to preclude adverse impact upon fishing opportunities for the many millions of anglers who continue to look to recreational fishing for contemplative purposes—as well as for rewarding catches.

Up to the time this resolution was adopted, tournament promoters had paid relatively little attention to their ecological public relations. Thereafter, tournament promotors began routinely to require release of tournament-caught fish. Initially, however, handling of fish by contestants was so rough that up to 98 percent of bass released were shown to have died within a few hours, days, or weeks after their release.[17,18]

In a study of the activities of 206 competitive bass fishing clubs in Texas, it was concluded that releasing bass taken during tournaments might have some merit—*provided* the fish are carefully handled.[15] It was also recommended that serious consideration be given to a permit system requiring fees from private organizations that sponsor bass tournaments for personal profit on public waters of Texas. The recommended fee was $1,000 or more per tournament.

FUTURE TRENDS. All of the available indicators show that angling is one of the most popular forms of active outdoor recreation. Moreover, it is the form that also reflects the greatest latent public demand. Recreational fishing is a complex experience, and this fact should be taken into consideration while developing fisheries programs. The modest interest that has been generated in the idea of catch-and-release fishing has served principally to emphasize this conclusion. One of the results of this application in various situations has been a clear demonstration that anglers must retain the privilege of keeping a significant part of their catches. This is the essential missing ingredient precluding the "fun" aspect in many so-called "fishing-for-fun" programs. This circumstance applies since most sport fishing, these days, is essentially for "fun" vs. "bacon." Lacking that element, anglers quit going fishing in droves.

No crystal ball is needed to foretell a growing trend toward reservation of many marine species other than industrial fish to satisfy sport fisheries needs, first, before consideration will be permitted for their use in the commercial industry. This will mean, in cases of scarce marine resources, that there will be increasing reservation of certain species of fish for recreational fishing. In fresh water, too, there must probably also be increasing utilization of the presently less popular species and the presently more prolific but relatively under-harvested species, now loosely called pan fishes, "spiny-rays," or rough fish.

At the same time, in future decades, there may well be increasing protection of predaceous fishes, perhaps implemented through selective applications and careful evaluations of the catch-and-release principle. Just such reservation of muskellunge has prevailed since 1962 at an experimental pond under management by the Ohio Division of Wildlife.[12] It is to be hoped that research will provide fisheries managers with needed guidelines relative to handling mortality and other factors that influence the survival and recapture of fishes released under such programs.

OPTIMUM YIELD OBJECTIVE. Fish conservation must be dynamic in the future, though it will include the judicious if limited use of preservation (non-use). Above all, it must feature an optimum-yield concept.[13] The latter differs markedly from the traditional and historic concept of fisheries resource management, exemplified most vividly in the marine field, where the traditional narrow concept of maximum sustainable yield has been overwhelmingly stressed to the present time. OY and MSY differ conceptually because their implicit objectives are different. MSY looks narrowly and exclusively toward maximum yield of protein; OY looks toward broader socio-ecological objectives.

The concept of optimum yield best accommodates the elusive element of "quality" in recreational fishing. Not universally defined with respect to angling, it obviously includes considerations of both the species and the sizes as well as quantities of the fishes involved, the situations in which they are found, and the methods by which they are sought or harvested.

The optimum yield concept also allows for the establishment and maintenance of ecological reserves of some species to maintain other desired species, or merely to assure maximum variety or diversity of life forms. It also allows for establishment of safety factors with respect to allowable harvest, not heretofore contemplated, in order to accommodate unanticipated natural and other disasters.

IN CLOSING. Little reason exists for either anglers or conservationists to fear the future, although many people take a very dismal view of the impact upon fisheries resources of projected angling demands. In my considered view, recreation and conservation leaders can be confident that the potential of the fisheries resources is sufficiently great, given aggressive resources management, to meet projected use demands well beyond the turn of the current century. They can also anticipate, in my view, that fisheries science, given the opportunity to flourish, possesses the innate capability to provide this kind of needed resources management.

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TOXAPHENE EFFECTS

According to a boxed item in SCIENCE for April, 1975 (Vol. 188, No. 4186: 343), toxaphene is bad news for fish, because of elimination of vitamin C from their diet as it is used for detoxification of toxaphene. Paul M. Mehrle and Foster L. Mayer told the Philadelphia national meeting of the American Chemical Society that low background levels of toxaphene caused stunted growth in at least the three species of fish they studied, together with a skeletal fragility most often exhibited in the form of broken backs. The utilization of vitamin C in the natural detoxification process left little excess for use in bone development and growth.

QUARTER-MILLION JUDGMENT

On June 2, 1975, The Ohio Department of Natural Resources announced that a $250,000 judgment, issued that same day in Cuyahoga County Common Pleas Court against Gould, Inc., Cleveland, for damages to Ohio's unique clam population, is the first trial judgment ever awarded in the state for the destruction of wild animals. It is also one of the largest amounts ever awarded by a court anywhere in the United States for the destruction of wildlife on an inland waterway.

The court decision resolves a year-long dispute between attorneys representing the Division of Wildlife of the Ohio Department of Natural Resources and legal representatives of Gould, Inc. The decision is the result of more than three years of research and investigation by biologists and enforcement officers from the Division of Wildlife and assistant attorneys general from the staff of the Ohio Attorney General, William J. Brown. It is considered a landmark decision by the Division of Wildlife.

The judgment awarded resulted from a $3.1 million lawsuit filed in May, 1974, by Ohio Attorney General Brown at the request of the Division of Wildlife. The suit alleged that discharges of copper and other heavy metals from Gould Engine Parts and Foil Plant, near McConnelsville in Morgan County, killed more than 17,528,450 freshwater mussels or clams in a 22-mile stretch of the Muskingham River from 1971 to 1974. Shortly after the lawsuit was filed, a ban was placed on the commercial harvesting of clams in Ohio by the Division of Wildlife, which was concerned that the clam population was in danger.

The mussel beds in the Muskingum River are the largest ones found in Ohio, and it is one of the few places in the United States where the thick-shelled clams are found in large enough quantities to be commercially harvested. The clam industry was revived in Ohio around 1967, after being dormant for a number of years. The shell material once was used extensively by the button industry of the U.S. The industry was revived after it was discovered the material could be used by the Japanese pearl industry. After clams are harvested by commercial mussel operations, a portion of each shell is removed and sent to Japan, where the shell material is inserted in pearl-producing oysters, which form cultured pearls around it.

STRAY SALMON?

On June 3, 1975, an 11-¼-pound Atlantic salmon was found by a commercial fisherman in a gillnet he had set in the Brockway Island channel in the estuary of the Connecticut River. This catch was immediately touted by U.S. Fish & Wildlife Service biologists as evidence that their restocking program, initiated in 1970, is a success. The implication, rather optimistic at this juncture we fear, is that Atlantic salmon restoration in the Connecticut River has succeeded. On the contrary, it's a tenuous beginning, at best . . . .

The particular fish taken last June was identified from its markings as a survivor of 10,880 fingerlings that had been released in the Tarkill Brook (a Connecticut River tributary) near Agawam, Massachusetts, in March, 1973. The fish was presumed to have been returning to its point of origin in response to its adult spawning instinct. Approximately 95,000 fingerlings were stocked in the spring of 1975 in the Salmon River (41,549) and tributary Dickinson Creek (12,061), the Farmington River (25,894), Connecticut; and Tarkill Brook, Massachusetts (17,302)—all "nursery" streams tributary to the Connecticut River—in a continuation of the program.

Other individual Atlantic salmon have been taken similarly in Connecticut coastal waters, from time to time past, as well. For example, an evident stray Atlantic salmon was taken in the Connecticut River in 1947. Another stray was taken by a commercial fisherman in the Niantic River in 1956. The current occurrence is somewhat encouraging, at that, since it follows by about one year the finding of a dead Atlantic salmon at the edge of the Connecticut River near Middletown, Connecticut. More promising is the fact that a second Atlantic salmon, weight of 10 pounds, was caught alive in good condition in the Connecticut River on July 10, 1975, about 86 miles upstream from the ocean. The fish, a male, was spotted and taken in the counting chamber of the Holyoke Water Power Company fish ladder, in Massachusetts. It was dipped out and transferred alive to the National Fish Hatchery of the U.S. Fish and Wildlife Service, at Berkshire, Massachusetts. It is hoped to obtain additional upstream migrant salmon, but it may be a long vigil . . . .

Across the Atlantic, similar hope is rising in British breasts, evidenced by an editorial in TROUT AND SALMON magazine (Vol. 20, No. 235), January, 1975, Peterborough, England. The editorial noted the capture on November 12, 1974, of an 8-¼-pound Atlantic salmon on the intake screens at West Thurrock power station on the Thames. As such, it was the first salmon taken from the Thames since 1860. Its capture delighted the Thames Water Authority as some proof of their efforts made over recent years to clean up that once-famed (up to about 1820) salmon river.

BEHAVIOR OF ANGLERS

An intriguing discussion of "Sport Fishermen and Their Behavior" was presented to the Texas A&M Chapter, American Fisheries Society, February 27, 1975, by R.B. Ditton and A.R. Graefe, Department of Recreation and Parks of Texas A&M University, College Station, Texas. These researchers acknowledged that traditionally-developed catch-and-effort statistics are important factors in fisheries management. But, they asserted, the economic output of a recreational fishery is not fish, but fishing. And the ultimate goal of recreation resource management is benefits for the user. Fisheries managers must therefore determine what provides outdoor sportsmen with quality experiences if they are to provide these benefits.

Mess'rs Ditton and Graefe explained, in this context, that there are three essential components of recreational fisheries: the fish, their environment or habitat, and the people who are dependent on fish populations. Sound fisheries management, decision-making aimed at optimizing satisfaction for sport fishermen, requires scientific study and experimentation in all three of these areas. All three are closely interrelated and, they noted, are amenable to management if fully understood. As increasing pressure is put upon limited natural habitats in the future, and as widely diverse uses compete for these valuable resources, the fisheries manager must place greater emphasis on managing people in the process of managing fish.

With this management framework in mind, the two researchers discussed the types of information that social scientists can provide which will be useful to fisheries biologists. They then enumerated types of data that could be valuable and presented examples how this information is useful:

—fishing behavior: who goes fishing? how often? how do they fish? what do they catch? where do they come from? in which other activities do they participate?

—spending behavior: how much is spent? on what? where?

—attitudes and motivations: why do they fish? what do they prefer? how do they react to management alternatives? what is important to them?

—perceptions: does the angler see things as the manager does?

According to Ditton and Graefe, it is not enough merely to assert that this type of research is valuable in and of itself. If this type of information is available, we need to establish how the manager can make use of it.

Perhaps the most obvious implication derives from information concerning spending behavior. Most of our fishing resources are publicly owned. Today, more than ever before, public decision-makers are interested in economic comparisons of the value of alternative uses of land and water resources. Therefore, carefully documenting the impact of sport fishing on local, regional or state economics can be a valuable tool for the justification of resource allocation and the making of more objective management decisions.

Information about the user of a given fishery resource can enable the manager to relate supply to the demand for the fishery. What factors, other than supply, affect angler participation? User studies can determine present and future levels of fishing interest. If it is found that supply and demand are out of balance, the Ditton-Graefe team said, it may become necessary to focus on people management.

One way this can be done is through the manipulation of angler preferences. Educational and marketing efforts can be directed to shift species preferences to previously underutilized species. It may be practical to strive for more efficient use of present fisheries as well as trying to meet an ever-increasing demand by increasing the supply of already-desirable fish.

Information concerning what fishermen look for in a fishing experience can provide useful guidelines for habitat management. Some studies imply that aesthetic factors are an important part of the fishing experience. In the Ditton-Graefe view, this might suggest that the management of the surrounding environment should be emphasized as an important aspect of management of the total fishery resource. Keep in mind the key word "resource" for, in a sport fishery management scheme, the resources are fish, environment, and fishermen.

Studies of fishing motivation and preferences demonstrate, the two investigators stated, that a "quality fishing experience" can be defined. After it is determined what variables contribute to angler satisfaction, manipulation can be performed upon any or all important factors. Thus, by knowing your constituency, you increase the range of management tools available to you. Perhaps most important, by knowing what the angler wants, they said, you identify specific expectations and determine management alternatives aimed at providing satisfactory fishing experiences.

A major area of concern to biologists and recreationists, alike, is the impact of sport fishing on aquatic resources. Environmental scientists continually conduct research aimed at assessing the status of fish populations. Catch-and-effort statistics from their studies do provide some understanding of fishing pressure and demand. According to Ditton and Graefe, however, a multidisciplinary effort is needed to really explore the question, just how popular is fishing?

Fishing pressure should be understood in terms that are useful to a fisheries manager. It doesn't help him much to know how many people fish and what they catch nationally, or even in his state. The manager needs to complement his knowledge of fisheries dynamics with knowledge of what species are most heavily fished, the fish harvest, and the areas fished by sport fishermen. Area-specific data of this type can lead to a greater understanding of the actual impact of sport fishing on the fisheries.

MYRIAD ISLANDS ANGLING

Results of a survey of the "Characteristics of the Sport Fishery in the Ten Thousand Islands Area of Florida from June 1, 1971—June 30, 1974"—an area on the southwest Florida coast between Little Marco Pass and Lostman's River—are available in form of a 62-page mimeo report (dated April, 1975) from the Marco Applied Marine Ecology Station, Marco Island, Florida. It was calculated that about 250,000 boat fishermen caught over 1½ million fish from this complex area, containing 118,000 acres of water averaging no more than 5 feet deep.

Angler success rate was somewhat better than one fish per hour of angling effort. Among anglers expressing a preference (only half of the total), 82 percent stated they hoped to catch snook. Five species made up over 75 percent of the total catch, in the following estimated quantities (numbers of fish) for the three-year period covered: spotted seatrout—375,694, snapper—234,928, red drum—249,091, sheepshead—200,239, and snook—216,172.

The highest boat count on any given day, determined by aerial reconnaissance, was 347 throughout the area. It was estimated that about 300 acres of water were available per boat using the area. In consequence, it was suggested that there is ample water to absorb anticipated future increases in fishing pressure.

NOMINEES FOR STATE FISH

There are 26 states that have officially-designated State Fish (by legislative act) to complement State Flowers, State Birds, etc., including the latest, New York—eastern brook trout. In addition, a nominee is reported awaiting possible legislative action in Iowa (channel catfish). In recent mail, there arrived from Dr. Harry Jopson of Bridgewater College, Bridgewater, Virginia, the following list of further tongue-in-cheek "nominees" for all the remaining states (except Hawaii), some of whom may wish to suggest that Harry go somewhere . . .

Arizona—pupfish; Colorado—squawfish; Connecticut—white perch; Delaware—croaker; Georgia—warmouth; Idaho—river sturgeon; Kansas—picket pin gopher fish; Louisiana—alligator gar; Missouri—spoonbill cat; Montana—furred trout; Nevada—chuckawalla fish; New Jersey—pumpkinseed; New Mexico—Rio Grande sucker; Rhode Island—broadbill swordfish; South Dakota—red horse sucker; Tennessee—catfish; Utah—alligator lizard fish; Virginia—carp; Wyoming—cutthroat trout.

