Bull Trout

TRAVELIN'

by John Fraley

THE RUBBER-SUITED BIOLOGIST pulled himself upstream, crawling like a turtle over the rocks in the shallow water. Through his mask he counted a few cutthroat trout, a whitefish, a bigger cutthroat. Then, as he entered a pool, he saw a tail fin as big as his hand poking out from under a log. Slowly pushing sideways through the water, the biologist quickly grasped just past the tail fin with his neoprene-covered fingers. He stood up in a stream small enough to jump across, with a wriggling fish over two feet long. The biologist's assistant carefully inserted a tag behind the dorsal fin and returned the fish to the stream.

The fish was a bull trout: olive-colored back, orange belly—a male about 28 inches long weighing seven or eight pounds. He had migrated 145 miles upstream from Flathead Lake to spawn in this headwater tributary of the Middle Fork of the Flathead River within the Bob Marshall Wilderness Area. Migrating bull trout from Flathead Lake also spawn in Middle Fork streams within Glacier National Park and in tributaries of the North Fork of the Flathead (up to 150 miles upstream into Canada). Bull trout in Swan Lake spawn in tributaries of the Swan River upstream from the lake.

These unusual "chars" (member of the trout family) scoop nests or "redds" up to the size of a pickup bed in the gravels of relatively small tributaries. They are considered a symbol of the Bob Marshall and Great Bear wildernesses, and are often used as indicators of the quality of water and fish habitat. Biologists have often cited protection of bull trout spawning and rearing habitat in streams as reason to modify timber sales and mineral exploration plans.

Biologists have studied bull trout intensively in the Flathead system and their biology is becoming better understood, but many questions remain unanswered about the status of the populations and their management. Biologists and managers concerned with this unique species have recently begun to debate these questions.

A Species of Special Concern

The bull trout is one of the largest fish native to Montana waters—it can reach three feet in length and weigh up to 25 pounds. Anglers value it as a challenge and a trophy and in the Flathead system, an angler may fish for 20 hours to catch just one.

Montana has recognized the uniqueness of the bull trout by classifying it as a "Species of Special Concern." It was so classified because the large form of the species (20 to 36 inches, four to 25 pounds) has limited distribution, and because smaller forms of the bull trout can hybridize with the eastern brook trout. Trophy-sized bull trout (fish weighing more than eight pounds) are found in relatively large numbers in only the Flathead Lake and River system (including Swan Lake) in northwestern Montana. Smaller numbers of competition. "I'm also happy to be able again to personally contribute my talents for the benefit of the waterfowl stamp program."

IN EXPLAINING HIS WORK on the painting, he noted he wanted a finished product not distinctly Montana in character. "What I wanted was an appropriate setting, a misty morning that would appeal to a broader audience than just Montanans," he said. "After all, the name of the game is to create funds for the program."

Since 1986, hunters have been required to possess a state waterfowl stamp as well as the long-required federal "duck stamp" to hunt waterfowl in Montana. The 1985 Montana Legislature gave the Department of Fish, Wildlife and Parks authority to produce and sell a waterfowl hunting stamp and market related items. In 1987, more than 17,000 stamps were sold to Montana waterfowl hunters and several thousand collector's stamps were sold throughout the country.

Proceeds from sales of the waterfowl stamps and related artwork are used exclusively to develop and enhance Montana's wetlands for the long-term benefit of waterfowl on cooperating private, federal, and state-owned lands.

Funds for these wetland projects, as in previous years, will be garnered through sale of the 1989 waterfowl stamp ($5) and a series of limited edition prints that range from $140 for a signed print and stamp to $755 for the Executive Edition Print—a numbered and signed color remarque print with a stamp and 24k gold-plate medallion embossed with the Cruwys painting. The 1989 waterfowl stamp prints can be ordered through most art galleries in Montana.

Jeff Herbert, statewide waterfowl coordinator for the Department of Fish, Wildlife and Parks in Helena, said portions of the money raised to date have been spent on nesting platforms for geese, mallard net baskets, and wood duck nest boxes that have been placed in strategic locations throughout Montana. Private individuals and sportsman's clubs can participate in the program by contacting their nearest DFWP offices for more information.

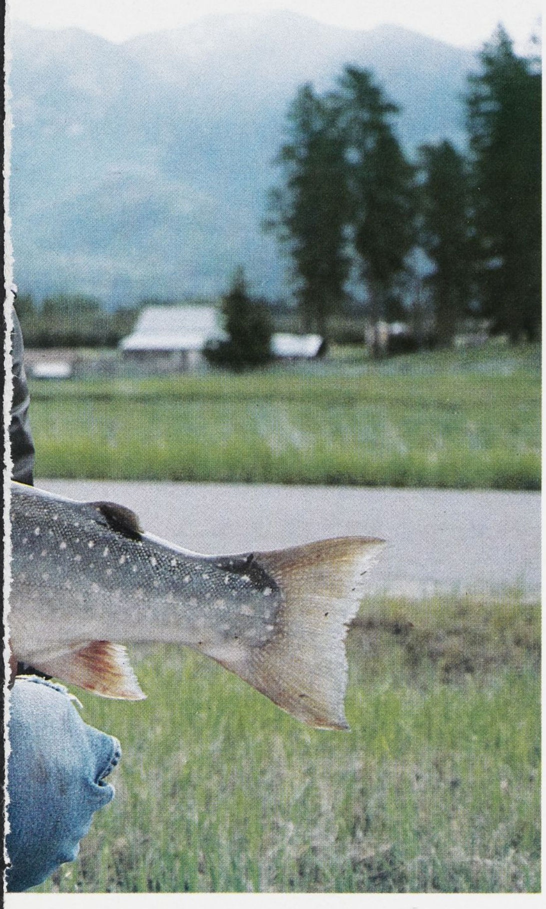
One of the most important advantages of generating money for wetland enhancement projects through a state waterfowl stamp program is that it allows states, like Montana, to participate in Ducks Unlimited's MARSH program, Herbert said. MARSH—or **M**atching **A**id to **R**estore **S**tate's **H**abitat—provides state wildlife agencies with matching funds to be used to conserve local waterfowl habitat. Montana matches DU MARSH dollars with revenues generated from sale of the state waterfowl stamp and related items. Since it began in January 1985, DU has committed over $30,000 of MARSH funds to the DFWP for wetland improvement projects. A recently dedicated wetlands enhancement project at Canyon Ferry Wildlife Management Area north of Townsend is one of three Montana projects that have utilized these funds. A nesting island construction project on Big Lake near Billings and the department's artificial nesting structure program were recipients of the remainder of those funds. Three additional projects totaling $51,000 have recently received approval from DU under the MARSH program.■

Second Place—Bob Kercher, Great Falls

Third Place—A. Nadine Pickthorn, Nashua

Fourth Place—Connie Tveten, Wolf Point

FISH



MIKE ADERHOLD

The bull trout, one of Montana's most highly prized trophy game fish, can reach three feet in length and weigh 25 pounds. This 21-pound, 12-ounce specimen, caught in Flathead Lake last year by Bob Staudenmayer, is the largest bull trout documented by the DFWP in more than 20 years.

large bull trout live in the Kootenai and Clark Fork systems.

Another reason the state is concerned about bull trout is their vulnerability to poaching and overharvest. These fish are easily snagged (illegally) in their spawning tributaries. People fishing legally in the river could also reduce the population because of the bull trout's readiness to attack spoons and plugs.

Bull trout are also threatened by degradation of tributary habitat. Forest practices and mineral development can increase sediments and water temperature in streams used by spawning adults and maturing young fish. Because most large bull trout use both lake habitat (to grow and mature) and stream habitat (for spawning and rearing of young), they depend on the health of the entire aquatic system for survival.

Patterns of Life

Most bull trout mature in lakes, where they reach trophy-size, then spawn in tributaries. This migratory lifestyle is referred to as "adfluvial." Some spend their entire lives in tributaries; when they are mature, they are about a foot long (these fish display a "resident" lifestyle). In the Clark Fork system, the fish grow two or three feet long in the rivers and then migrate into tributaries to spawn (this is referred to as the "fluvial" lifestyle). In Isabel Lake in Glacier National Park, "dwarf" bull trout mature at about a foot long.

Large, adfluvial bull trout grow to maturity in lakes (like Swan and Flathead), migrate upriver in the late spring, spawn in tributaries in the early fall, and return to the lake in the late fall. Young bull trout hatch in the early spring and live one to three years (reaching three to eight inches in length) in the tributaries before moving downstream through the river system to the lake (see Figure 1).

Adfluvial bull trout are particular in their choice of spawning areas, selecting low-gradient mountain streams with beds of clean gravel and areas of upwelling groundwater. Hiding cover such as logs and undercut banks is also important. These strict requirements make good spawning habitat limited and valuable.

Suitable habitat for rearing juvenile bull trout is also limited. Young bull trout require cold-water tributaries with good cover (rocks and woody debris) and relatively little streambed sediment. For example, most young bull trout are found in Flathead tributaries with average summer afternoon temperatures below a chilly 59°F.

Bull trout in the Flathead probably developed their migratory lifestyle in Glacial Lake Missoula, which drained near the end of the last ice age (about 10,000 years ago) leaving Flathead Lake as its remnant. This life strategy seems hard and inefficient, considering that mature fish are in the river system, away from the abundant forage fish of the lake, for nearly half of the year. That's probably why many adfluvial bull trout spawn every other year.

However, the adfluvial lifestyle may offer some advantages. These bull trout spawn in clean, well-oxygenated gravels of headwater tributaries, which greatly improves egg survival. When the young hatch, they aren't exposed to large predatory fish in the river and lake. While in the lakes, bull trout can take advantage of the abundant forage fish and suitable water temperatures for rapid growth. It could be that their use of a wide range of habitats has helped them survive.

Population Status

Biologists are using four methods to track the status or "health" of the bull trout population in the Flathead Lake and River system: (1) redd counts in the tributaries, (2) counts of juveniles in selected tributaries, (3) age and growth of fish in the lake, and (4) success rate of anglers fishing in the lake.

Since 1979, biologists have counted redds in four tributaries of the Middle Fork (Morrison, Lodgepole, Granite, and Ole creeks) and four tributaries of the North Fork (Whale, Trail, Coal, and Big creeks). Biologists believe the number of redds in the creeks reflects the number of spawning bull trout migrants from Flathead Lake (at a ratio of about three spawners per completed redd). The same creeks are surveyed each year, so the redd counts serve as an index of the spawning run from Flathead Lake.

Biologists have found that the number of bull trout in the spawning run from Flathead Lake (based on redd counts) has fluctuated from year to year (see Figure 2). More fish spawned in the index tributaries of both the North and Middle forks in 1982 than in any other year, but beyond that it's difficult to note any trend. In general, numbers of spawners in the the last few years are higher than in 1979-81, but lower than in 1982.

The second indicator of the status of the Flathead bull trout is the number of juveniles in tributaries of the North and Middle forks. To estimate the number of young bull trout in the tributaries, biologists introduce electric current into the stream through electrodes, and then net and count the stunned fish. The researchers make several passes through a stream section (usually 500 feet) and then derive an estimate for the entire section.

Biologists have used this technique to estimate the abundance of young bull trout in many tributaries of the North and Middle forks, but long-term information is available for only two streams: Coal Creek (North Fork) and Morrison Creek (Middle Fork). Because these are major bull trout spawning and rearing streams, biologists selected them as index sites for following the abundance of juvenile bull trout.

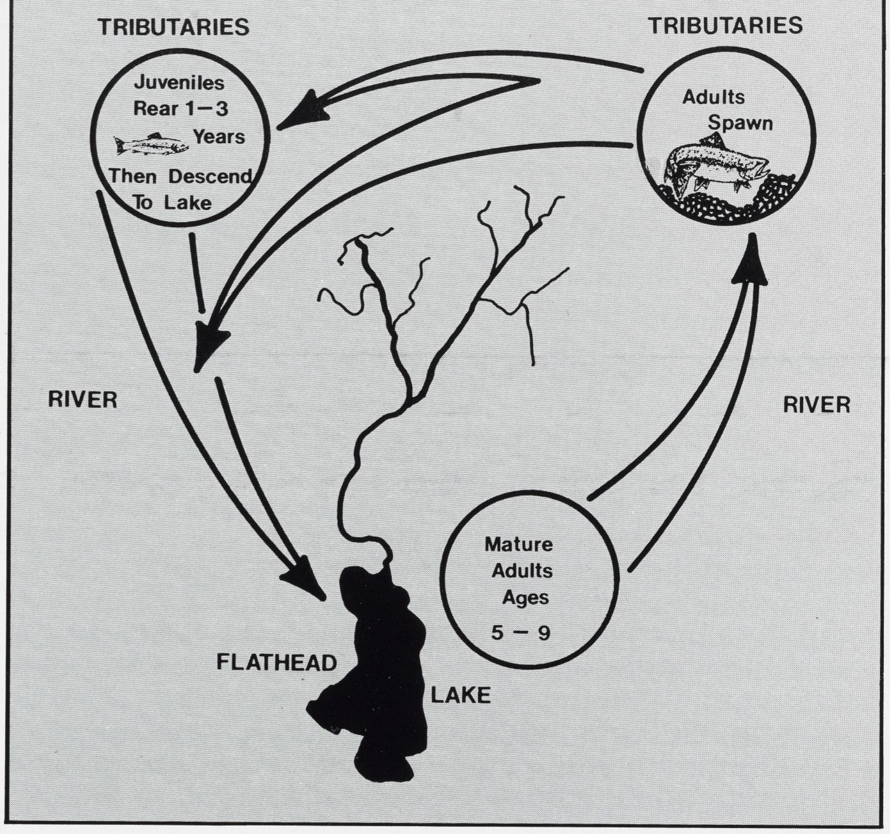
The number of young fish in the two creeks has varied from year to year (see Figure 3). Biologists have found from 85 to 179 young bull trout per 500 feet of Coal Creek and from 70 to 138 bull trout per 500 feet of Morrison Creek.