WATER QUALITY CRITERIA

We recently reviewed the volume, WATER QUALITY CRITERIA 1972 (Report of The Committee on Water Quality Criteria of the Environmental Studies Board of The National Academy of Sciences and The National Academy of Engineering; edited by Robert C. Rooney) at the urgent request of the Committee's Scientific Coordinator, Carlos Fetterolf. We indicated that this important volume (Stock No. 5501-00520) is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20240, for $12.80 per copy. It turns out, most unfortunately, that this volume is out of print—a fact that was not previously known to us. We regret any inconvenience this circumstance may have generated and suggest, alternatively, that this key work should be available in the libraries of most natural resource agencies and major academic institutions. It may possibly be borrowed from The U.S. Environmental Protection Agency, 401 M St., S.W., Washington, D.C., 20240, or its regional offices:

I —Rm. 2203, Kennedy Fed Bldg., Boston, MA 02203
II —Rm. 908, 26 Federal Plaza, New York, NY 10007
III —Curtis Bldg., 6th & Walnut, Phil., PA 19106
IV —1421 Peachtree St., N.E., Atlanta, GA 30309
V —230 S. Dearborn, Chicago, IL 60604
VI —1600 Patterson St., Dallas, TX 75201
VII —1735 Baltimore Ave., Kansas City, MO 64108
VIII —1860 Lincoln St. (Rm. 900), Denver, CO 80203
IX —100 California St., San Francisco, CA 94111
X —1200 Sixth Ave., Seattle, WA 98108

FISH MANAGEMENT WETLANDS*

A primary goal of the Sport Fishing Institute is the conservation of sport fisheries resources and related aquatic habitats. The Institute also has strong concerns for a broad range of related environmental issues. In the past decade, the Institute's Board of Directors has adopted six wetland-related resolutions, concerning (1) highway construction and aquatic resources, (2) protection and development of estuaries, (3) dredging and filling controls, and (4) management of the coastal zone.

A national inventory of wetlands would have obvious benefit to fisheries managers. In many instances, a fish species is a characteristic of a wetlands type as are its other characteristics. Thus, a wetlands inventory would be invaluable in the quantitative measurement of specific fish habitat.

Eliminating the Great Lakes, a very high percentage of all U.S. waters would be classified as wetlands. The importance of streams and deepwater wetlands to the sport fisheries resources is obvious. A few of the highly specialized kinds of wetlands which have important sport fisheries values are as follows:

ESTUARIES [Semi-enclosed coastal waters, open to the sea within which the sea water is measurably diluted by fresh water[1]]. When measured in terms of their landed value, 63% of the Atlantic coast commercial catch is made up of species believed to be estuarine-dependent at some stage of their life cycles.[4] The Sport Fishing Institute estimates that more than 90% of recreationally-harvested fish are similarly affected. Obviously, estuaries are indispensable to the future of the coastal fisheries resources.

SPRINGS. Because of their constant supply of cool, even-temperatured, oxygen-rich water, the availability of natural springs is often crucial to the success of eastern brook trout. Such areas are also ideal sites for trout and salmon hatcheries, and their protection is vital.

HIGH-WATER MARSH. In Nature, completion of their life cycle by nothern pike is dependent upon the availability of flooded marsh lands adjacent to waterways inhabited by these fish. These marshlands must be flooded when the fish are ripe for spawning in the spring and must, of course, be accessible to the spawning fish. Young nothern pike are dependent upon the larger zooplankters found in such areas, until they become large enough to prey on other fishes.

CHANGING LAKE MARGINS. The weight of fish harvested from Bull Shoals Reservoir, Arkansas, in 1974, was five times the average for the period from 1971-73. The increase was attributed to high reservoir surface-levels in 1973[3]. Temporary lake-level increases caused flooding of dense shoreline vegetation and resulted in: (1) improved spawning habitat, (2) better protection for eggs and fry, and (3) increased biological productivity—resulting from increased surface area and related recycling of nutrients through decay of shoreline vegetation. The zones of fluctuating reservoir margins may not normally be classified as wetlands, but they should be. As fisheries management becomes more and more sophisticated, there will be much more deliberate manipulation of fluctuating lake margins.

POTENTIAL WETLANDS. More than 43 percent of all freshwater angling is done in man-made lakes, ponds, and reservoirs.[2] These artificial waters are more easily managed than natural lakes and, in consequence, generally provide superior recreational fishing opportunities. The National Water Commission asserts that water areas are the focal point of more than half of all outdoor recreation.

The estimated 59 million Americans who evidently fish, today, are increasing at a rate of nearly 3 percent each year. The Sport Fishing Institute conservatively predicts a 200-percent increase in the sport fishing demand by the turn of the century. To meet that demand anti-pollution efforts must be continued, wetlands protected, fisheries management effectiveness improved, and new fishing waters created—especially near urban concentrations.

In May, 1974, the Board of Directors of the Sport Fishing Institute unanimously adopted a resolution calling for a "National Inventory of Recreational Lake Sites." The resolution called attention to the limited number of suitable recreational impoundment sites, and the urgency of identifying such sites for protection until such time as their development becomes practical.

Good near-urban impoundment sites are rare and correspondingly valuable. The use of such sites for recreational purposes evidently represents their highest and best possible use. There is a national urgency to locate and identify such sites so that, hopefully, they will be zoned to reserve protect them until such time as construction is possible. A good recreational impoundment site must have the following characteristics:

1. **Size**—A minimum surface area of 50 acres, up to an approximate maximum of 1,000 acres.
2. **Location**—Relatively close to areas of high population (within about two hours driving time).
3. **Depth**—Generally not over about 40 feet maximum.
4. **Drainage Area**—Generally, not less than 10 nor more than 25 acres in the drainage basin for each actual acre to be impounded, actual ratio governed by other factors. (This is a key condition that may rule out many otherwise acceptable sites).
5. **Cost**—There must be suitable topography to facilitate construction of the dam so that its cost, in ratio to resulting surface acreage, is reasonable (suggested not to exceed approximately $5,000 per surface acre, in terms of 1975 dollars).
6. **Water Quality**—Must be of sufficiently good quality to be capable of supporting warmwater fishes, as a minimum.
7. **Soil**—Must be relatively impermeable.
8. **Improvements**—Area to be inundated must be devoid of cemeteries, elaborate highways, railroads, factories discharging toxic wastes, or other improvements, construction, or developments that preclude feasibility due to excessive costs of purchase or relocation.

An outstanding example of a potential wetland after development is the 218-acre Burke Lake (Fairfax County, Virginia), located about twenty miles from Washington, DC. Burke Lake accommodated more than 59,000 anglers in 1971—among the most intense fishing pressures in the nation. Uncounted more thousands used adjacent county-owned park lands for hiking, picnicking, camping, golfing, etc.

The Sport Fishing Institute considers these "potential wetlands" to be indispensible to future fisheries management. Only a finite number of such sites exist, and many

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**Condensation of remarks by Carl R. Sullivan, Executive Secretary, Sport Fishing Institute, Washington, D.C., entitled "A Fisheries Management Perspective Toward The Wetlands Inventory," at the National Wetland Classification and Inventory Workshop, July 21-23, 1975, College Park, Maryland. Complete details will be available as part of The Workshop Proceedings when published by the U.S. Fish & Wildlife Service, which is conducting The National Wetlands Inventory and which sponsored the discussions.*

have been lost to other developments. This is particularly true in or near metropolitan areas where the need for recreational waters is greatest. As the National Wetlands Inventory proceeds, adequate attention must be given to identifying and cataloging these priceless resources.

LITERATURE CITED

(1) *Cameron, W. M. and D. W. Pritchard. 1963.* In: *The Sea—Ideas and observations on the progress in the study of the seas. Vol. 2, Chapt. 15, Estuaries: 306-322. Interscience Publishers, John Wiley and Sons, New York.*

(2) *U.S. Bureau of the Census. 1970. National Survey of Fishing and Hunting–1970 Res. Pub. No. 95:63. U.S. Fish and Wildlife Service, Washington, DC.*

(3) *Keith, William. 1975. Bull Shoals creel survey shows harvest is up. Arkansas Outdoors (News Release; Brad Kennedy, Ed.), 5D2:1-2. Arkansas Game & Fish Commission, Little Rock, Arkansas.*

(4) *McHugh, J. L. 1966. Management of estuarine fisheries.* In: *A Symposium on Estuarine Fisheries. Spec. Pub. No. 3: 133-154. American Fisheries Society, Washington, DC.*

THE ANTI-ANGLERS

We've heard much about the growing effort to stop hunting in recent years. At first, it was the outcry of a few isolated, presumably eccentric, sentimentalists. Soon, however, their relatively ineffectual protestations were greatly enhanced by the impact of the Walt Disney cartoons—giving rise to the well-known "Bambi Complex." The widely-shown American Sportman-TV series has belatedly responded, after inadvertently fanning the anti-hunting flames during its earlier shows, by featuring scientific game management instead of having celebrities chortle inanely over the "fun" of killing—as they once did. . . .

Now, here comes anti-fishing, according to an editorial in WESTERN OUTDOOR NEWS for June 20, 1975. According to that well-known publication, literature distributed by the National Humane Education Center, Waterford, Virginia, carries a message in strong opposition to fishing. WON reported that at least one elementary school system in Michigan is currently using the Center's information. The "information" is organized according to three age groups: The Kindness Club (ages 6-10), Defenders (11-14), and EcoloKIND (15-18). Study materials include such items as the rather interesting report that "a fish likes to jump and play just as we do when we feel happy," and a discussion of fishermen's cruelty to worms!

Don't laugh—You may be next on the list. Obviously, nothing is sacred so far as the Holier-than-Thou moralistic Do-Gooders are concerned . . . .

FISH FARMERS

As noted in a recent issue (May/June, 1975) of THE COMMERCIAL FISH FARMER & AQUACULTURE NEWS (Little Rock, Arkansas), the U.S. Soil Conservation Service has found more than 9,000 commercial fish farming operations throughout the U.S.A. They comprise over 167,000 surface acres and 15.7 million cubic feet of water and 1,200 linear feet of raceways, viz:

1,934 commercial catfish operations, with 46,441 acres and 1,200 linear feet of raceways in production.

663 commercial trout operations, with 1,913 acres in production plus about 15.7 million cubic feet of raceways.

790 commercial minnow producers utilizing 40,255 surface acres of ponds.

1,759 commercial operations producing largemouth bass, smallmouth bass, redear sunfish, bluegills, crappies, northern pike, common carp, Israeli carp, goldfish, green sunfish, longear sunfish, muskellunge, mullet, suckers, salmon, tropical fish, crawfish, tadpoles, and frogs in 39,993 acres of water.

There are 3,947 fee-fishing enterprises encompassing 42,690 acres of ponds, lakes, and reservoirs.

STATEMENT OF BASIC PRINCIPLES AND PROVISIONS

The following purposes and provisions are held by the undersigned recreational fishing and conservation organizations to be the *minimum* basic requirements of an effective marine fisheries management regime:

1) A clear and unequivocal commitment to long-term conservation goals including the restoration of depleted stocks and the maintenance of productivity of all fisheries.

2) A clear and unequivocal commitment to obtaining and maintaining the scientific data base essential to effective fisheries management and to expansion of biological research concerning the interdependencies between species, the impact of pollution, the vital importance of coastal estuaries in providing food or shelter at some stage in the life cycles of many fish species, and other factors bearing upon the abundance and availability of commercial and recreational fish species.

3) A clear and unequivocal commitment to the broad concept of optimum yield in management of the fisheries in place of the narrow concept of maximum sustained yield, i.e., to consideration of recreational, social, ecological and economic as well as biological factors in the determination of allowable catches within every fishery under management.

4) An opportunity for substantial participation by all parties interested in the fisheries including State administrators, commercial, recreational, conservational and other interests at every level of policy making and regulation making in the fisheries management procedure.

5) A clear and unequivocal commitment to equitable allocation of the allowable catch in each fishery under management with due regard to the interests of recreational fishermen in the fishery itself, or in other species related to, or affected by, the condition of such fishery.

Endorsing Organizations

African Leadership Foundation, American League of Anglers, American Littoral Society, American Fishing Tackle Manufacturers Association, The Emergency Committee to Save America's Resources, Federation of Fishermen, Friends of the Earth, The Georgia Conservancy, International Atlantic Salmon Foundation, International Association of Game, Fish and Conservation Commissioners, International Game Fish Association, National Audubon Society, National Coalition for Marine Conservation, National Wildlife Federation, The Nature Conservancy, Ocean Fish Protective Association, Port Aransas Rod & Reel Club, Save Our Stripers, Inc., Sierra Club, Sport Fishing Institute, United States Atlantic Tuna Tournament, Inc., Wildlife Management Institute, The Wildlife Society, and World Wildlife Fund.

COARSE FISH CONFERENCE

The 124-page PROCEEDINGS OF THE SEVENTH BRITISH COARSE FISH CONFERENCE, held at The University of Liverpool, England, March 25-27, 1975, are now available directly from Janssen Services, 14 The Quay, Billingsgate, London, EC3, England, for £ 5.50 (about $11.59) Seamail or £ 6.50 (about $13.69) Airmail. The Conference, sponsored by The University of Liverpool and The

National Federation of Anglers, was organized by Dr. Jack W. Jones, Department of Zoology, University of Liverpool, and Peter H. Tombleson, Secretary of The National Anglers' Council. Subjects covered during the Conference included: introduction of exotic fishes into the U.S., effect of water transfers on coarse fisheries, water quality and heavy metals, water abstractions, decline of the bleak in the Lower Nene, skin diseases of coarse fish, spawning behavior of barbel, principles and problems of feeding fish, recirculating systems for coarse fish rearing, eel and carp culture in power station cooling water, fish stocking and other sportfishery problems, electrophoretic analyses, laws controlling fish diseases, 1974 Control of Pollution Act, pike production in the River Frome, future fisheries organization, induced spawning in fish culture, and closing remarks. The fabric of the Conference can be instructive to U.S. fish managers in the context of future possible sport fishing in the event water quality control fails in America or future angling demand escalates beyond current projections.

MINNESOTA FISHING

The current FISHING EDITION of THE MINNESOTA VOLUNTEER (Vol. 38, No. 220, May-June, 1975), published by the Minnesota Department of Natural Resources (St. Paul, Minn. 55155), is well worth reading. It describes the socioeconomic impact of recreational fishing upon the state, the various types of lake and stream fish ecosystems, the popular sport fishes and sizes they attain. It also discusses the fish management work being undertaken by the department's fisheries biologists to maintain the essential environment and enhance the fish populations to satisfy present and future fishing demand. There is a discussion of the impact of technology on fishing fun, and a final section on preparing fish for eating—the final act of a fishing trip in many cases.

OFF THE PRESS

PRINCIPLES OF FISHERY SCIENCE, by W. Harry Everhart, Alfred W. Eipper, and William D. Youngs. This recently published fisheries science text is intended primarily for graduate and upper division undergraduate fisheries students. Professional fisheries workers will find the volume generally helpful for background reference. Although the authors have incorporated many of the most pertinent tenets of fisheries science in the text, the treatment and emphasis accorded various topics is frequently uneven. This circumstance results, no doubt, from the increasingly difficult task of providing comprehensive coverage of the many facets of this burgeoning science.

The Introduction defines and provides an excellent overview of the important role of research. Chapters devoted to Age and Growth, Fish Marking, Estimating Population Size, Mortality, Factors Limiting Abundance, and Recruitment and Yield are reasonably comprehensive. Other topics were treated less comprehensively than might be desired although partially compensated by the inclusion of an extensive list of supplementary references following each chapter. Particularly sketchy treatment was accorded chapters on Pollution and Small Pond Management.

Little or no consideration was given the subjects of hatchery management or fish pathology, although the operation of fish cultural facilities requires substantial and growing outlays from the limited budgets of most state fisheries agencies. Chapters on Regulations, and on Recruitment and Yield appear to be more attuned to "maximum sustained yield" than to "optimum yield" concepts appropriate for sport fisheries management. Scant attention was afforded the potential of minimum-size limits, trophy-fishing regulations, etc., for improving catch rates, if not higher total yield. Furthermore, occasional errors are evident from place to place, probably inevitable in any such undertaking.

The statement on page 22 that, "the number of anglers in this country is increasing *five times faster* than the population" (emphasis added), is a considerable exaggeration of all known statistical indicators. Based on U.S. Bureau of Census figures for 1960 and 1970, the population increased about 13.4 percent (from 179,323,175 to 203,325,298). The estimated number of substantial anglers increased about 30.9 percent over this same time (from 25,323,000 to 33,158,000). The latter is approximately 2.5 times greater than the increase registered for the population as a whole over the same period.