The third indicator of the status of the bull trout in Flathead Lake is the rate of growth of the individual fish. Bull trout in the lake grow about four inches per year, and can reach 34 inches or more by their ninth year. Studies conducted in 1980-81 found no major differences in growth rates or average size of mature bull trout in the lake as compared with investigations in the 1960s. Also, from the 1950s to the early 1980s, the size of fish in the river system spawning run has averaged about 25 inches.

These studies suggest as many large fish in recent years as there were 20 years ago, and that the growth rate for individual fish is about the same. Department of Fish, Wildlife and Parks biologists report that catches of bull trout in gill nets during the 1960s and early 1980s also show a similar size range. These factors point to a healthy population.

The fourth index of population status is bull trout angler catch rates. Stable catch rates usually indicate a stable population, although environmental conditions can change angler success from year to year. Biologists interviewed anglers on Flathead Lake in 1963, 1981, and 1985 as part of intensive creel surveys. Anglers caught bull trout at about the same rate in each of the three years (18 to 20 hours of angling required to catch a large fish). Surveys conducted on the Flathead River in 1975, 1981, and 1987 showed a similar catch rate for migrating spawners.

Figure 1—Life cycle of the adfluvial bull trout.



Threats to the Population

Large, adfluvial bull trout are sensitive to changes in their tributary and lake environs, and they can be susceptible to poaching and overharvest. These fish take from six to eight years to mature, and are never very numerous compared with many fish species. Because of these factors, bull trout can be easily harmed by man's activities.

Timber Harvest, Sedimentation

In the Flathead system, timber harvest has affected habitat in tributary streams used by spawning bull trout. When an area is logged, the access roads can cause increased sediments to be washed into the stream. The sediments can settle into the streambed gravels, reduce water and oxygen exchange for incubating trout eggs, and decrease egg survival. Decreased survival of eggs results in fewer young fish that rear in the tributary and later swim downstream to the lake.

To help assess the potential for logging-related impacts, the Flathead National Forest has studied the sediment problem in tributaries of the North Fork of the Flathead River. To what extent does logging cause increased sediments in stream gravels? U.S. Forest Service Biologist Mike Enk is cautious about the study's results.

"There's strong indication that road development and logging have contributed to high levels of sediment in some streams, particularly in Coal Creek," says Enk. "The problem is that we don't have any information on the creek *before* logging took place—we're stuck with looking at data from only the last five or six years."

According to Enk, the Flathead Forest is concerned about how timber sales may affect stream habitat. "We're trying to find better ways of managing timber activities to cut down on the amount of sediment entering the stream from roads and cuts," he said.

Other efforts are being made to address the impacts of forest practices and sediment on streams. A study by the Environmental Quality Council and a cooperative Flathead Basin Commission study focus on "Best Management Practices," or measures required during logging activities to protect watersheds. Information from these studies should help to refine these protective measures and reduce the harmful effects of logging on water quality, fish, and fish habitat.

Cabin Creek Coal Mine

A major threat to bull trout in Flathead Lake is the proposed Cabin Creek coal mine along Cabin and Howell creeks (tributaries which support up to 10% of all spawning bull trout from Flathead Lake) in the North Fork drainage in Canada. Sage Creek Coal Ltd. has received Stage II approval for the mine—approval in principle of the mining plan, given certain studies are undertaken—from the British Columbia government. In April 1985, the matter was referred by the governments of Canada and the United States to the International Joint Commission (IJC) for environmental review because of concern over transboundary effects of development on the North Fork of the Flathead River and Flathead Lake.

The IJC established a joint Canada/U.S. Flathead River International Study Board and the board set up several technical committees (Mine Development, Water Quality and Quantity, Biological Resources, and Water Uses) to report on the potential environmental impacts of the mine on the North Fork drainage. The committees began work in July 1985 and completed their analyses by fall of 1987.

According to the reports prepared by the Mine Development Committee and the Water Quality and Quantity Committee, the mine would severely degrade the aquatic habitat of Howell Creek. The water temperature of the creek would be raised and increased sediments would settle into the streambed because of the removal of forest canopy and road building during the preliminary phase of mine construction. Dissolved nitrogen (from explosives) would increase in the groundwater feeding the stream. The channel of Howell Creek could be modified and damaged.

These environmental changes would mean the end of significant bull trout spawning and rearing in Cabin and Howell creeks, according to the Biological Resources Committee.

"The construction of the mine would eliminate the habitat which supports bull trout spawning and rearing in Howell and Cabin creeks," says Alan Martin of the British Columbia Ministry of the Environment and Canadian co-chair of the Biological Resources Committee. "The mine might not kill the fish directly, but the destruction of fish habitat would quickly reduce the population to low or nonexistent levels."

U.S. co-chair of the Biological Resources Committee, Loren Bahls of the Montana Department of Health and Environmental Sciences Water Quality Bureau, echoes Martin's sentiments.

Figure 2—Number of bull trout "redds" or nests in selected North Fork tributaries, Middle Fork tributaries, and both forks combined, 1979-88.

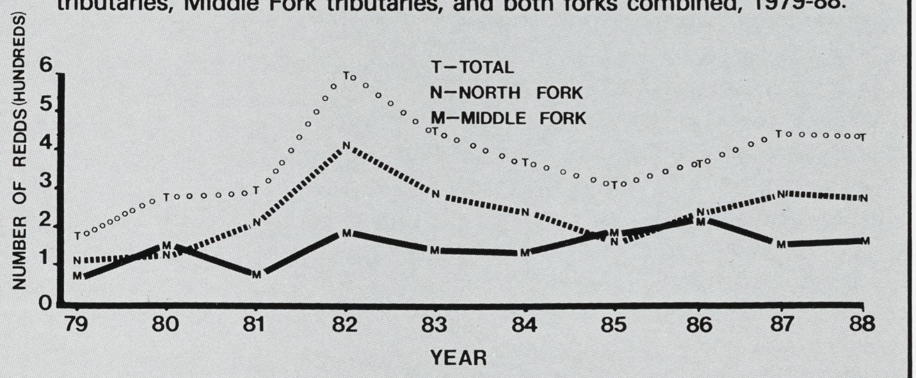
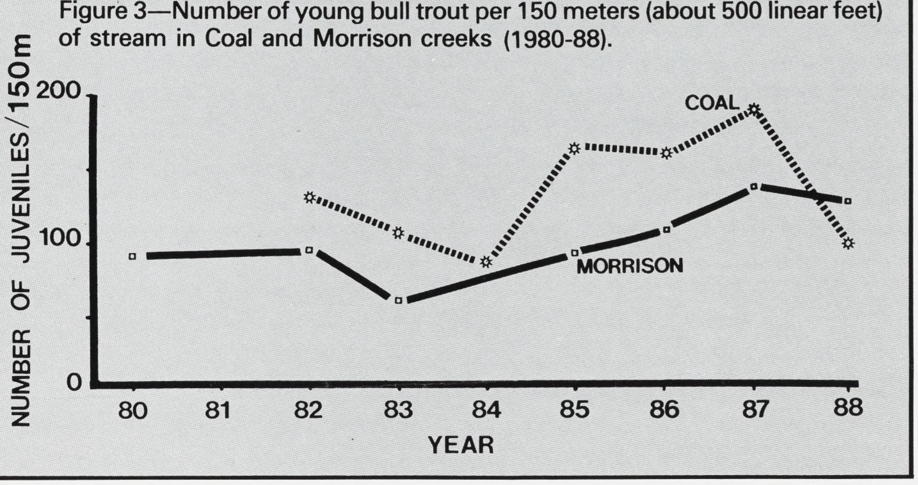


Figure 3—Number of young bull trout per 150 meters (about 500 linear feet) of stream in Coal and Morrison creeks (1980-88).



"Even if mature bull trout moved into Howell Creek after the mine was built, they probably couldn't spawn successfully," says Bahls. "Their eggs would be destroyed by high sediment and nitrogen levels in the gravels."

Neither Martin nor Bahls sees any prospect for recovery of bull trout in Howell Creek if the mine were built. They cite the unique nature of the habitat in the mine site area that would be lost, probably forever. Adds Bahls: "There's just nowhere else for the fish to go."

If the Howell Creek segment of the bull trout population is lost, it could result in a 10% reduction in the bull trout population of Flathead Lake. Besides being a serious blow to the Flathead Lake population, this loss would hurt the economy of the Flathead Valley. The Water Uses Committee calculated a total value of $4.97 million annually (1986 U.S. dollars) for the bull trout fishery in the Flathead Lake and River system in Montana. The loss of Howell and Cabin creeks as producers of bull trout would mean a loss of hundreds of thousands of dollars annually to the area's economy.

The board considered findings of the technical committees and submitted an overall report to the IJC for deliberation. In September, hearings were conducted on the proposed mine in Kalispell and in Cranbrook, British Columbia; public sentiment at both meetings indicated overwhelming opposition to the mine as planned. Negotiations between the U.S. and Canadian governments continue.

Overharvest

Because of the restricted distribution of bull trout spawning in the Flathead Basin and the limited size of the known annual spawning run, harvest of mature fish by anglers in both the lake and river can have a dramatic impact on the population. Biologists estimate that only 3,000 to 5,000 bull trout from Flathead Lake escape harvest and successfully spawn in tributaries. Any increase in fishing pressure and harvest could reduce the spawning population, causing a loss of juvenile production, and reducing the population in Flathead Lake.

The segment of the population most vulnerable to overharvest is the upper river stocks. These fish can be seen in the clear headwater streams, and must run the angling "gauntlet" through the entire river system to reach spawning areas. Mostly because of this vulnerability, DFWP lowered the creel limit in the lake and river from two to one fish in 1982. The B.C. Ministry of the Environment reduced the creel limit to one fish in the Canadian portion of the North Fork in 1983.

Bull trout are mostly protected from angling once they reach the tributaries in which they spawn. The DFWP closed most of the important spawning streams to angling in the early 1960s, and Glacier Park did likewise on important streams within park boundaries in the 1970s. In 1983, the B.C. Ministry of the Environment closed to angling all North Fork tributaries in Canada used by spawning bull trout.

Hybridization with Brook Trout

Bull trout, especially those in the Clark Fork system, are jeopardized by hybridization with the non-native eastern brook trout. The two species interbreed readily, and most of the hybrids are sterile. According to DFWP records, brook trout live in over one-third of Montana's bull trout streams. Where ranges overlap, brook trout may be able to outcompete bull trout.

Hybridization is probably a serious problem only to the smaller, tributary-resident bull trout. The University of Montana Genetics Laboratory identified bull trout/brook trout crosses in Lolo Creek, a tributary of the Bitterroot River, south of Missoula.

Future Management of Bull Trout

The keys to managing large, adfluvial bull trout in Montana are two: (1) protection of their tributary spawning and rearing habitat, and (2) control of harvest by anglers.

To a large degree, the quality of spawning and rearing habitat controls the bull trout populations in Flathead Lake and Libby Reservoir. Biologists believe that timber harvest and other human activities already have damaged some streams used by spawning bull trout. The challenge will be to prevent further harm to the delicate habitat in these tributaries.

DFWP Region 1 Fisheries Manager Jim Vashro emphasizes the importance of continued work with the U.S. Forest Service on forest plans and timber sales. Says Vashro: "One thing we'd like to see more of in the forest plans is an emphasis on long-term monitoring of the effects of timber harvest on aquatic habitat."