The discrepancy in the rates of increase of anglers and population may possibly have been even less in more recent years. The population of the United States increased about 3.14 percent from 1970 through 1973 (from 203,325,298 to an estimated 209,705,000) in 1973. Using as an index the number of "paid fishing license holders," published annually by the U.S. Fish and Wildlife Service, the number of anglers evidently increased, correspondingly, by some 5.16 percent (from 25,751,494 to 27,080,305). The latter is only 1.64 times greater than the increase registered by the population as a whole.

Another slip appears on page 222, viz: "In 1960 there were *35 thousand small ponds* in the United States with surface areas between 0.04 and 4.00 ha" (emphasis added). According to annual estimates compiled by the United States Soil Conservation Service, a cumulative total of 1,058,635 farm ponds had been developed in the United States by 1960. A total of 56,104 are recorded to have been constructed in the single year of 1960 with the assistance of the Soil Conservation Service, alone.

Apart from such scattered discrepancies, the volume constitutes a well-organized and authoritative survey of the methods and concepts basic to fisheries science. Appropriately illustrated and conveniently indexed, this 288-page volume is published by Comstock Publishing Associates, Ithaca, New York. Price $12.50 per copy, postpaid.

RESERVOIR RECREATION

A two-year study of recreation on 4,400-acre Thomas Hill Reservoir, Missouri, and on 6,000 acres of adjoining land, was completed recently by Missouri fisheries biologist Will Hanson. Most visitors (78 percent) to Thomas Hill come from a 75-mile radius. Sight-seeing led the number of trips made, with 25.3 percent. Boating accounted for 21.4 percent of trips made, angling 19.7, camping 15.6, and swimming 9.3. In hours spent, however, camping accounted for 42.3 percent of the total, boating 22.4, angling 20.6, and swimming 5.6. Most trips (67 percent) were made during the summer.

RHStroud

EXECUTIVE VICE PRESIDENT

Permission for publication of any material used in this Bulletin is granted to any interested parties. It is not necessary to credit the Sport Fishing Institute.

JOB PERFORMANCE REPORT

State of Idaho

Project No. F-59-R-6

Job No. I (Part 2)

Name: EVALUATION OF ANGLING REGULATIONS IN MANAGEMENT OF CUTTHROAT TROUT

Title: Distribution and Abundance of Cutthroat Trout in the Selway River (Research)

Period Covered: 1 March 1974 to 28 February 1975

ABSTRACT:

From 6-10 August 1974, fisheries personnel snorkeled a total of 35 transects in the Selway River from White Cap Creek to Race Creek and counted a total of 193 cutthroat trout for an average of 5.5 cutthroat per transect. In 1973, we counted 164 cutthroat in 37 transects for an average of 4.4 per transect. Though numbers of cutthroat increased in 1974, the percent of fish over 305 mm (12 in) decreased from 18.1% in 1973 to 10.4% in 1974. In the lower Selway from Race Creek to the mouth, where a road parallels the river, we saw 0.4 cutthroat per transect in 1974. We saw no cutthroat over 305 mm (12 in) long in this section.

Flows in the Selway were considerably higher and water temperatures cooler in the summer of 1974 than in 1973. This apparently resulted in a change in distribution of the cutthroat so that we saw 5.9 cutthroat per transect below Moose Creek in 1974 compared to only 3.6 in 1973. Numbers of cutthroat above Moose Creek remained relatively stable at 5.2 per transect in 1974 compared to 5.6 in 1973. The highest concentration of cutthroat was seen between Moose Creek and Halfway Creek where we saw 9.0 per transect. The greatest percentage of cutthroat over 305 mm (12 in) was from White Cap Creek to Running Creek where 16.7% of the fish seen exceeded 305 mm (12 in).

Author:

Ronald L. Lindland
Senior Fishery Research Biologist

JOB PERFORMANCE REPORT

State of Idaho

Project No. F-60-R-6

Job No. 1

Name: ST. JOE RIVER CUTTHROAT TROUT AND NORTHERN SQUAWFISH STUDIES

Title: Life History of St. Joe River Cutthroat Trout

Period Covered: 1 March 1974 to 28 February 1975

ABSTRACT:

In 1973 the Idaho Fish and Game Commission closed four tributaries of the lower St. Joe River (Reeds, Bond, Trout, and Mica creeks) to angling. To evaluate the effects of these closures on cutthroat trout populations in tributaries and the St. Joe River, we assessed the abundance, species composition and movements of trout in the closed tributaries, in tributaries open to angling and in tributaries of the upper river with "trophy fish" regulations.

After one year of closure, cutthroat trout abundance and size had increased in the closed tributaries. The largest increases in abundance occurred in sections of the closed streams accessible by road. We observed the largest densities of cutthroat in inaccessible sections of the closed streams and the abundance of fish increased only a small amount in those sections.

Brook trout exceeded cutthroat in abundance only in the meadow section of Mica Creek. Cutthroat densities more than doubled in the Mica meadow section from 1973 to 1974. Rainbow trout of hatchery origin had virtually disappeared from Big Creek in 1974 after the cessation of stocking, while cutthroat doubled in abundance in the lower sections of the creek.

We tagged and released 5,200 salmonids in the St. Joe River and tributaries in 1973 and 1974 and recovered 460 of the fish. Twenty-one cutthroat trout (4.6% of recoveries) migrated from nine different tributaries into the St. Joe River.

We conducted a creel census on Big Creek to determine angler effort and catch from a tributary and to assess angler opinions on tributary fishing. Anglers made an estimated 1016 angling trips and creeled 1346 cutthroat trout in Big Creek during the census period. Cutthroat trout comprised 86% of the catch. Catch rates in the unroaded zone were nearly six times larger than in the roaded zone of Big Creek. The majority of the anglers were Idaho residents, used flies or worms, and fished the roaded zone.

JOB COMPLETION REPORT

RESEARCH PROJECT SEGMENT

State of Idaho

Name: EVALUATION OF ANGLING REGULATIONS IN MANAGEMENT OF CUTTHROAT TROUT

Project No. F-59-R-6

Job No. 1

Title: Same as above.

Period Covered: March 1, 1974 to February 28, 1975
(also summarizes 6 years of pertinent data)

ABSTRACT:

We report here the effects of special angling regulations on native cutthroat trout populations in three Northern Idaho streams. The Kelly Creek drainage has been under a catch-and-release regulation since 1970. A trophy-fish regulation was initiated on the upper St. Joe River in 1971. The drainage of the North Fork of the Clearwater River above Kelly Forks has a standard catch-and-keep regulation and serves as a control stream.

Cutthroat trout abundance and mean size has increased in the streams with special regulations. We counted 5 times more cutthroat per snorkeling transect on Kelly Creek in 1974 compared to 1970. In the upper St. Joe River, there has been a 2- to 8-fold increase in cutthroat numbers since 1970. The numbers of cutthroat counted in the North Fork have remained virtually unchanged since 1970.

Cutthroat caught by project personnel from Kelly Creek in 1974 averaged 36 millimeters (1.4 inches) longer than fish caught in 1970. Cutthroat trout caught from the sections of the St. Joe River under the trophy-fish regulation averaged 33 millimeters (1.3 inches) longer in 1974 than in 1969-1970.

We observed large numbers of age I and II cutthroat trout in the St. Joe River transects for the first time in 1974. These fish are the offspring of cutthroat first saved by the trophy-fish regulation and/or the result of good spawning success in 1973. We observed trout fry and juvenile cutthroat in newly established transects in upper Kelly Creek in 1974, but did not find trout fry or juvenile cutthroat in the North Fork transects.

The catch of cutthroat per hour on the St. Joe River in 1974 was 6 times the rate of 1968. Three percent (3%) of the cutthroat we captured were "keepers" (longer than 13 inches) in 1974 while only 0.1% were "keepers" in 1969-1970. Project personnel caught 1 "keeper"/angler/day in 1974.

Cutthroat move down out of the three study areas in the fall and many return the next summer. Fish tagged in the summer remain close to the point of tagging all summer. Multiple recaptures of tagged cutthroat is common during the summer.

Squawfish were present in Kelly Creek and the North Fork for the first time in 1974.

Authors:

T. H. Johnson
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— Wallace — — paper — ?

— Bjorn — Yellowstone symposium pers. ?

	O	I	II	III	IV	V	VI
spring	0	50-100					
		80	150	225	250	300	- 350
fall	~~30~~ 60 50 mm.	75 - 150					
survival	0 - 1	1. - 2					
	20 - 50 %						
	~~25~~	25%	- 25%	- 33%	- ~~25~~		
1000	~~250~~	62	15	5	- 1	- 0	

	O	I	II			
May	0	80	125	175	7 - 3	- 10 fish harvested
Oct.	50	125	175	225		9 - 31
10,000 - 1000	250	~~6~~2	15	5	1	
					22	
		15	7			
biomass		2 lb.	1 lb			

— detailed age - growth not feasible on small scale — adequate information - base mgt. decision from spring - fall electrofishing and/or creel census

— Ball, K. 1971. Evaluation of catch-and-release regulations on cutthroat trout in the North Clearwater R. Id. F. & G. , F-59-R-2 : 38 p.

Hunt, Brynildson & McFadden 1962 - "mortality due to angling is an inverse density dependent factor, If angling intensity remains constant, rate of exploitation increases as trout density decreases". (Effects of angling regulations on a wild brook trout fishery. Tech. Bull. 26 Wis. Div. Conservation 58 p.

Anglers harvested 36% tagged cutthroat - prob. exceeded 50%.

Horak & Klein 67 - rainbow less than 5% mortality after 5 wks. fly caught

Mornell-Shap 70 - cutts - 5% . no dif - barbed, barbless or lures.

" Young age groups, males, non-resident, professionals, student, high income more favorable to catch-release.

Webster & Little 1944 - 601 rainbow trout caught & released of in 54 days of 180 trout stocked.

Wallis, 1971 - mgt. of aquatic res. & spt. fish. in Nat. P. by special reg. Proc. West. Div. AFS - 51st meet.

Platts, Wm. S. 1974. Geomorphic and aquatic conditions influencing salmonids and stream classification in the Salmon River drainage, Idaho, 1970-1972. Ph.D. thesis, Utah St. Univ., Logan Ut., 202 p.

p.11 - sculpin, chinook salmon, brook trout, whitefish prefer lower gradient channels while cutthroat trout inhabit channels of higher gradient (in SEAM pol. also?) - total fish density highest in grass-brush type (chinooks highest in grass - rainbow brush type) - Cutthroat trout highest density in channels w/ dominant tree cover.

gradient ~/ elevation - headwaters (coldest), highest gradient smallest channels & less depth.

Fish pop. density highest in channels w/ 30-50% pools (rather than commonly accepted 50% optimum) - deeper, wider stream at lower elevations w/ fewer pools have highest fish density.

Marcuson, P. 1971. Rock Creek floodplain study. Mont. F. & G. D-5 Rept. - F-20-R-14: 4p. ungrazed section had 149.7 lb. /acre = 1056 brown trout /acre more than grazed section.

- Gunderson. D.H. 1968. Floodplain use related to stream morphology and fish population. J. Wildl. Mgt. 32(3): 507-514.

Lorz, H.W. 1974. Ecology and management of brown trout in Little Deschutes River. Ore. Wildl. Comm., Fish. Res. Rep. 8: 49p.

Mgt. "tips"

Questions to what can be accomplished — why? How info used to attain goals. — Res. — Mgt. —

— Stress, limiting factors — not the limit of tolerance environ but when at competition disadvantage — Temp, O_2, turbidity, reproduction — w/ coexisting with active segregation — slight preference — tip balance —

— Forest Ser. Reg VI — Impact Guideline
× Grazing

— BLM — Dus Duff — Grazing study — Birch Crk.

— Habitat Mgt. Symposium —

Radford, D. S. 1975. The harvest of fish from Dutch Creek, a mountain stream open to angling on alternate years. . Alberta Dept. Recreation, Parks and Wildlife, Fish. Mgt. Rept. 15: 54p.

SW Alberta - mountain streams - Alberta's current recreational fish. mgt. program - trib. streams are open on alternate years. based on premise: 1. current biennial harvest of cutthroat trout (6 in +) is product of previous closed season. 2. high percentage of mature & harvested during season, 3. late opening (June 1) date restrict harvest to summer period of high demand. 4 - daily catch limit (10) is satisfactory.

Limit of 10 would have to be reduced to 4 to ~~restrict~~ reduce & redistribute harvest by 20%.

— May be necessary to prohibit motorized travel along road paralleling Dutch Crk. - to avoid further decline in angler success.

Emphasis on value of recreat. fish - fish in water not in creel -

Miller, R.B. 1952. The role of research in fish. mgt. in the prairie provinces. Can. Fish. Cult. 13: 13-19 - pointed out fallacy of many ~~str~~ regulations. -

Duncan - Little Jack cns
.977

Little Jack - Hatchery
.987

Bob -

Here is a copy of the article from Utter's lab on the redband trout. Interesting, but not unexpected, I think.

Regards

Dick

BIOCHEMICAL GENETIC CHARACTERISTICS OF NATIVE TROUT POPULATIONS OF OWYHEE COUNTY, IDAHO

Final Report

Bureau of Land Management
Boise District Office
Contract #ID-010-CT9-20

June 30, 1980

by

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ABSTRACT

This report is concerned with the ancestral status of collections of trout from Owyhee County in southwestern Idaho and includes fish from tributaries of the Owyhee River and from streams flowing directly into the Snake River. The purpose of the study was to determine the relationships of these populations to one another and to other native and introduced inland populations of rainbow trout-like salmonids including so-called "redband" trout. These relationships were delineated using detailed biochemical genetic analysis (starch gel electrophoresis) and numerical clustering techniques.

Frequencies of genetically determined protein variants were collected at 29 loci from eight native Idaho populations and one hatchery population--Eagle Fish Hatchery. These data were compared among populations and to data collected from other inland and coastal *Salmo* sp. populations. Suspected redband trout controls from the McCloud River, California, drainage were also analyzed for comparative purposes.

The study findings were as follows: 1) The preliminary data indicate that the Owyhee County populations do not show recent common origins with McCloud River redband trout, rather they are most similar to upper Columbia River and upper Fraser River rainbow trout. 2) The Eagle Hatchery population proved to be distinctly separate from all of the Owyhee County populations. The cluster analysis revealed relationships which followed geographic patterns--Owyhee drainages grouping together and the independent Snake River tributaries grouping together. These findings are inconsistant with any significant hatchery introgression, and, therefore, the genetic relationships identified probably represent historical population structures. (3) Significant genetic differences occurred between nearly every pair of sample collections indicating that a number of distinct native trout gene pools exist within Owyhee County.

The implications of these findings to management strategies in Owyhee County and to the general problem of defining "redband" trout are discussed.

TABLE OF CONTENTS

INTRODUCTION

Qualitative biochemical genetic analysis using the technique of electrophoresis has been increasingly applied to fisheries questions concerning stock identification, separation, and hybridization. These methods detect the existence of protein genetic variants (alleles) at particular genetic loci (positions on the chromosome). The frequencies of these alleles can be used to characterize populations or species and to quantify genetic differences among related groups. Groups of individuals which share a common gene pool will have similar allelic frequencies. However, if isolation between groups occurs, the isolates may develop significantly different frequencies. These frequency differences can be used as an effective tool to determine if noninterbreeding groups occur and to distinguish genetically distinct stocks and species.

The differences between biochemical and other more "classical" stock separation techniques--such as coloration, meristic counts, growth rates, and morphological measurements--are several. These "classical" parameters may reflect environmental influences to an unknown extent so that studies using controlled environments are necessary to establish the genetic basis of the trait. Furthermore "classical" traits may be influenced by more than one gene or the interaction of several genes with the result that different genotypes (the actual genetic make-up of an individual) may yield the same phenotype (physical expression of the genotype). On the other hand, properly chosen electrophoretic variants reflect single gene differences at a particular locus, and the inheritance of many of these variants has been established through simple breeding experiments (May, 1979; Utter, et al., 1973) so that environmental influences can be excluded.