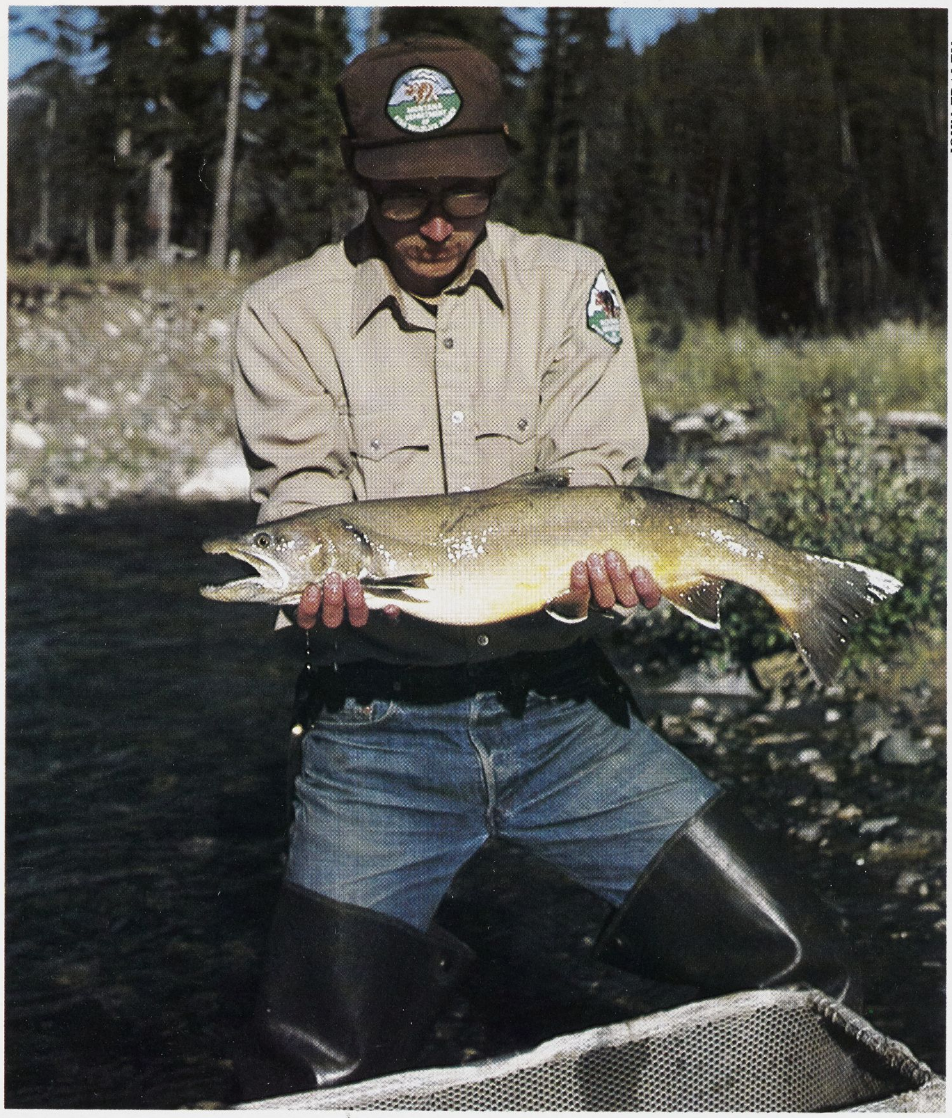
Vashro cites the difficulty of balancing timber harvest with a quality environment. "It seems that the best we can do is a compromise," he says. "To protect one portion of a stream, we sometimes have to sacrifice another portion."

There have been successes in the battle of habitat protection in the Flathead system. For example, in 1985, a timber sale in the Akinkoka drainage of the North Fork was halted and is being modified because of the potential damage to bull trout spawning and rearing habitat in Akinkoka Creek and downstream in Whale Creek.

Future management of bull trout must also focus on control of the harvest of mature fish by anglers. Vashro notes that the bull trout has been managed as an individual species in the Flathead system for over 20 years. The species is protected by reduced creel limits and tributary closures.

"We feel we can maintain the current level of harvest in both the river and the lake as long as our abundance indicators remain stable," says Vashro. He adds that a creel census was conducted for the North Fork of the Flathead River during the spring and summer of 1987. This was the first census of the river harvest since 1981, and it yielded a direct measure of angler impact on migrating fish.

Preliminary results from the 1987 census indicated a harvest of approximately 200 bull trout, as compared with a harvest of 400 estimated during the last census conducted on the North Fork in 1981. This apparent reduction in harvest could be related to the change from a two-fish to a one-fish angling


JOHN FRALEY

Classified as a "Species of Special Concern," the bull trout is being closely monitored by DFWP biologists in the Flathead Basin. One indicator of its status is the number of juveniles in tributaries of the North and Middle forks. Biologists are able to derive population estimates by netting and counting the young fish stunned through electrofishing in a stream section.


JOHN FRALEY

limit in 1982, or to an increase in catch and release fishing.

"We don't want to cut the angling public out of the picture," says Vashro, noting that the bull trout is the only trophy-sized fish available to anglers in the Flathead River system. "To a large extent, the anglers support our management and protection efforts for the species," he added.

Even though the abundance indicators for bull trout in the Flathead Lake and River system have remained relatively stable, the Confederated Salish and Kootenai tribes, co-managers with the DFWP of the Flathead Lake fishery, advise caution in managing harvest of the spawners by anglers. The Tribes are worried that anglers may be taking too many migrating bull trout in the river system. In 1985, Tribal biologists tagged 17 adult bull trout in Flathead Lake. Subsequently, eight of these fish were caught on their spawning run in the Flathead River. Although these findings are based on a small sample of tagged fish, they raise a red flag on the potential for overharvest in the river system.

The DFWP is also working closely with the B.C. Ministry of the Environment on controlling harvest of migrating spawners. Says Alan Martin of that agency: "The fish is already heavily protected, and I don't think it's time to push the panic button yet. But if we see further declines in the spawning run in the Canadian portion of the North Fork, we will have to look at closing the river to angling." Martin adds that, based on a limited survey, harvest was light on the North Fork during the summer of 1987.

So the trophy bull trout has been studied and protected. It's becoming obvious, though, that yet more study and protection is needed to sustain the present population level of adfluvial bull trout in Montana. As many ecologists and naturalists, including Muir and Thoreau, have noted, quality habitat is the major requirement for healthy populations of animals. If managers can win the battle of habitat protection in important tributaries, they will be much of the way toward protecting the bull trout. ■

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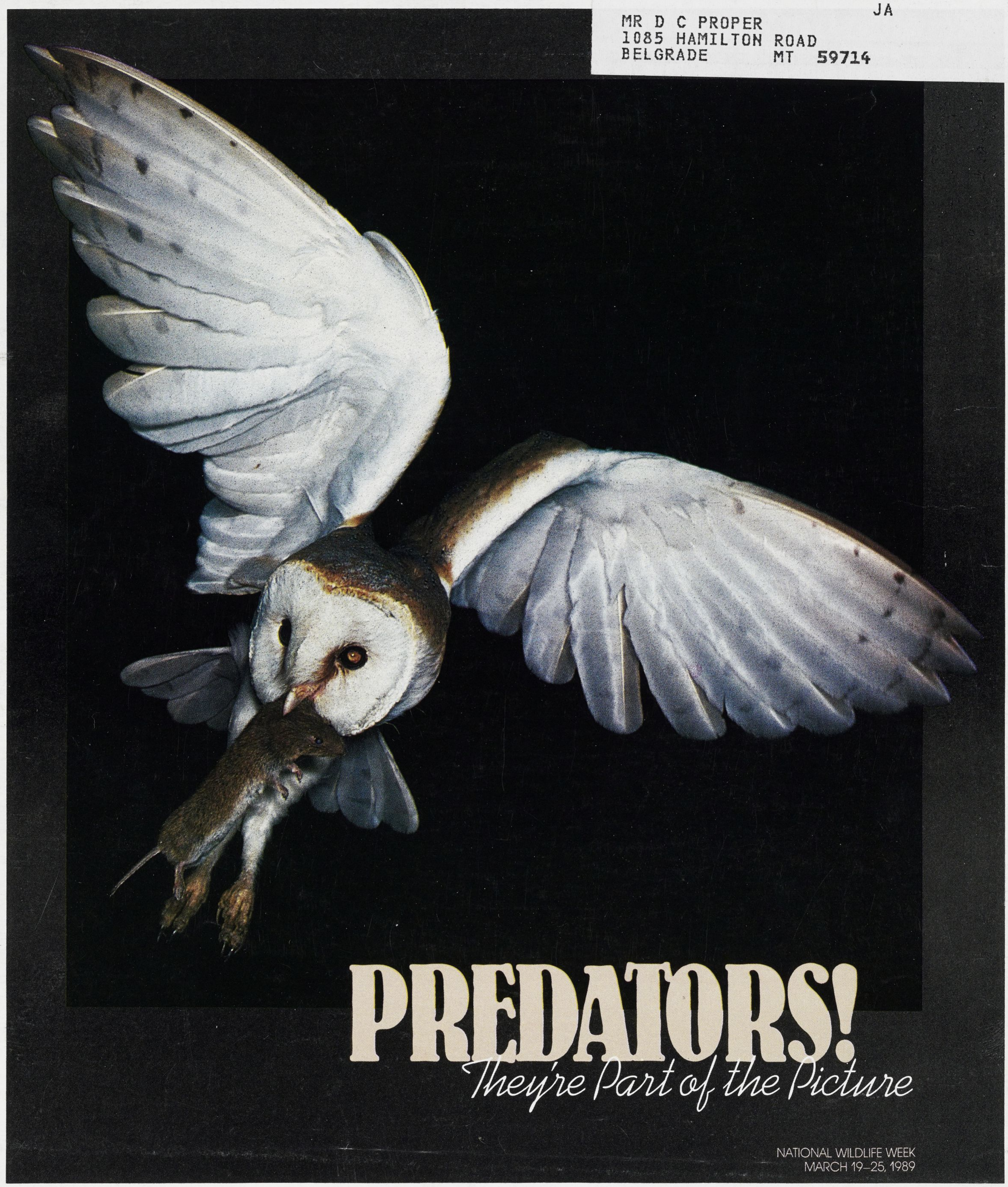
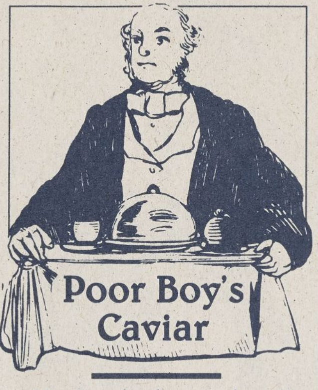




Here's a dandy spread or dip made from the roe of bluegills, bass and other freshwater panfish. It can also be made with the roe of shad, herring, cod and menhaden. For best results, the angler should field-dress his catch and keep the roe cold. Here's what's needed:

- ½ cup fish roe
- 1 bay leaf
- 1 package cream cheese (6-oz. size)
- 1 small onion, minced or grated
- juice of 1 lemon
- ½ tbsp. Worcestershire sauce
- ½ tsp. Tabasco sauce
- salt to taste

Bring the cream cheese to room temperature and soften. In a pan of suitable size, bring a little salted water to light boil and add the bay leaf. Simmer the fish roe (in their sacs) in water for 10 minutes. Discard the water and the bay leaf. Drain the sacs, then cut them and squeeze out the roe. Mix with the other ingredients, adding a little salt to taste. Serve with cracker thins. It's better than caviar—and cheaper. —*A.D. Livingston.*

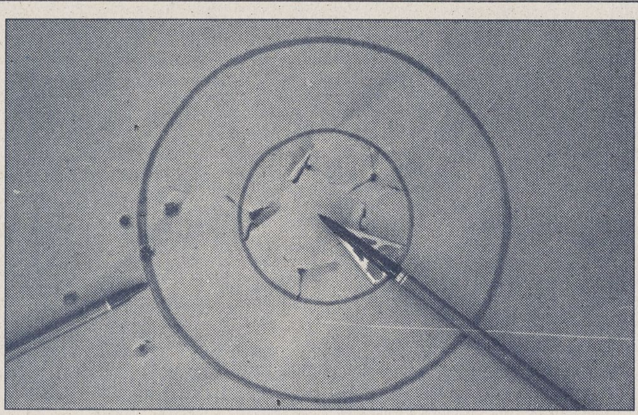
FLOAT-TUBING ENHANCED

A float tube is about the most comfortable way to fish that I have ever come across, but at first I had a few glitches. Air pressure must be maintained—not only for proper buoyancy but also to minimize water taken on by the tube cover. When my tube is underinflated, the cover has to be unzipped to let all the water out—a tedious process at best.

Another problem I had was that the tube chafed my elbows raw. Now I wear long-sleeved shirts or elbow pads.

Finally, I found that the handles on all my spinning rods were too long for the float tube. I took one rod and cut four inches off the butt, and it is much easier to maneuver now. —*Fred Everson.*

The world's largest salamander is native to Japan.