This report is concerned with the ancestral relationships of collections of trout from Owyhee County in southwestern Idaho and includes fish from tributaries of the Owyhee River and from streams flowing directly into the Snake River. The purposes of these collections were to determine the relationships of these populations to one another and to other native and introduced populations of rainbow trout-like salmonids using biochemical genetic techniques. Specific topics of interest included estimating the extent of hybridization between native fish and hatchery rainbow trout and determing if native populations were "redband" trout. It is first necessary to establish what has been historically labelled a redband trout before proceeding into the data of this report.

The taxonomy of populations of rainbow trout (*Salmo gairdneri*) east of the Cascade Crest and related trout populations such as the California golden trout (*Salmo aquabonita*) and the redband trout is presently uncertain. A sizeable body of electrophoretic and other evidence is accumulating that suggests a divergence of this entire inland group from coastal ancestors during or preceding the last period of glaciation (Allendorf, 1975; Behnke, 1979). Inland (i. e. east of the Cascade Crest) rainbow trout populations of the Fraser and Columbia Rivers differ markedly from coastal populations of these rivers and adjacent drainages in allelic frequencies at a number of protein loci (Allendorf, 1975; Utter and Allendorf, 1977; Parkinson, 1980).

A different set of allelic frequencies separate trout populations centered in dessicated basins of southeastern Oregon from coastal populations of rainbow trout (Wilmot, 1974; Allendorf, 1975). These southeastern Oregon populations and similar populations radiating northward and southward to include native non-migratory populations of adjacent arid regions (including the Owyhee River) have recently become informally regarded as a distinct species--the redband trout (Wilmot, 1974; Bakke, 1977; Bacon et al., 1980). These populations are characterized by adaptations to severe environments including low stream flows and high temperatures, and many of them may be on the threshold of extinction through loss of habitat and pollution (Wilmot, 1974; Bakke, 1977).

Behnke (1979) has proposed an even broader concept of the redband trout. He has observed that all inland populations of rainbow trout-like salmonids are distinguishable from coastal groups of rainbow trout by morphological differences including smaller scales, fewer pyloric caeca, vestigial basibranchial teeth, yellow and orange coloration, traces of a cutthroat mark, and yellow or white tips on dorsal, anal, and pelvic fins. These differences of coastal and inland populations of rainbow trout-like salmonids have prompted him to suggest that all inland populations of such fishes ranging from the California golden trout northward to inland Fraser River populations of steelhead and non-migratory Kamploops trout be considered a separate species--the redband trout (*Salmo newberryi*).

This report compares allelic frequency data from Owyhee County populations with available data from other native inland and coastal populations of possibly related trout such as steelhead of the Snake

Ri er and the lower Columbia River. Comparisons are also made with data collected from a hatchery population of rainbow trout having allelic frequencies that are typical of hatchery populations that may have contributed to the gene pools of these populations. Ancestral relationships are considered relative to this hatchery population and to the broad and restricted concepts of redband trout. Complementary investigations are being carried out concurrently on these populations including studies on life history, meristics, habitat evaluation, and stream ecology. This report and reports from these other studies will be incorporated by Bureau of Land Management personnel into a comprehensive document intended to aid in the management of these populations.

MATERIALS AND METHODS

Electrophoetic Theory

The technique of electrophoresis relies heavily on the "central dogma" of molecular genetics. Briefly, genes are the fundamental units of genetic information and are packed into the chromosomes of each cell. Structurally genes are made up of long sequences of DNA nucleotides with each nucleotide coding for a particular amino acid. These amino acids are joined together in polypeptide chains to form enzymes (i.e. proteins). Thus each enzyme is a direct reflection of the DNA sequence. Changes in the DNA sequence may result in changes in the amino acid sequence of the protein. Many of these changes will affect the mobility of the protein molecule in an electric field by changing the charge or structure of the protein.

In starch gel electrophoresis tissue extracts are applied to a starch gel medium and connected to an electric current through a buffer solution. The proteins migrate varying distances through the starch at a rate determined by their charge and structure. Electrophoresis is so sensitive that it can detect proteins that diffe. by a single amino acid. Once the current is shut off the products of individual loci can be identified on the gel by staining for specific enzyme activity. The areas of activity show up as distinct bands on the gel. Typically a homozygote (an individual with only one type of allele at a locus) will show one single band, while a heterozygote (an individual with different alleles at a locus) will show two or more bands. Each individual is scored for the number of doses of each observed allele and, thus, the overall genotype of each individual is determined.

Electrophoresis

Samples were collected by personnel of the Bureau of Land Management, Boise District Office, who provided pertinent collection data (Table 1) and selected sampling locations (Figure 1). All fish were frozen on dry ice upon collection and remained frozen through shipment and storage up to six months. Each fish was thawed, and one eye, the heart, a piece of liver, and a small piece of skeletal muscle were extracted and placed in 12 X 72 mm culture tubes to which equal volumes of water were added. Fork lengths were taken, and each fish was assigned a permanent number and refrozen as soon as possible. The samples were shipped frozen to Dr. Richard Wallace, University of Idaho, Moscow, Idaho, for morphological and meristic analysis. The results of the morphological and meristic analyses and this analysis will be combined at a later date.

Various redband trout samples from McCloud River, California, were received from Dr. Graham Gall, Univ. of California, Davis, California, who is currently undertaking a biochemical genetic study of native trout from California, Oregon and Nevada. The samples sent were not collected at random, rather they were chosen to reflect representative variants from each population. Therefore, allele frequencies could not be calculated without a substantial bias; however, qualitative differences were documented which allowed comparisons of gross differences between the McCloud River redband trout and trout from Owyhee County. A thorough comparison of the California, Oregon, and Nevada trout with the Owyhee County trout can be made once Dr. Gall's work is complete and available.

Electrophoresis followed procedures outlined in May (1975) and May et al. (1979). Five buffer systems were used: (1) MF--tris-boric acid-

Table 1. Sampling locations, descriptions, population estimates, and sampling dates for the nine Idaho trout collections analyzed in this study. All data were provided by personnel of the Bureau of Land Management, Boise, Idaho.

Sampling Site	Location (Township, Range, Section)	Elevation	Sampling Date	Summer High Water Temp. (°F)	Summer Low Flows (cfs)	Population Estimates per surface acre ± 95% C.I.	Catch per unit effort (#trout/sec. electroshocker time)
Jordan Creek	4S 3W 31	6000	6-21-79	64	18	1741±808	.040
Little Jack's Creek	8S 3E 16	3600	6-19-79	64	3	7134±2056	.111
Current Creek	10S 3W 8	5400	6-20-79	54	2	not available	.007
Boulder Creek (South Fork)	8S 4W 11	6200	7-03-79	68	2	2675±597	.056
Cabin Creek	9S 5W 15	5400	7-02-79	68	2	not available	.029
Reynolds Creek	3S 4W 13,35 4S 4W 11	5000	6-04-79 6-05-79	75	2	755±170	.019
Castle Creek	6S 1W 26,34 7S 1W 3	4200	6-07-79 6-08-79	58	12	723±150	.023
Duncan Creek	10S 4W 18,19	4200	6-12-79	67	2	2433±376	.138
Eagle Hatchery, Idaho	--	--	8-01-79	--	--	--	--

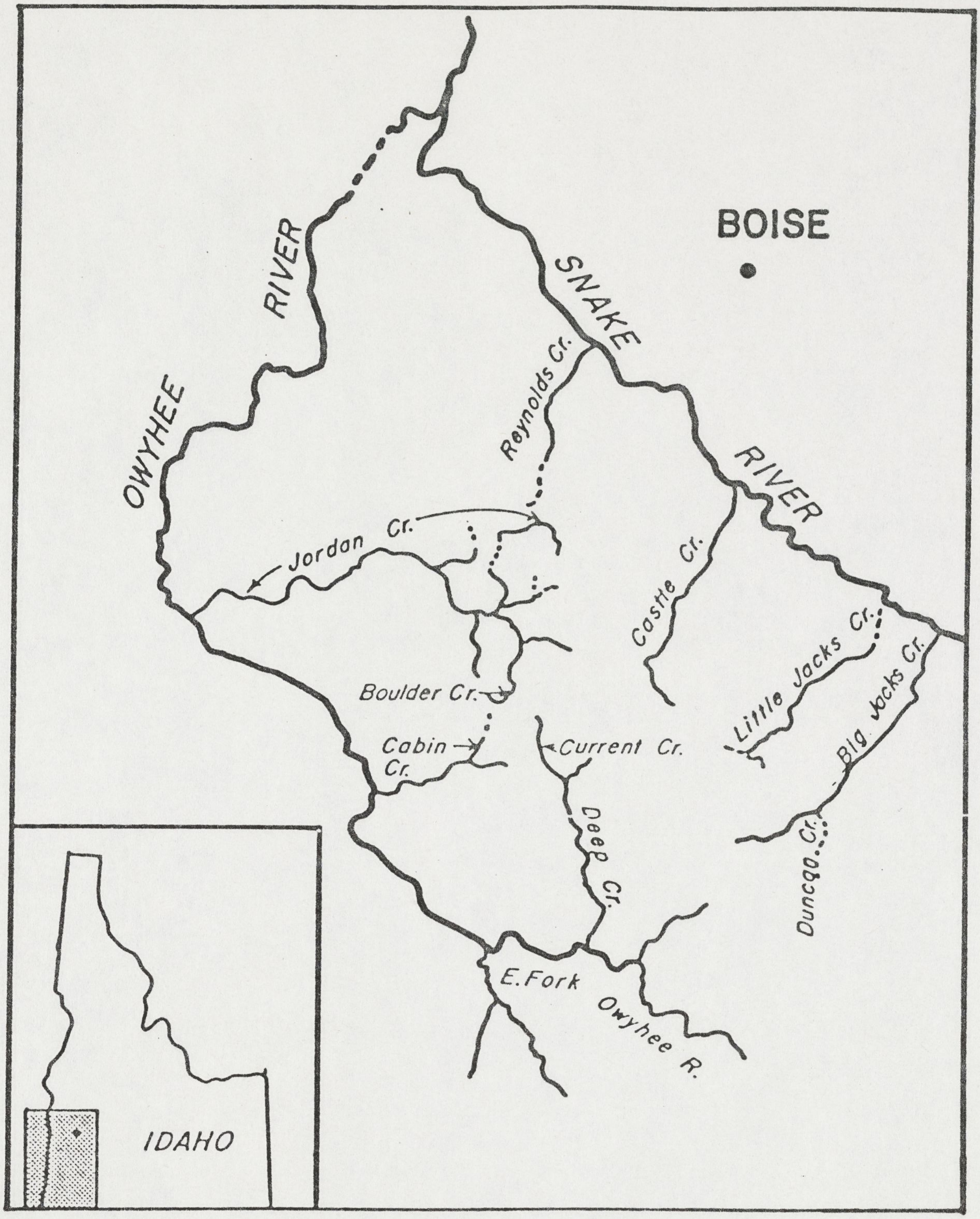

Figure 1. Map showing the sample collection sites of the eight native trout populations analyzed in this study. Dotted lines indicate subsurface flow.

EDTA gel and tray buffer (pH 8.5) (Markert and Faulhaber, 1965); (2) RW--a tris-citric acid gel buffer (pH 8.5), lithium hydroxide-boric acid tray buffer (pH 8.5) (Ridgway, et al., 1970); (3) RW + -- a modification of the previous gel buffer (pH 8.0), tray remains unchanged (pH 8.5); (4) AC--amine citrate gel and tray buffer (pH 6.5) (Clayton and Tretiak, 1972); and (5) SEL--citric acid-tris-lithium hydroxide-boric acid gel buffer (pH 8.1) (Selander, et al., 1971). Staining for enzyme activity followed methods outlined in Harris and Hopkinson (1976) and Allendorf et al. (1977). A list of the protein stains used, the numbers of loci expressed, and the optimal buffer and tissue are given in Table 2.

For each electrophoretically detectable locus the mobility (distance traveled) of the most common allele was used as a standard and designated (100). The mobility of all other alleles was calculated relative to this common form. For example, an allele that migrated half as far as the common allele was designated (50). In the case of multiple forms of the same functional enzyme, a hyphenated number was attached to the protein abbreviation to designate the locus (e.g., *LDH*-2 was the second LDH locus).

Statistical procedures

After electrophoresis each fish was scored for its observed genotype and allelic frequencies at each locus were calculated for every population. A 95% confidence interval ($\pm$ 2 standard errors) was calculated for each allelic frequency. Computing formulas for these and other statistical procedures used are given in Appendix 1. Three other statistical methods were used to evaluate the gene frequency data. The first method measured the amount of electrophoretic variation (heterozygosity); the second procedure measured similarities between each pair of population sample

Table 2. Designation of loci coding for the different enzymes. Enzyme abbreviations are also given. An X indicates that the particular locus could be reliably scored and was used in the analysis. References for the buffer systems are given in the text. The tissue abbreviations are as follows: L=liver, H=heart, M=muscle, and E=eye.

Enzyme	Abbreviation	Locus designation (if multiple)	Used in population genetic analysis	Buffer system	Best activity and resolution
Acid phosphatase	ACP			AC	L
Adenosine deaminase	ADA			MF	E, M
Albumin	ALB	1	X	SEL	E
		2	X	SEL	E
Aspartate aminotransferase	AAT	1		AC	H, M
		2		AC	H, M
		3		RW	E
Creatine kinase	CK	1	X	RW	M
		2	X	RW	M
Esterase	EST	1	X	RW+, AC	M, E
		2	X	RW+, AC	L
		3		RW+, AC	L
		4		RW+, AC	M, L
		5		RW+, AC	M, L
B-Galactosaminidase	BGAL		X	AC	L
B-Glucuronidase	BGLUC			RW	L
Glutamate pyruvate transaminase	GPT	1		MF	M
		2	X	MF	M
α-glycerophosphate dehydrogenase	AGP	1	X	AC	M, H
		2		AC	M, H
		3		AC	M, H

Table 2 continue

Enzyme	Abbreviation	Locus designation (if multiple)	Used in population genetic analysis	Buffer system	Best activity and resolution
Glyceraldehyde-3-phosphate	GAPDH				
		1		AC	M
		2		AC	H, M
		3		AC	H, M
		4		AC	E
Glycyl-leucine peptidase	GL				
		1	X	MF	E, M
		2	X	MF	E
Glyoxylase	GLO			RW	L
Isocitrate dehydrogenase	IDH				
		1		AC	M
		2		AC	M
		3		AC	L
		4		AC	L
Lactate dehydrogenase	LDH				
		1	X	RW	M
		2	X	RW	M
		3	X	RW	M
		4	X	RW	M, L, E
		5	X	RW	E
Leucylglycyl-glycine peptidase	LGG		X	MF	E, M
Malate dehydrogenase	MDH				
		1	X	AC	L
		2	X	AC	L
		3	X	AC	M
		4	X	AC	M

Table 2 continue.

Enzyme	Abbreviation	Locus designation (if multiple)	Used in population genetic analysis	Buffer System	Best activity and resolution
Malic enzyme	ME	1		AC	M, L
		2		AC	M
		3		AC	L
		4		AC	M
Phenylalanine-proline peptidase	PHAP			MF	E
Phosphoglucomutase	PGM		X	RW	M
6-phosphogluconate dehydrogenase	6PG		X	AC	M, L
Phosphoglucose isomerase	PGI	1	X	RW	M
		2	X	RW	M
		3	X	RW	M, L
Phosphomannose isomerase	PMI			AC	E, M
Sorbitol dehydrogenase	SDH	1	X	RW	L
		2	X	RW	L
Tetrazolium oxidase	TO		X	AC	L

collections over all loci; and the third analyzed the amount of heterogeneity of gene frequencies within and among regions.

In each individual two conditions are possible: either the alleles at a particular locus are identical (homozygous) or they are different (heterozygous). Average heterozygosity ($\overline{H}$), the average proportion of genome heterozygous per individual (Selander and Johnson, 1973), was estimated for each sample collection. This statistic estimates the total amount of genetic diversity within a population and can often be related to the effective population size, the time since the last bottleneck (periods of very low population numbers), and the amount of migration reaching the population. Populations with small numbers either presently or in the recent past and with low levels of migration will tend to have low heterozygosity values. Thus, this measure can provide insights into the population history and structure and the amount of genetic interchange between populations.

To quantify the relationships between populations a variety of identity or similarity measures have been proposed. Nei's (1972) gene identity (I) measure was used in this paper. This measure ranges from zero (no alleles in common at any locus) to one (the same alleles at identical frequencies at all loci). A matrix of (I) values between all pairs of populations was generated and used to construct a dendrogram using the unweighted average linkage method (UALM) (Sneath and Sokal, 1973).

A log likelihood ratio analysis was used to test for heterogeneity of gene frequencies within and among the trout collections in a method analogous to an anlaysis of variance (Smouse and Ward, 1978). This analysis subdivides in a hierarchial fashion the total gene frequency dispersion at each locus into within- and among-group components. This analysis was handled in a nested form--the Snake River and Owyhee River drainages were analyzed first, then all the Owyhee County populations combined, and finally the Owyhee County populations and Eagle hatchery combined. The Owyhee River was divided one step further since Little Boulder Creek is a tributary of Jordan Creek. Each Snake River tributary flows independently into the Snake River, so no analysis of the Snake River components was attempted.

The likelihood analysis used the computational formula of Sokal and Rolf (1969). This statistic is distributed approximately as the chi-square statistic with (no. of alleles-1) X (no. of regions-1) degrees of freedom (df). The likelihood values (G) can be summed over all loci to obtain a total value at each level of analysis. This in turn can be standardized (likelihood value/degrees of freedom or G/df) to compare the relative magnitude of the heterogeneity at each level of analysis. Since a number of simultaneous tests were made at each locus, the probability levels associated wtih the tests were adjusted by dividing the desired significance levels by the number of tests (Cooper, 1968).

RESULTS AND DISCUSSION

Protein Systems

A broad electrophoretic screening was initially conducted to maximize the number or resolvable loci. The Mendelian nature of much of the known electrophoretic variation has been established in rainbow trout or other salmonids through breeding studies (Utter, et al., 1973; May, et al., 1979). Simple inheritance in the absence of breeding data has been inferred for some loci under the following criteria (Allendorf and Utter, 1979): (1) a predictable pattern of electrophoretic variation for a given protein conforming to the known molecular structure of that protein; (2)consistent individual phenotypes from multiple tests of a tissue; and (3) parallel expression of the variant from different tissues of the same organism.

A summary of the proteins detected and their tissue distribution is given in Table 2. Fifteen loci were found to be polymorphic (occurrence of more than one allele in any individual) in at least one population. In the case of duplicated loci (*MDH-1,2; MDH-3,4; ALB-1,2*) it was impossible to arbitrarily assign a particular variant to a particular locus, so it was assumed that the variants occurred at an equal frequency at both loci. Frequencies of the polymorphic loci are given in Table 3. An additional 14 loci were consistently scored as monomorphic (*CK-1,2; EST-1; GPT-2; LDH-1-3; 6PG; PGI-1,3; LDH-5; SDH-1,2*). No individuals in this study had *CK-1,2* phenotypes typical of both coastal and inland cutthroat trout subspecies (Utter, et al., 1979). Possible cutthroat trout

Table 3. Sample size, collection date, and allele frequencies for each locus analyzed in this study of Idaho trout.

Location	Date	N	AGP-1	ALB-1,2	GL-1	LGG	IDH-3,4				PGM
			100	100	100	100	100	38	67	171	100
HATCHERY RAINBOW, IDAHO											
Eagle Fish Hatchery	8-79	50	.893	.517	1.000	1.000	.786	.120	.042	.052	.723
OWYHEE DRAINAGE											
Jordan Creek	6-79	52	.981	.625	1.000	.981	.695	.060	.230	.015	.962
Little Boulder	7-79	52	.990	.628	1.000	1.000	.853	.064	.074	.010	.962
Cabin Creek	7-79	52	1.000	.841	1.000	1.000	---	---	---	---	1.000
Current Creek	6-79	25	1.000	.542	1.000	1.000	---	---	---	---	1.000
SNAKE RIVER DRAINAGE											
Little Jacks	6-79	68	1.000	.469	1.000	1.000	.774	.024	.183	.020	.925
Castle Creek	6-79	35	1.000	.486	1.000	1.000	.669	.125	.206	.000	1.000
Duncan Creek	6-79	44	1.000	.430	.989	1.000	.716	.057	.227	.000	1.000
Reynolds Creek	6-79	39	1.000	.645	.974	1.000	---	---	---	---	.974

Location	Date	N	LDH-4	ME-1	MDH-3,4				TO			ME-2
			100	100	100	81	120	76	100	152	48	100
HATCHERY RAINBOW, IDAHO												
Eagle Fish Hatchery	8-79	50	.990	.969	.896	.073	.010	.021	.667	.333	.000	1.000
OWYHEE DRAINAGE												
Jordan Creek	6-79	52	.356	1.000	.981	.019	.000	.000	.962	.038	.000	.846
Little Boulder	7-79	52	.289	.990	.976	.019	.005	.000	.961	.029	.010	1.000
Cabin Creek	7-79	52	.327	1.000	.976	.000	.024	.000	1.000	.000	.000	1.000
Current Creek	6-79	25	.360	1.000	1.000	.000	.000	.000	.920	.040	.040	1.000
SNAKE RIVER DRAINAGE												
Little Jacks	6-79	68	.709	.933	.962	.026	.004	.008	.962	.038	.000	1.000
Castle Creek	6-79	35	.486	1.000	.964	.029	.007	.000	.971	.014	.014	1.000
Duncan Creek	6-79	44	.080	1.000	.994	.000	.006	.000	1.000	.000	.000	1.000
Reynolds Creek	6-79	39	.615	1.000	.987	.006	.000	.006	.974	.000	.026	1.000

Table 3. Continue.

Location	Date	N	MDH-1,2	EST-2				ME-3	GL-2	B-GAL
			100	100	92	88	102	100	100	100
HATCHERY RAINBOW, IDAHO										
Eagle Fish Hatchery	8-79	50	1.000	.813	.187	.000	.000	1.000	.980	.728
OWYHEE DRAINAGE										
Jordan Creek	6-79	52	.995	.382	.618	.000	.000	1.000	1.000	.870
Little Boulder	7-79	52	1.000	.336	.654	.010	.000	1.000	1.000	.904
Cabin Creek	7-79	52	1.000	.471	.529	.000	.000	1.000	1.000	1.000
Current Creek	6-79	25	1.000	.500	.500	.000	.000	1.000	1.000	1.000
SNAKE RIVER DRAINAGE										
Little Jacks	6-79	68	1.000	.575	.425	.000	.000	1.000	1.000	.877
Castle Creek	6-79	35	1.000	.500	.471	.000	.029	1.000	1.000	.829
Duncan Creek	6-79	44	1.000	.415	.585	.000	.000	1.000	1.000	.511
Reynolds Creek	6-79	39	1.000	.447	.553	.000	.000	1.000	1.000	.974

ancestry or introgression in these populations was therefore excluded.

A number of presumptive genetic loci were either not adequately resolved or the genetic basis was not fully understood, and so were not included in the analysis. Those that had inadequate resolution but appeared monomorphic were *ACP, AAT-3, EST-3, BLUC, GPT-1, GAP-1-4, GLO, IDH-1,2, ME-4, PMI*. Those with inadequate resolution that appeared to be polymorphic were *AAT-1,2, ADA, PHAP, EST-4*, and *EST-5*. At the liver *IDH-3,4* loci the various genotypes could not be reliably differentiated. Approximate frequencies for *IDH-3,4* are listed in Table 3 although these data are not included in the analysis.

ME from the muscle and liver was also excluded from the analysis because the expression was not consistently parallel between liver and muscle tissue. Three populations (Eagle Hatchery, Little Boulder, and Little Jack's) showed consistent parallel expression in liver and muscle. However, Jordan Creek showed a variant that was expressed in muscle only. McCloud River presumptive redband samples showed variants expressed solely in the liver as well as variants expressed in both liver and muscle. As a first approximation, three loci were assigned to ME. *ME-1* is expressed in liver and muscle, *ME-2* is expressed in muscle only, and *ME-3* is expressed in liver only. Other explanations including possible gene regulatory differences, are equally feasible. Since the genetic basis was not fully understood, all ME loci were excluded from the analysis, but the frequencies are given in Table 3. Breeding studies are necessary to clarify the inheritance of these variants.

Distribution of Protein Variants

Patterns of genotypic and allelic frequencies of polymorphic protein systems (Table 3) differed considerably among the different proteins examined in the Owyhee and Eagle hatchery populations. Some systems (e.g. *LGG*) were fixed for the common allele in most populations with infrequent variants occurring only in a single population. Allelic frequencies varied widely for other protein system (e.g. *PGM*). Phenotypic frequencies of highly polymorphic loci conformed to Hardy Weinberg expectations in some instances (e. g. *PGM*) but not in others (e.g. *ALB-1, 2*). Much of the latter occurrence undoubtedly reflects polymorphism at both loci of a duplicated system; Hardy Weinberg estimates are invalid in such instances because it is impossible to determine true allelic frequencies at individual loci (see Allendorf, et al., 1975). Loci where data were lacking for one or more populations (e.g. *PHAP*) were excluded from the analysis involving all populations.

The allele frequencies at each locus for each population were compared to those of every other population for significant differences (Table 4). The hatchery population differed significantly in allele frequencies from all other populations at a minimum of three loci. Within the Snake River tributaries all populations differed significantly from every other population for at least one locus. Within the Owyhee River tributaries, however, there were no significant differences in allele frequencies between Jordan Creek and Little Boulder Creek. All other populations of Owyhee River tributaries differed significantly for at least one locus. Little Boulder is a tributary to Jordan Creek, so it is likely that there

Table 4. Matrix giving loci at which significant gene frequency differnces exist at or below the .05 level.

	Duncan	Reynolds	L. Jacks	Castle	Jordan	Boulder	Cabin	Current
1-Duncan Creek	*							
2-Reynolds Creek	LDH-4 BGAL	*						
3-Little Jacks	PGM LDH-4 BGAL	ALB	*					
4-Castle Creek	LDH-4 BGAL	BGAL	LDH-4 PGM	*				
5-Jordan Creek	BGAL LDH-4	LDH-4	LDH-4	none	*			
6-Boulder Creek	BGAL LDH-4	LDH-4	LDH-4	none	none	*		
7-Cabin Creek	BGAL LDH-4 ALB	LDH-4 ALB	BGAL LDH-4 ALB PGM	BGAL ALB	BGAL ALB	BGAL ALB	*	
8-Current Creek	BGAL LDH-4	LDH-4	PGM BGAL	BGAL	BGAL	TO BGAL	ALB	*
9-Idaho Hatchery	MDH-3,4 LDH-4 BGAL TO EST	LDH-4 BGAL TO EST	LDH-4 TO EST	LDH-4 TO EST	LDH-4 TO EST	LDH-4 BGAL TO EST	LDH-4 TO MDH-3,4 ALB BGAL EST	LDH-4 TO BGAL EST

is sufficient interchange between the two streams to maintain essentially identical gene frequencies.

The likelihood analyses (Table 5) reveal pertinent features about the distribution of genetic variation within and among the Owyhee County populations and between these populations and the hatchery rainbow trout. It is initially useful to examine an overall summary of these data through a comparison of standardized measures (i.e. likelihood value (G) summed over all loci/degrees of freedom (df)). This comparison reveals (1) that most of the measured heterogeneity (genetic variation among all populations examined) results from inclusion of the hatchery rainbow trout in the analysis (G/df = 24.44), (2) that the Snake River populations (G/df = 4.52) are considerably more heterogeneous than the Owyhee River populations (G/df = 1.93), however (3) the total magnitude of differences among all eight Owyhee County populations (G/df = 5.68) was similar to the magnitude of differences within the drainages (G/df = 3.23). It is apparent from examining the likelihood values at individual loci that some loci contribute more than others to these major features. Many of the polymorphic loci contribute significantly to the hatchery rainbow trout-Owyhee County trout heterogeneity including *AGP-1, LDH-4, MDH-3,4, PGM, TO,* and *EST-2* ($p < .001$ at each locus). Loci playing a major role in the internal heterogeneity of the Snake River group and the Owyhee River group included *LDH-4, PGM,* and *BGAL* for the Sanake River populations and *ALB-1,2, PGM,* and *BGAL* for the Owyhee River populations ($p < .001$ at each locus). A priori pairings were possible within the Owyhee River populations between Jordan Creek and Little Boulder Creek. No significant likelihood values exist at any locus between these two populations.

Table 5. Log likelihood analysis from nine populations of Idaho trout. A (*) indicates the value is significant at ($p < .01$); a (**) indicates the value is significant at ($p < .001$).

Source of Variation	LOCI df	AGP-1	df	ALB-1,2	df	GL-1	df	LGG	df	LDH-4	df	MDH-3,4	df	PGM
Among Owyhee Co. & Hat.	1	31.05**	1	1.80	1	.25	1	.50	1	145.41**	3	16.37**	1	60.76**
Owyhee County	7	7.93	7	51.67**	7	4.24	7	7.84	7	124.40**	21	21.21	7	25.89**
Among Owyhee County	1	4.24	1	23.15**	1	1.37	1	2.82	1	21.56**	3	1.43	1	.74
Within Owyhee County	6	3.69	6	28.52**	6	2.87	6	5.02	6	102.84**	18	19.78	6	25.15**
Snake River	3	.00	3	8.69	3	2.87	3	.00	3	101.50**	9	10.29	3	16.15*
Owyhee River	3	3.69	3	19.83**	3	.00	3	5.02	3	1.34	9	9.49	3	9.00
Among Owyhee River	2	3.35	2	19.83	2	.00	2	2.23	2	.26	6	9.49	2	9.00*
Jordan & Boulder	1	.34	1	.00	1	.00	1	2.79	1	1.08	3	.00	1	.00
Total	8	38.98**	8	53.47**	8	4.49	8	8.34	8	269.81**	24	37.58	8	86.65**

Source of Variation	LOCI df	TO	df	GL-2	df	BGAL	df	MDH-1,2	df	EST-2	df	Sum Over All Loci	Standardized
Among Owyhee Co. & Hat.	2	93.16**	1	8.58*	1	10.76*	1	.13	3	46.69**	17	415.46**	24.44
Owyhee County	14	27.77	7	.00	7	121.80**	7	1.96	21	30.85	119	425.56**	3.58
Among Owyhee County	2	.65	1	.00	1	30.09**	1	.71	3	9.74	17	96.50**	5.68
Within Owyhee County	12	27.12*	6	.00	6	91.71**	6	1.25	18	21.11	102	329.06**	3.23
Snake River	6	14.00	3	.00	3	64.07**	3	.00	9	12.92	51	230.49**	4.52
Owyhee River	6	13.12	3	.00	3	27.64**	3	1.25	9	8.19	51	98.57**	1.93
Among Owyhee River	4	11.59	2	.00	2	27.06**	2	.56	6	6.42	34	89.79**	2.64
Jordan & Boulder	2	1.53	1	.00	1	.58	1	.69	3	1.77	17	8.78	.52
Total	16	120.93**	8	8.58	8	132.56**	8	2.09	24	77.54**	136	841.02**	6.18

Average heterozygosity is the standard parameter used to compare amounts of electrophoretically detectable variation. Low heterozygosities would be expected in cases of isolated populations with low numbers and possible genetic drift and inbreeding effects. Initial investigations indicate low population numbers for only Current Creek (Table 1 and Debby Stefan, Bureau of Land Management, Boise, Idaho, personal communication). The heterozygosity values in the eight Owyhee County populations ranged from .048 in Cabin Creek to .074 in Castle Creek (Table 6). These values fall close to the average (.060) recorded for 41 populations of *Salmo gairdneri* (Allendorf and Utter, 1979). No unusually low heterozygosity values were recorded; the effective population sizes as measured by heterozygosity, do not appear to be significantly different from other *S. gairdneri* populations.