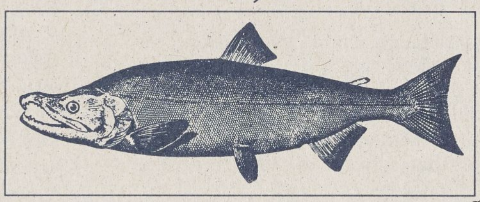
Mixing Broadheads & Field Points

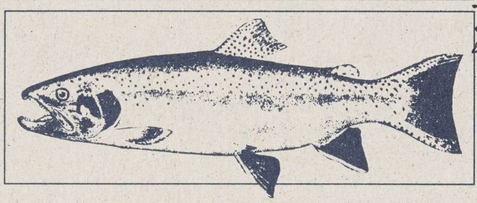
A common mistake made by bowhunters is shooting their hunting bows with field points, then changing to broadheads without resighting. Even with broadheads and field points of the same weight, flight differences are likely to occur.

The problem often originates from lack of a good broadhead target. Pulling broadheads from a bale or target butt presents a real problem, so bowhunters resort to sighting with field points.

Irrespective of point weight, impact differences between field tips and broadheads can be as much as a foot or more at 25 yards. The usual causes contributing to the impact differences are: widely varying point weights, poorly aligned broadhead ferrules, wrong arrow spine for bow/broadhead weight, or a poorly tuned bow.—*Norman E. Johnson.*

Is It A Trout, Or What?

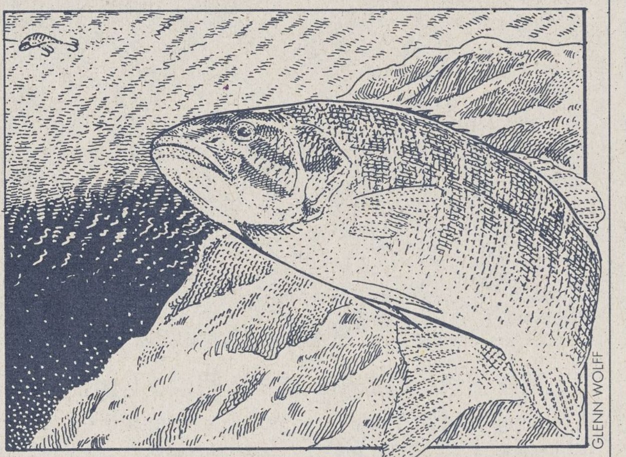




Recent research by paleontologists Gerald Smith and Ralph Stearley at the University of Michigan has cast doubt on one of the fishing world's longest-standing assumptions. In the university's *Research News*, they reported that their study of fossil records of 17 million years of trout and salmon evolution convince them that rainbow and cutthroat trout are more closely related to coho, chinook, and sockeye salmon that belong to the genus *Oncorhynchus* than they do to the *Salmo* genus which includes Atlantic salmon and brown trout.

Smith and Stearley are not the first to suggest that rainbows and cutts have been classified in the wrong genus. The British anatomist C.T. Regan made the same suggestion in the early 1900s. His assumptions were based on his study of the bones of salmon and trout, but his observations were largely ignored by other biologists.

The new research also suggests that modern trout and salmon are much older than is often believed. Some biologists have suggested that trout and salmon as we know them evolved in western North America only in the few thousand years since the glaciers of the last ice age receded. Smith and Stearley insist, however, that fossil evidence proves species of trout and salmon remarkably similar to those found in the same region were flourishing 6 million years ago.



HUNTING AND FISHING TIPS

Smallmouths in natural lakes like underwater reefs. These are seldom visible and generally lie away from shore; thus they're overlooked by most anglers. Locate them on a topo map and/or with a good depthfinder; then work the reefs with jigs, crankbaits or live minnows.

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Opening day is a great time to bag a buck, but choose your tactics carefully. This is a poor time for still-hunting because so many other hunters are already in the woods that deer are skittish and already moving themselves. A better bet is to take a stand and wait for deer to come to you. This is also much safer than moving with so many people out and about.

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Don't give the lure too much action when fishing for crappies with jigs. Just a slow, steady retrieve with cast lures is best. If you're fishing vertically, don't jerk the lure up and down. Try to hold it stationary around cover such as brush or bridge pilings. The natural movement of your arm and hand will impart all the action to the lure you need.

•

You can decide whether ducks are worth trying to call by how they are flying. Birds that are high up, flying fast and in a straight line know where they are going and aren't likely to come to your spread. Lower birds, however, that don't look quite as purposeful in their flight can often be lured in with a good spread and artful calling.

•

Most people think of crappies as lake fish, but you'll often find populations of these delectable black-and-white panfish in slow- and medium-current rivers as well. Look for them around bends and in slow, deep pools near brush and logjams along shore. Fish for them with small jigs or minnows under a bobber.

•

If you're planning a major hunt in the West during the fall, start an exercise regimen at least two months ahead of the trip. This will get your muscles, lungs and heart in shape, and make it easier for you to cope with the high elevations.

•

If you catch a fish while drifting or trolling, toss a buoy marker over the spot. Chances are there may be a school there. If not, pull in the buoy and continue searching for a better concentration of fish.

Colored Aiming Bead

Usually hunters ignore the aiming bead on the front of a shotgun barrel when wingshooting. The aiming bead is used for shooting slugs, or with shot in a tight choke for turkey hunting. Most aiming beads are difficult to see, however, because they are the same color as the barrel. A bead of a contrasting color is much easier to see and aim.

The choice of color is important. Red tends to fade in low light; white and fluorescent beads stand out from the barrel and remain visible in faint light. To paint the bead, cover the barrel with masking tape. Make

sure all the gaps are covered, especially around the base of the bead. Spray on a light, even coat of paint from a foot away. Two light coats are better than one thick layer.

Remove the tape as soon as the paint is dry. If left on too long, the tape adhesive dries to the barrel.—*John Haviland.*

FISH CLEANING TIPS

• To avoid back strain, clean your fish on an old ironing board, so your work is at waist level. When through, simply hose off the vinyl cover.

• Wear cotton gardening gloves to protect your hands. Even when wet, they'll ensure a firm grasp.

• Don't allow your knife to become dull. After every fish, take a few swipes across a whetstone and avoid a lengthy resharpening time later.

• To remove fish odors from your hands after cleaning your catch, wash your hands with soap and water. Then sprinkle a bit of lemon juice on your hands and rub. Wash again in soapy water, and there will be no trace of fish odor.

Save your fish cleanings in a plastic bag, then work into the soil of your vegetable or flower garden.

MONSTER ALERT

The infamous gila monster (*Heloderma suspectum*) of the American Southwest is known for its bad temper and toxic bite. Herpetologists say that the poison is rarely fatal, however, and that the bite itself—not the poison—can be more of a problem than the toxin. It seems that once the big lizard has a grip on its victim, it is often reluctant to let go, and it has the nasty habit of chewing while holding on.