A third measurement of variation uses a matrix (Table 7) of identity values (I) between all populations at 26 loci to construct a dendrogram (Figure 2) that visually depicts genetic relationships among these populations on the basis of these loci. The tight grouping of the Owyhee River populations in one cluster contrasts with a union of the Snake River populations at a lower level of identity; the Duncan Creek population is particularly divergent in the latter group. The hatchery population is distinctly separate from all of the Owyhee County populations. A second identity matrix was calculated using data from other studies (Allendorf, 1975; Dr. J. McIntyre, U. S. Fish and Wildlife Service, Seattle, WA, personal communication) and common data of this study. Only data from 5 loci common to all studies (*LDH-4, MDH-3,4, AGP-1, PGM, TO)* were used (Table 8), so the matrix (Table 9) and resulting dendrogram

Table 6. Sample size (N) and average heterozygosity ($\bar{H}$) for each population of Idaho trout analyzed in this study.

Population	N	Average Heterozygosity
Idaho Hatchery	50	.096
Jordan Creek	52	.073
Little Boulder Creek	52	.066
Reynolds Creek	39	.064
Cabin Creek	52	.048
Current Creek	25	.062
Little Jacks Creek	67	.073
Castle Creek	35	.074
Duncan Creek	44	.064

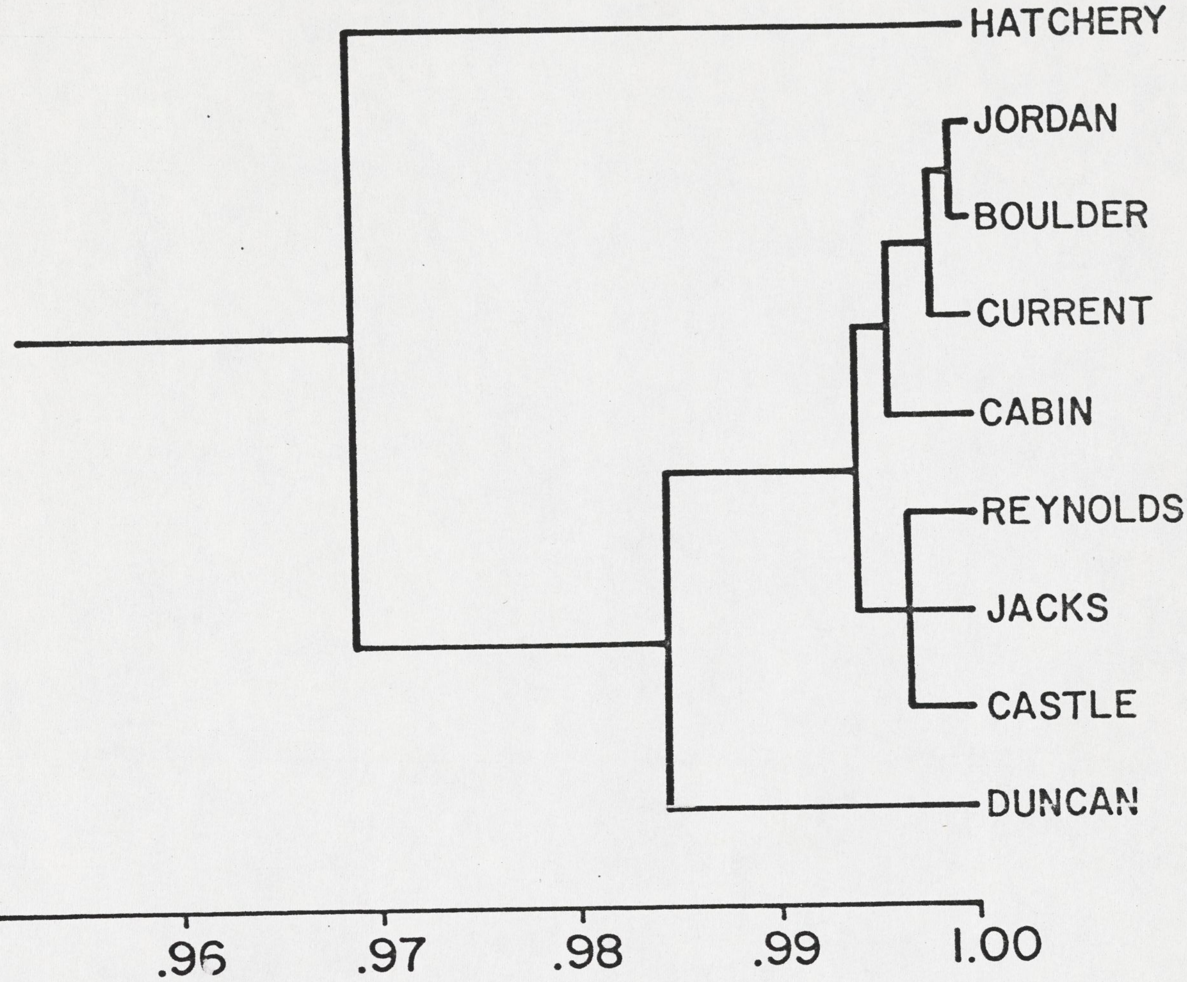

Figure 2. Dendrogram (UALM) based on Nei's (1972) coefficient of genetic identity showing the relationships of populations analyzed in this study. Twenty-six loci were used.

Table 7. Matrix of Nei's (1972) genetic identify values between the nine populations analyzed in this study.

1-Idaho Hatchery	1.000								
2-Jordan Creek	.968	1.000							
3-Little Boulder Ck.	.962	.999	1.000						
4-Reynolds Creek	.978	.997	.995	1.000					
5-Cabin Creek	.961	.997	.997	.995	1.000				
6-Current Creek	.969	.998	.998	.997	.996	1.000			
7-Little Jacks Creek	.987	.992	.989	.997	.987	.994	1.000		
8-Castle Creek	.977	.998	.996	.997	.993	.998	.997	1.000	
9-Duncan Creek	.948	.990	.990	.977	.981	.986	.977	.988	1.000
	1	2	3	4	5	6	7	8	9

Table 8. Data on five loci used to compare inland steelhead, and Coastal steelhead from Allendorf (1976) to populations in this study. Only the common allele frequencies are given. Data from Chino Creek, Nevada, (McIntyre, pers. comm.) are also given.

Location	LDH-4 100	MDH-3 100	TO 100	AGP-1 100	PGM 100
Inland Steelhead	.433	.985	.930	.990	1.000
Coastal Steelhead	.874	.886	.663	.982	.997
Idaho Hatchery	.990	.896	.667	.893	.723
Jordan Creek	.356	.981	.962	.981	.962
Little Boulder Ck.	.289	.976	.961	.990	.962
Cabin Creek	.327	.976	1.000	1.000	1.000
Current Creek	.360	1.000	.920	1.000	1.000
Little Jacks Ck.	.709	.962	.962	1.000	.925
Castle Creek	.486	.964	.971	1.000	1.000
Duncan Creek	.080	.994	1.000	1.000	1.000
Reynolds Creek	.615	.987	.974	1.000	.974
Chino Creek	.587	1.000	1.000	1.000	1.000

Table 9. Matrix of Nei's (1972) genetic identity values between inland steelhead, coastal steelhead, the populations analyzed in this study, and Chino Creek.

1-Idaho Hatchery	1.000											
2-Jordan Creek	.863	1.000										
3-Little Boulder Ck.	.842	.999	1.000									
4-Reynolds Creek	.923	.984	.975	1.000								
5-Cabin Creek	.848	.999	.999	.981	1.000							
6-Current Creek	.863	.999	.998	.984	.999	1.000						
7-Little Jacks Ck.	.947	.970	.959	.997	.965	.970	1.000					
8-Castle Creek	.894	.996	.991	.996	.994	.996	.987	1.000				
9-Duncan Creek	.765	.984	.991	.939	.988	.984	.913	.965	1.000			
10-Inland Steelhead	.886	.998	.994	.991	.996	.998	.981	.999	.973	1.000		
11-Coastal Steelhead	.976	.913	.895	.957	.902	.917	.970	.940	.833	.935	1.000	
12-Chino Ck., Nevada	.915	.987	.979	.999	.985	.987	.995	.997	.946	.994	.953	1.000
	1	2	3	4	5	6	7	8	9	10	11	12

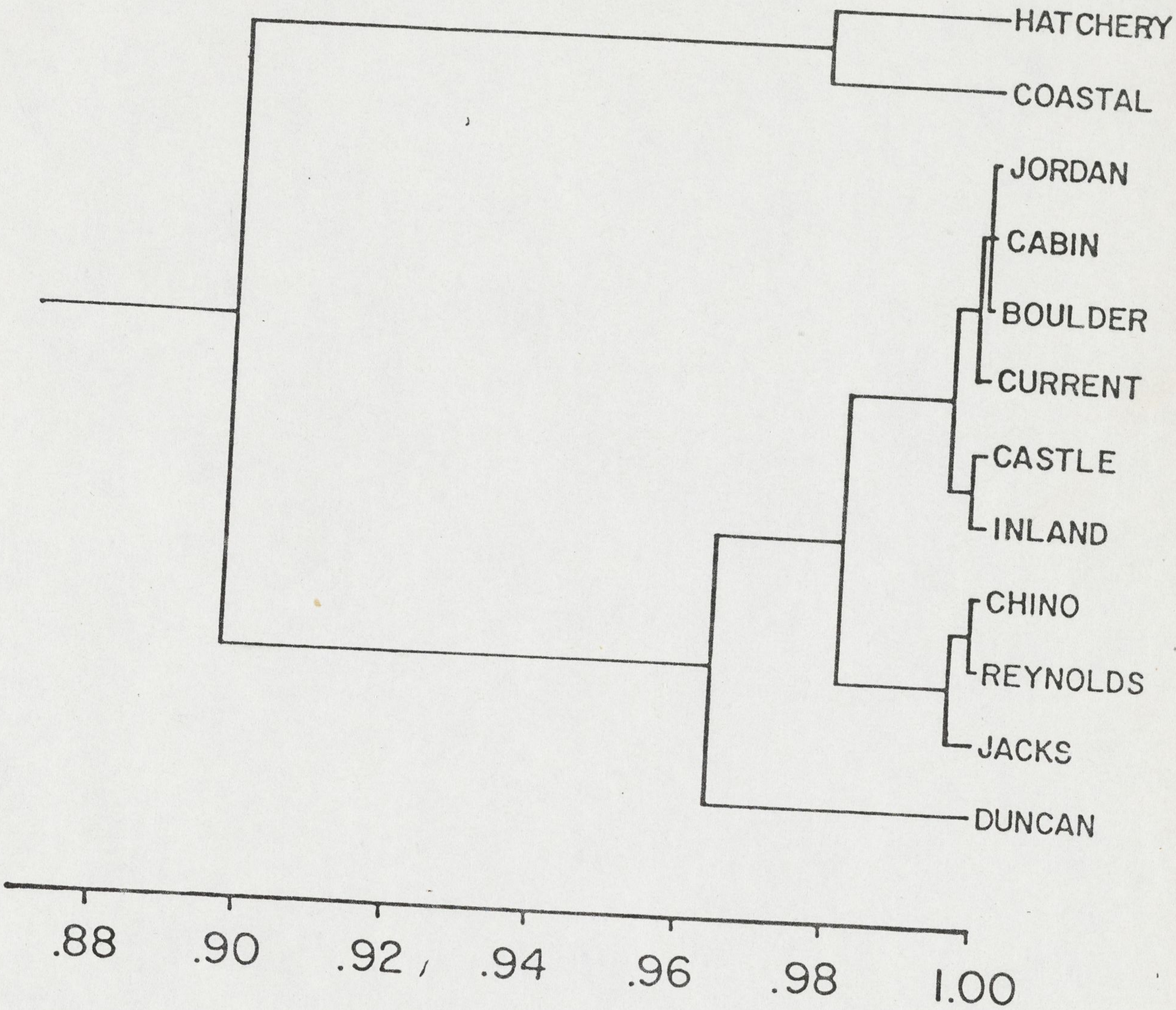

Figure 3. Dendrogram (UALM) based on Nei's (1972) coefficient of genetic identity showing the relationship of populations analyzed in this study to coastal and inland steelhead (Allendorf, 1975) and to Chino Creek (J.McIntyre, pers. comm.). Data from five loci were used.

(Figure 3) are not directly comparable to the previously calculated ones. These additional data permitted comparison of inland and coastal steelhead with the populations of this study and with Chino Creek, a tributary of the Owyhee River in Nevada. It is apparent that the Owyhee County, inland steelhead, and Chino Creek populations form a cluster distinct from the hatchery rainbow trout and the coastal steelhead populations.

Relationships of Owyhee Co. and Eagle hatchery populations

The likelihood analysis and Nei's identity values identify a clear separation of the hatchery population from any of the Owyhee County populations. Although the Eagle Hatchery stock was not the sole or even the major contributor to plantings of the Owyhee County streams, its allelic frequencies are typical of most domesticated rainbow trout populations originating in the late 19th century from the McCloud River, California (MacCrimmon, 1971; Allendorf and Utter, 1979) and are therefore regarded as representative of all rainbow trout planted in these streams. (These McCloud River hatchery fish should not be confused with McCloud River "redband" trout). These findings are inconsistent with a significant amount of hatchery introgression into the native Owyhee County populations. The clustering clearly follow geographic patterns. Each of the streams that received plants (Little Boulder, Castle, and Jordan; see Appendix 2) fell within its appropriate geographic cluster rather than indicating any influence of hatchery plantings regardless of intensity or frequency of plantings. It is therefore concluded that these patterns of genetic variation among the Owyhee County trout populations sampled in this study are reflections of natural relationships and have negligible, if any introgression from hatchery rainbow trout. Behnke (1979) has obtained meristic counts and observed parr marks and spotting patterns from native trout of this area; he also found no evidence of influence from non-native trout despite a long history of rainbow trout stocking in these areas.

These data shed some light on the relationships of these trout populations to each other. The clustering of the Owyhee River populations clearly suggest a single divergence from ancestral populations of this region. The near identity of the Jordan and Little Boulder Creek populations would be expected from their close geographic proximity and suggests either very recent divergence or more probably some gene flow between these populations. The heterogeneity observed between Current and Cabin Creek populations may reflect a fair amount of genetic drift due to greater divergence time coupled with small population size (based on estimates of stream flow and population sizes; Table 1). Additionally, Current and Cabin Creeks are separated by a geographical distance of about 100 stream miles. The three Snake River tributary populations proximal to the confluence of the Owyhee River form a cluster suggesting a similar divergence time from the ancestral populations of the Owyhee River drainage. The considerably greater divergence of Duncan Creek suggests either a somewhat different ancestral seeding from the other Owyhee County popualtions or one or more population bottlenecks (periods of low population numbers) that accelerated divergence of allelic frequencies.

However, the clustering by drainages should not obscure the fact that there are significant differences evident between nearly every pair of populations. As an example, Castle and Little Jack's both belong to the Snake River cluster, but they differ significantly at two loci (Table 4). With the exception of Little Boulder and Jordan Creeks the populations seem to be maintaining discrete gene pools. Additionally, these gene pools show no indication of introgression from exotic hatchery plantings. The streams themselves should be treated as the units of management and any cultural or transplant projects should be evaluated in the light of these findings. Transplants between these streams (with the possible exception of Jordan and Boulder) or stocking with hatchery fish should be recognized as introdutions of exotic and potentially maladaptive gene pools. Furthermore, since these streams themselves are the effective population units, habitat degradation or loss of stream habitat could result in the loss of native and uniquely adapted gene pools.

Relationship of Owyhee Co. populations to other inland trout

It is next pertinent to consider the relationships of the Owyhee County populations to other inland trout populations. The allelic frequencies of the Owhyee County population in general typify all other rainbow trout-like populations of the upper Columbia River and Fraser River basins examined to date (Utter and Allendorf, 1977; Milner and Teel, 1979; Parkinson, 1980), as reflected in the relationships of Figure 3. Major features of these populations include distinctive *LDH-4* and *TO* allelic frequencies. This same pattern of variation has also been observed from a sample of 40 individuals from Chino Creek, Nevada, a stream of the Owyhee River drainage (this population will therefore be included in subsequent discussions of Owyhee River populations in this report). These inland populations of the Columbia and Fraser Rivers (including the Owyhee County populations) collectively have widely differing life history patterns and occupy highly diverse habitats, but all fall into Behnke's broad concept of redband trout. Behnke (1979) has suggested *Salmo newberryi kamloops* as a possible designation for this northern group.

It is necessary to examine this concept from the perspective of the present data before proceeding further. Two factors argue against the validity of *Salmo newberryi* as a distinct specific entity from *S. gairdneri*. The levels of genetic similarity based on 26 loci in this study between hatchery rainbow trout (*S. gairdneri)* and populations included under *S. newberryi* (I = .95 or greater) lie well within the limits of conspecific populations of diverse organisms (White, 1978; Avise, 1976). Similar comparative values between coastal and inland rainbow trout-like salmonid populations have been reported elsewhere (Allendorf and Utter, 1979).[1/] In addition, all inland rainbow trout-like populations of the Columbia and Fraser Rivers form a genetic unit that is distinct from all other coastal or inland populations. These factors favor the retention of *S. gairdneri* for all coastal and inland rainbow trout-like populations--particularly where I values exceed .90--but do not exclude subspecific recognition.

1/ An (I) value of 1 means that no detectable differences in allelic frequencies were observed between two groups whereas a value of 0 means that no common alleles were identified between the groups. Valid comparisons among organisms are usually based on a reasonably large number of loci (e.g. greater than 20). Thus the (I) values of Figure 2, based on 26 polymorphic and monomorphic loci, are valid for objective comparisons with other investigations involving any organism while those of Figure 3--based only on five polymorphic loci--should be restricted to use as a relative scale for estimating relationships among the populations included.

Comparative allelic frequency data from populations included in the more restrictive concept of redband trout of the dessicating basins of California, Oregon, Idaho and Nevada are not extensive. Wilmot (1974) examined approximately 120 individuals from two streams flowing in dessicated basins in southcentral Oregon and found only the common allele for *LDH-4*. Allendorf (unpublished) observed no *LDH-4* variation in approximately 20 individuals collected in the same region. Samples from McCloud River redband trout likewise showed no *LDH-4* variation. They also showed a high frequency for an *MDH-3,4* (95) allele absent in the Owyhee County collections and indicated differences at the *LGG*, *EST-2*, and *IDH-3,4* loci. High frequencies of *LDH-4* variation such as observed in the Owyhee County populations are common to inland trout of the Columbia River and Fraser River basins (Allendorf and Utter, 1979; Milner and Teel, 1979).

Based on biochemical genetic criteria the Owyhee County populations of trout are most similar to upper Columbia River and upper Fraser River basin native rainbow trout. The high frequency of *LDH-4* variation in Owyhee County excludes a recent common ancestry for these and redband trout from either southcentral Oregon or the McCloud River. Consequently, the Owyhee County populations should not be considered redband trout if the term "redband" reflects taxonomic or evolutionary significance and McCloud River redband populations are to be used as the standard for comparison.

However, the redband trout populations examined by Wilmot (1974), those of the McCloud River described by Bacon, et al. (1980) and Hoopaugh (1974), and at least some of those of the Owyhee County drainages share similar physiological attributes being able to survive in harsh arid environments. Wilmot (1974) describes populations maintaining themselves in waters with greatly reduced stream flows and high temperatures. Behnke (1979) praises the fighting qualities and condition of trout from waters of 83^{o} F in Chino Creek. These physiological similarities therefore appear to be convergent adaptations from different lineages.

Thus the exclusive combining of only these and similar populations under the name of redband trout is an adaptive rather than a systematic categorization. Such populations are doubtlessly worthy of recognition, protection, and preservation - but not as a single taxonomic entity. These populations are jointly considered under Behnke's broad concept of *S. newberryi*. However, so are such diverse groups as Salmon River steelhead, Kamloops trout, and California golden trout, each group having vastly different sets of adaptive characteristics. A dilemma is therefore apparent regarding the management of these physiologically robust populations as a taxonomic unit; management under any broad concept of common ancestral relationship (regardless of validity) is excluded because of adaptive diversities requiring alternate strategies, while management under the restricted concept ignores ancestral differences.

Perhaps an entirely taxonomic basis for management and protection of these hardy populations of inland trout is inappropriate. Their prime unifying attribute seems to be their ability to thrive in environments that are hostile to other populations of trout. It may be useful to initially focus on this characteristic in different populations as a basis for management regardless of taxonomic relationships. We therefore recommend the following:

1. The term "redband trout" should not retain any taxonomic significance with

regard to these populations. However, the term should continue to be used to describe inland rainbow trout-like populations that are adapted to harsh arid environments; the term "steelhead" is effectively used in a similar manner to describe anadromous rainbow trout, regardless of ancestral origins.

2. The initial management of resident rainbow trout-like fishes that are native to arid regions of the western United States should focus on the physiological attributes of these populations with particular attention directed towards their identification, their habitat requirements, and their population dynamics.

3. Any cultural or transplantation projects involving these populations should include identification and consideration of relationships among populations prior to any poolings or transplantations.

ACKNOWLEDGEMENTS

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Appendix 1

COMPUTING FORMULAS FOR STATISTICAL PROCEDURES

Calculation of allele frequencies

The frequency of an allele is given by

$$\frac{2H_o + H_e}{2N}$$

where H_o = number of homozygotes

H_e = number of heterozygotes

N = number of individuals

Standard errors of allele frequencies

The standard error is given by

$$s.\ e. = \sqrt{\frac{p(1-p)}{2N}}$$

where p = allele frequency

(1-p) = frequency of all other alleles at the locus

N = number of individuals

A 95% confidence interval can be placed on allele frequencies by $\pm$ 2 s. e. Two populations are frequently said to be differentiated if their confidence intervals do not overlap.

Heterozygosity

Heterozygosity per locus is calculated by

$$H = 1 - \sum p_j^2$$

where p_j is the frequency of the jth allele at a locus

Average heterozygosity over all loci is given by

$$\overline{H} = \left(L - \sum_{j=1}^{L} \sum_{i=1}^{A_j} p_{ji}^2 \right) / L$$

where L = number of loci

A_j = number of alleles at the jth locus

p_{ji} = frequency of the ith allele at the jth locus

<u>Genetic Identity</u>

Nei's (1972) genetic identity (I) between two populations at the j locus is defined as

$$I_j = \frac{\sum x_i \; y_i}{\left(\sum x_i^2 \sum y_i^2 \right)^{1/2}}$$

where x_i = frequency of the ith allele in population X

y_i = frequency of the ith allele in population Y

The overall genetic identity of X and Y for all loci is defined as

$$I = \frac{J_{xy}}{(J_x \; J_y)^{1/2}}$$

where J_x, J_y, and J_{xy} are the arithmetic means over all loci of

$\sum x_i^2, \sum y_i^2$, and $\sum x_i \sum y_i$, respectively.

<u>Log likelihood analysis</u>

A contingency table (R X C) for each locus for each likelihood analysis was set up where

R = the number of population in the analysis

C = the number of alleles at the locus

Numbers of observed alleles were used in each cell.

The likelihood value (G) is calculated as follows:

G = 2(($\sum f \ln f$ for the cell freq.) - ($\sum f \ln f$ for the row and column totals) + $n \ln n$)

where f = number of alleles at each observation

n = total number of alleles

Appendix 2. Planting records provided by Idaho Dept. of Fish and Game.

Stream	Year(s) of Last Plantings	Comments[1]
Boulder Creek	1956	
Castle Creek	1956	
Flint Creek	1953	Possible migration into Jordan Ck.
Jordan Creek	1976, 1977, 1978	
Juniper Creek	1952	Possible migration into Cabin Ck.
Louse Creek	1953	Possible migration into Jordan Ck.
Reynolds Creek	1953	
Rock Creek	1953	Possible migration into Boulder Ck.
Trout Creek	1953	Possible migration into Jordan Ck.
Williams Creek	1953	Possible migration into Jordan and Boulder Creeks but improbable

1/ Comments provided by Debby Stefan, Buréau of Land Management, Boise, Idaho.

Appendix 3

GLOSSARY

Allele: one of several alternate forms of a gene.

Gene: a unit of genetic inheritance. Generally, a gene refers to the part of the DNA molecule that encodes s single enzyme or structural protein unit.

Genetic drift; change in allele frequency due to random occurrences in a population.

Genome: the entire genetic complement of an individual.

Genotype: all the genetic characteristics that determine the structure and functioning of an organism; often applied to a single gene locus to distinguish one allele, or combination of alleles, from another.

Heterozygous: containing two forms (alleles) at a gene locus.

Homozygous: containing two identical alleles at a gene locus.

Gene pool: the total genetic information possessed by the reproductive members of a population.

Inbreeding: the crossing of closely related individuals.

Introgression: incorporation of genes of one species or population into the gene pool of another species or population.

Locus (plural, loci): the position that a gene occupies on a chromosome.

Polymorphism: occurrence of more than one allele at a locus in a species.

Phenotype: physical expression of the interaction of genotype and the environment. The banding pattern on the starch gel is one form of phenotype of an individual.

Electrophoresis: separation of proteins in an electric field using some type of support medium (e, g, starch, acrylamide)

Hardy Weinberg: the theoretical expectation of genotypes under conditions of random mating. If (p) is the frequency of allele A and (q) is the frequency of allele B, then (p + q) = 1 and after one generation of random mating the genotypes AA, AB, and BB will be in the ratio p^2, 2pq, q^2 respectively.

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Copy

November 27, 1978

Mr. Stacy Gebhards
Idaho Department of Fish & Game
600 South Walnut Street
Boise, Idaho 83707

Dear Stacy:

I am enclosing some information on the recent discovery of a population of Bonneville cutthroat, Salmo clarki utah, in the waters of southeastern Idaho. Also included is a short summary of information about the subspecies, as its decline, present distribution and status, and some management ideas. I would hope that your department would take some immediate action to protect and enhance this population of a rare subspecies of cutthroat native to Idaho waters.

If I can provide any further information please do not hesitate to ask.

Sincerely,

Dick

Richard L. Wallace
Associate Professor of
Zoology

RLW:pw

Enclosures

THE BONNEVILLE CUTTHROAT TROUT, Salmo clarki utah, IN IDAHO WATERS

This past summer I was sent a sample of cutthroat trout for analysis to determine if they represent a population of "pure" Bonneville cutthroat, Salmo clarki utah, a very rare subspecies of cutthroat. The sample was collected by John Heimer, I.F. & G. and David Hanson, U.S.F.S., and came from upper Giraffe Creek (Bear Lake Co), tributary to Thomas Fork, Salt River (Bear River drainage) in southeastern Idaho. I judged these trout to be class "B" in purity, using Binns' (1977) ranking scheme (phenotypically, i.e., spotting pattern and coloration, pure Bonneville cutthroat; meristically, slight hybridization indicated). This is the first record of the occurrence of this rare, native cutthroat trout in Idaho waters and some appropriate management practices are immediately needed, in my opinion.

Dr. Robert J. Behnke, Colorado State University, has prepared a number of reports on the Bonneville cutthroat trout (Behnke 1976a, 1976b and 1978). I will summarize some of this information. At one time S. c. utah was distributed throughout much of the Bonneville basin of Utah, eastern Nevada, southwestern Wyoming and southeastern Idaho. Populations in Bear Lake, Utah Lake and Panguitch Lake were especially large but soon were heavily exploited by the early settlers, both for sustenance and commerce. Soon thereafter non-native trouts, as the rainbow trout, brown trout, brook trout and subspecies of non-native cutthroat trout were widely introduced. After the initial decline from over-fishing and habitat loss, there was an accelerated loss of the native trout of the Bonneville basin due to the introduction of non-native trouts. Especially serious was the hybridization with rainbow trout and other subspecies of cutthroat trout.

By the 1950s a number of authors believed that S. c. utah was probably extinct as a pure form. These authors believed that the long history of replacement and hybridization with non-native trouts was the major cause for the probable extinction of the Bonneville cutthroat. Another problem was the lack of diagnostic criteria for positive identification of S. c. utah.

In the 1973 version of the U.S.D.I's "Red Book" of endangered species S. c. utah is listed as "status undetermined". The International Union for the Conservation of Nature lists this subspecies as "rare". The Bonneville Chapter of the American Fisheries Society considers it endangered. Behnke states "The U.S.D.I. does not include S. c. utah on its present list of endangered or threatened species, but when all the present facts are known, it is likely to be listed as "threatened". Hickman (1978), a graduate student of Behnke, has completed a thesis on the native trout of the Bonneville Basin and considers S. c. utah, the Bonneville cutthroat trout, a threatened species.

Recently Behnke reports that there are three slightly differentiated groups of S. c. utah native to the Bonneville basin. One of the groups is found in the Bear River drainage. The current "stronghold" of trout typical in appearance of Bonneville cutthroat trout occurs in the Smith Fork and Thomas Fork drainages of the Bear River system in Wyoming. Populations in Raymond Creek and upper Giraffe Creek, Wyoming (Thomas Fork, Bear River drainage) are considered the purist S. c. utah in the Bear River system. With the discovery in 1978 of the population in upper Giraffe Creek, Bear Lake Co., Idaho, I believe we can include the Idaho population as essentially pure, good phenotypic representatives of Bonneville cutthroat trout.

The discovery of this subspecies of cutthroat in Idaho waters adds a new subspecies of cutthroat native to the state. But more importantly, here is a native trout that should be recognized and managed to insure its integrity and enhancement, and to allow Idaho anglers a chance to catch (and probably release) a beautiful native subspecies of cutthroat trout. With proper management activities this population could be used for reintroduction into streams tributary to the Bear River in southeastern Idaho.

However, current management practices must be modified in order to protect and enhance this population. First, all stocking of non-native salmonids, especially Henrys Lake cutthroat and rainbow trout, in the Giraffe Creek drainage should be stopped immediately.

Behnke has shown that when stocking of non-native subspecies of cutthroat is discontinued it takes very little time for native Bonneville cutthrout to again dominate the fauna in Smith Fork, Bear River drainage, Wyoming. I think within a few years after all stocking is stopped, the cutthroat of upper Giraffe Creek will show less effects of hybridization and their status changed to the A ranking of Binns ("pure" Bonneville cutthroat trout, S. c. utah).

Secondly, every effort should be made to protect the aquatic habitat of upper Giraffe Creek in Idaho. Grazing should be reduced or eliminated to reduce potential damage to the stream banks and riparian vegetation. Cooperative efforts with the U.S. Forest Service should be attempted to protect the land drained by Giraffe Creek.

In summary, here is a chance for the Idaho Department of Fish and Game to protect, enhance and utilize a subspecies of cutthroat trout native to a small area in southeastern Idaho. The management ideas suggested above seem to fit in with the Department's goal of enhancing native, wild trout populations and fisheries. With careful planning and sound management Idaho anglers should at least be able to have the chance to angle for an additional native subspecies of cutthroat trout.

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Richard L. Wallace
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Zoology
University of Idaho
November, 1978

Isolated Streams of the Snake River Lava Plateau – Hubbs & Miller p. 76

Large no. of streams feed into Mud Lake or dry sinks. – From zoological point – treated as interior drainage – In the several streams – Camas, Medicine Lodge, & Birch & Lost & Little Lost rivers, we found 3 species – : endemic subspecies of cutthroat – Dolly Varden (prob. Glacial relict. & 5 highly localized races of Cottus.

– None are Bonneville types – despite stream complex lies in Upper Snake area which has Bonneville fauna – seem to be relicts of old Snake River fauna, which existed prior to lava flows & of Lake Bonneville discharge.

– Wood River – (S.W. of Camas & Lost) – contains peculiar fauna – Cottus leiopomus – Salmo clarki, Catostomus syncheilus – Rhinichthys osculus & R. cataractae – probably represent the old Upper Snake fauna (prior to lava flows) – Snyderichthys copei – a Bonneville species – known very locally from upper Snake River. – Occurrence below falls w/ typical Columbia R. fauna is somewhat anomalous. – Wood R. race probably isolated for some time – shows peculiarities other – is well marked endemic – Cottus leiopomus

4 ei mykiss ~ Clark Co. Idaho – Irving Cr. (Camas)

lewisi – above & below falls –

- Pit & Klamath similarities - ..

  * Pit captured interior drainages -

- Possible connection of Goose Lake - Pit R. with Klamath basin - but if Pit went into Klamath or stream piracy - not known.

* Nye Co. Nev. Lake Toiyabe -
  cutthroat introduced -

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University of Idaho
Moscow, Idaho / 83843

letter to Id. Fish,
Bonneville cutt
Giraffe Crk., Id., cutts.

MOSCOW IDAHO NOV 28 '78
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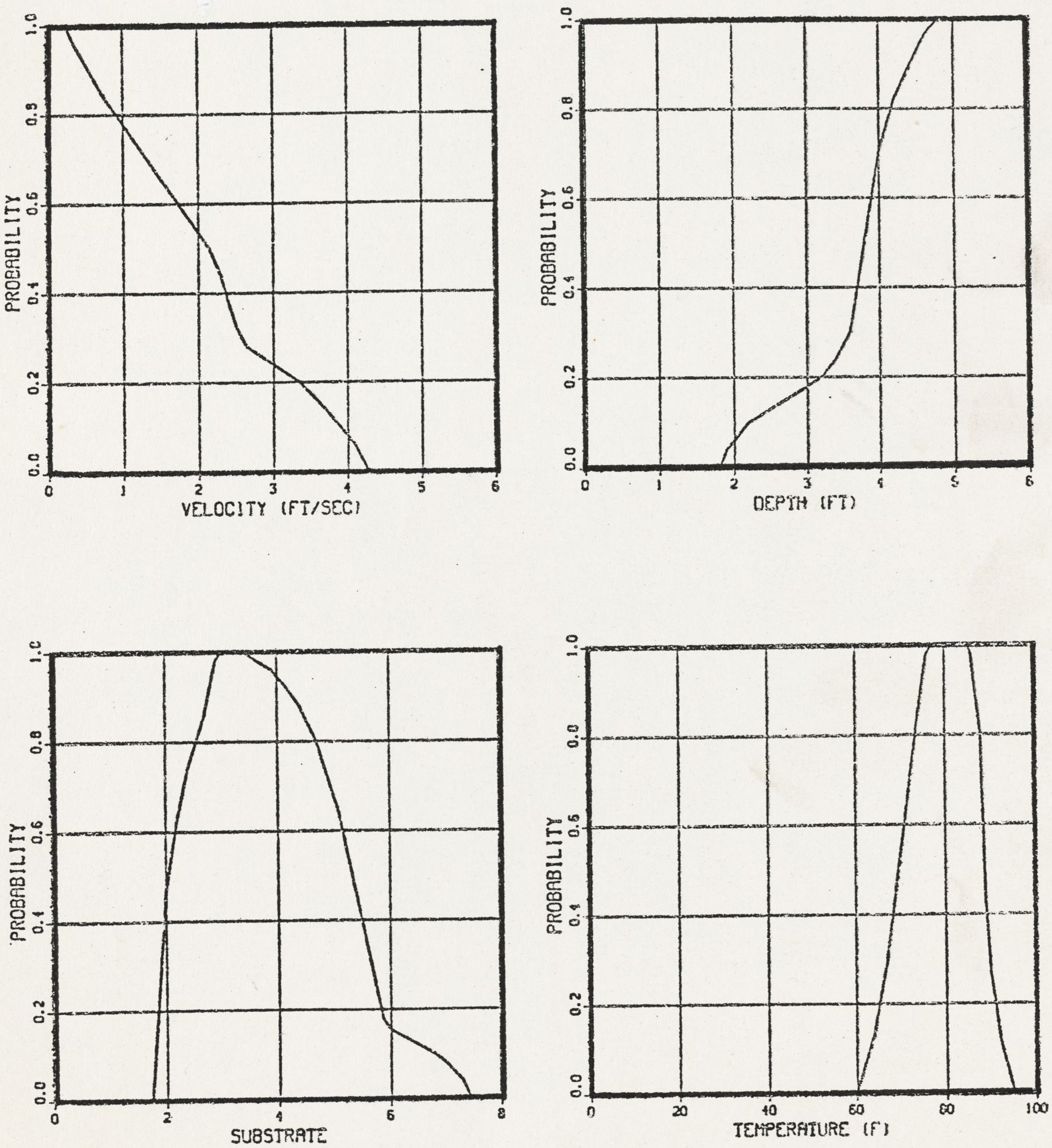
Dr. R.J. Behnke
Department of Fisheries & Wildlife Biology
Colorado State University
Ft. Collins, Colorado 80523

S1
2

CHANNEL CATFISH

ADULTS



CHANNEL CATFISH

FRY

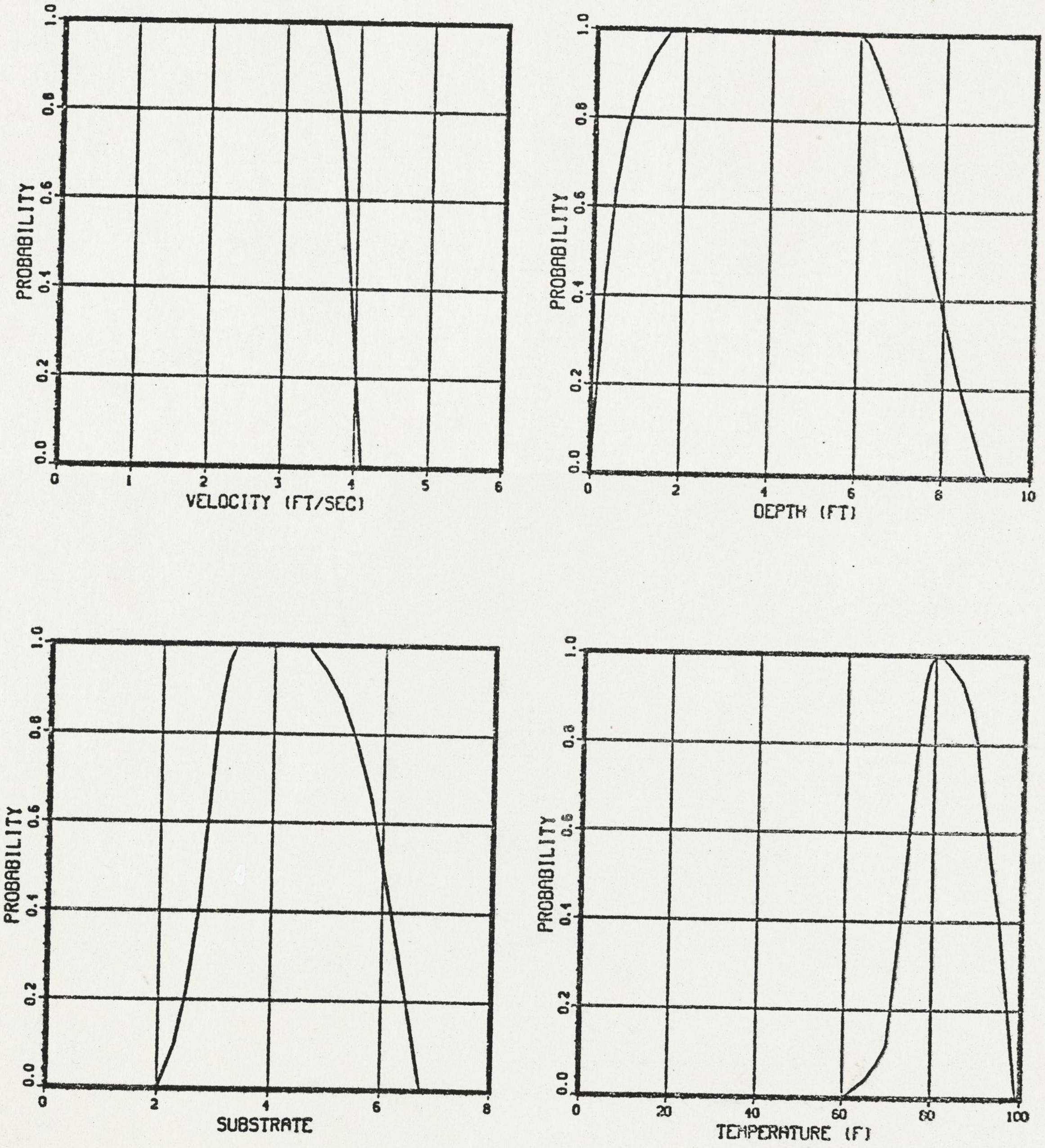


Table 2. Data Sheet Typically Used in Frequency Analysis for the Construction of Electivity Curves

Stream Shoshone Creek Below Hot Creek Date 7/21/77

Location Idaho Observer Cochnauer & Nelson

Water Temp. 70° Method Electro Shock

Species	Length (Ft)	Depth (Ft)	Velocity (Ft/sec)	Substrate	Comments
Rb	.7	1.5	.552	Gravel	Pool
Rb	.6	1.0	.771	Gravel	Middle of Stream
Brn	1.0	.9	.858	Gravel	Middle of Stream
Brn	1.1	1.2	.988	Gravel	Next to Bank
Rb	.6	1.2	.988	Gravel	
Rb	.3	.7	.661	Gravel	Next to Bank
Ct	.7	.8	.269	Gravel/Rubble 6"-10"	Middle of Stream
Brn	.7	.8	.269	Gravel/Rubble 6"-10"	
Rb	.9	.9	.269	Gravel/Rubble 6"-10"	
Rb	.8	1.7	.484	Gravel	Aquatic Vegatation Middle of Stream
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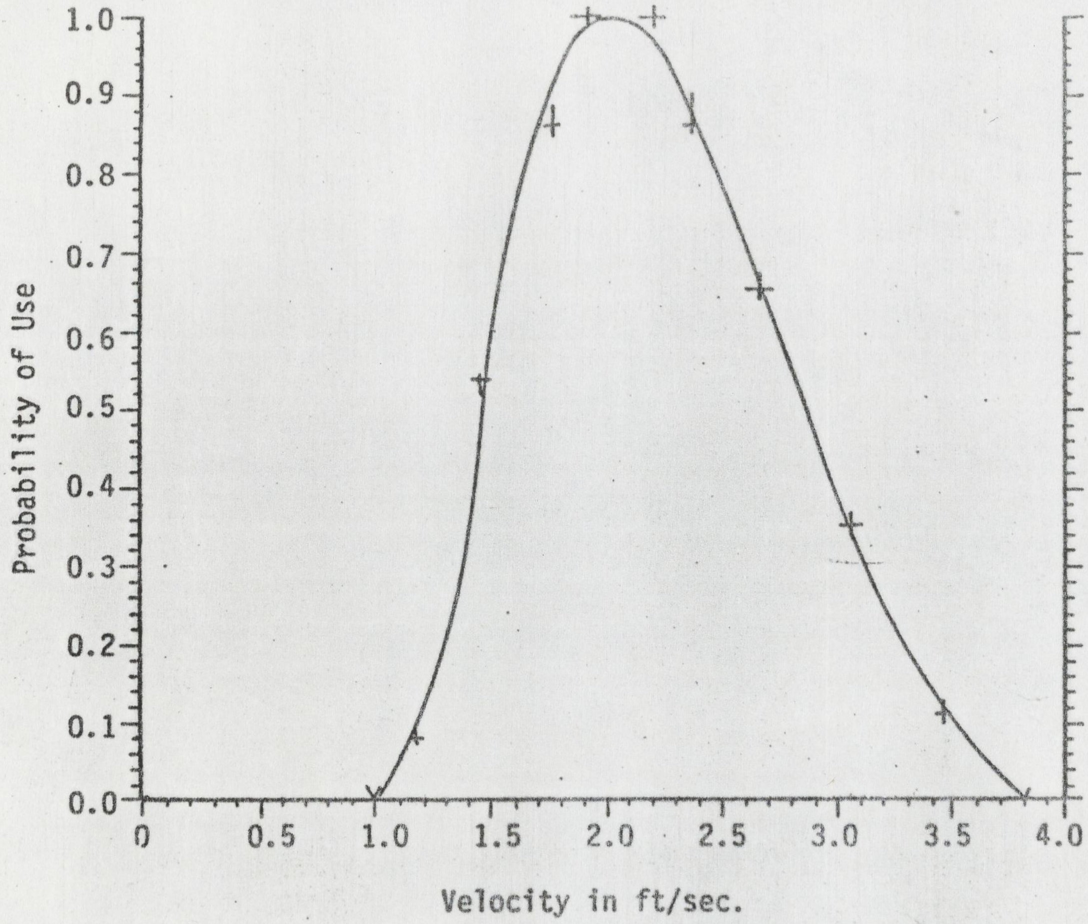
Table 3. Example of Frequency Analysis for Velocities Over Winter Steelhead Redds (Actual Data) Oregon Game Commission (1968), Hunter (1973)

Velocity	Tally	Frequency	Left Cluster	Right Cluster		Probability
.9		0		0		
1.0		0	1			0.0
1.1	|	1		3		
1.2	||	2	12			.08
1.3	卌 卌	10		19		
1.4	卌 ||||	9	17			
1.5	卌 |||	8		20		.54
1.6	卌 卌 ||	12	28			
1.7	卌 卌 卌 |	16		31		
1.8	卌 卌 卌	15	26			.86
1.9	卌 卌 |	11		35		
2.0	卌 卌 卌 卌 ||||	24	45			
2.1	卌 卌 卌 卌 |	21		37	$\overline{36}$	1.0
2.2	卌 卌 卌 |	16	26			
2.3	卌 卌	10		31		
2.4	卌 卌 卌 卌	21	28			.86
2.5	卌 ||	7		23		
2.6	卌 卌 卌 |	16	29			
2.7	卌 卌 |||	13		25		.67
2.8	卌 卌 ||	12	18			
2.9	卌 |	6		12		
3.0	卌 |	6	14			
3.1	卌 |||	8		13		.35
3.2	卌	5	7			
3.3	||	2		4		
3.4	||	2	5			
3.5	|||	3		4		.11
3.6	|	1	1			
						0.0

Figure 2: Example of a probability curve constructed from the frequency distribution shown in Table 3.



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1.8	15	15	26			.86
1.9	11	11		35		
2.0	24	24	45			
2.1	21	21		37	$\overline{36}$	1.0
2.2	16	16	26			
2.3	10	10		31		
2.4	21	21	28			.86
2.5	7	7		23		
2.6	16	16	29			
2.7	13	13		25		.67
2.8	12	12	18			
2.9	6	6		12		
3.0	6	6	14			
3.1	8	8		13		.35
3.2	5	5	7			
3.3	2	2		4		
3.4	2	2	5			
3.5	3	3		4		.11
3.6	1	1	1			0.0

Figure 2: Example of a probability curve constructed from the frequency distribution shown in Table 3.