The gila monster's cousin, **the Mexican beaded lizard, is our only other poisonous lizard, though two subspecies of the gila live in the same neck of the desert.**

Equipped with a clublike tail, the gila stores fat in that terminal appendage. In times of food scarcity, up to 20 percent of the tail—by weight—can be lost.

Attaining a length of two feet or so, the gila should always be handled with great care.—*Bob Newman.*

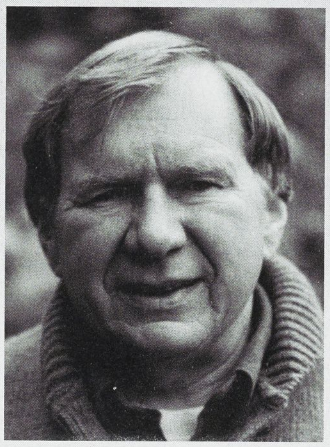
How Many Species?

A Provisional List of the Known, the Good and the Dubious Species of Salmonids

Robert J. Behnke

I CONCLUDED MY LAST COLUMN in the spring issue of Trout with an announcement that I would present my classifications of the species of trout, salmon and char of the world in this issue. This was somewhat of a rash statement on my part but, before I had second thoughts on the matter and could retract the announcement, the spring issue went to press.

My uneasiness in producing a classification concerns the uncertainties and ambiguities of classification – resulting in individual interpretations and controversy. Disagreement among fisheries experts regarding the classification of salmonid fishes is analogous to disagreements among experts giving opposing testimony during a trial on the sanity of a defendant, or among experts testifying on the true significance of cholesterol or the nutritive value of oat bran in relation to human health. In all of these situations, essentially the same data, evidence, and information is used to arrive at different and opposing conclusions – the experts disagree because of personal bias which results in different emphasis and interpretations. A personal bias may be the result of many reasons. A psychiatrist, testifying as an expert witness in court, using the same evidence, but with different emphasis and interpretation, could make a case for sanity or a case for insanity based on who was paying for the testimony.



Controversy over precise classification as species or subspecies should not interfere with conservation programs to preserve biological diversity.

If scientists lead or are part of a research program, they can also be expected to have a bias of self-interest to defend and promote their program as superior to contending programs. Thus, the diverse types of evidence used to classify organisms – morphological, biochemical, molecular, etc. – result in different types of research programs with biases reflecting different emphases. Different interpretations of the same evidence is possible because there is no set of rules or generally agreed upon definitions of categories of classification such as genera, species or subspecies. One ichthyologist may recognize two or three separate species, while another would classify these same fish as two or three subspecies of one species.

What does a nonspecialist do in such a situation? Typically, an "appeal to authority" is used. A committee of ornithologists might come up with a consensus of opinion on the number of species and genera of birds classified in a family. This is published as an "official" classification endorsed by a society. The classification is by decree; it may not be an accurate reflection of evolutionary reality but it is an official list which can be cited as the authority – yet subject to change.

As mentioned in the spring issue, there is still no official list of species of salmonid fishes of the world. The

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			gorbuscha
			nerka
			tshawytscha
			kisutch
			masou
		Rainbow, cutthroat trout (*Rhabdofario or Parasalmo*)	*mykiss*
			clarki
			gilae
			chrysogaster
	Salmo	Atlantic Salmon Brown Trout (*Salmo*)	*salar*
			trutta
			ischchan
			letnica
			marmoratus
		(*Platysalmo*)	*platycephalus*
	Acantholingua		*ohridanus*
	Salmothymus		*obtusirostris*
			zetensis
	Brachymystax		***lenok***
			savinovi
	Hucho	Huchen or taimen (*Hucho*)	***hucho***
		(*Parahucho*)	*perryi*
	Chars *Salvelinus*	(*Cristivomer*)	*namaycush*
		(*Baione*)	*fontinalis*
		(*Salvelinus*)	*albus*
			confluentus
			leucomaenis
			malma
			alpinus and others

American Fisheries Society has a list of North American fish species. I have some disagreement with this list concerning species versus subspecies classification of some of the trouts listed. But I have not elevated my disagreement to controversy status.

Before I present my interpretation of how many species of trout, salmon and char exist in the world, a brief review of concepts and definitions of a species would be helpful.

Historically, species have been defined as a group of organisms that reproduce their own kind. That is, species identity is maintained through time. In modern times, the biological species concept has developed which emphasizes the degree of reproductive isolation of a species. If a species is to maintain its identity (reproduce its own kind) it should not hybridize with other closely related species; if it did to any extent, it would lose its identity. A problem with the use of the reproductive isolation criterion for species recognition is that a whole spectrum of degrees of such isolation may occur between and within species, essentially unrelated to the magnitude of evolutionary divergence. For example, I would agree with the official American Fisheries Society's list that rainbow trout and cutthroat trout are two separate species. This is based on the fact that along the Pacific Coast, from northern California to southern Alaska, rainbow and cutthroat trout maintain their separate identities. The limited hybridization that does occur is insufficient to break down species identity to a significant degree. From a biological point of view, they are two separate species occupying two different niches when they coexist.

In inland waters where cutthroat trout are native but rainbow trout did not naturally occur, the two species did not evolve together. Niche differentiation is thus less distinct, resulting in a lack of reproductive isolation. In this case, the introduction and establishment of rainbows almost invariably has led to massive hybridization and loss of identity of native cutthroat populations. The subtleties and complexities of factors determining reproductive isolation – or lack thereof – can be observed within one subspecies of inland cutthroat trout: the west slope cutthroat, *Oncorhynchus clarki lewisi*.

In sections of the John Day River drainage of Oregon, and of the Salmon and Clearwater drainages of Idaho, the westslope cutthroat is native; it coevolved with native rainbow trout. In these waters the two species maintain distinct niches and avoid hybridization. In the Saint Joe drainage of Idaho and the Clark Fork drainage of Montana, westslope cutthroat trout are native and rainbow trout originally were absent (coevolution did not occur). Here, reproductive isolation is absent and the two species cannot maintain their separate identities after rainbows become established.

Another extreme of reproductive isolation between closely related populations of one species can be observed with rainbow trout. A single river might contain summer-run steelhead, winter-run steelhead and resident, non-anadromous rainbow trout – all coexisting with reproductive isolation from one another. In this case, separate species recognition is not given because different races of steelhead and rainbow trout are the result of multiple, independent origins within the species in relatively recent geological time.

With an admonition concerning the uncertainty involved in compiling a list of species, I will invoke my "authority" and proceed to examine the branches identified as genera in that part of the family tree identified as the subfamily Salmoninae in the spring issue of ***Trout***.

The first major divergence examined is the char genus *Salvelinus*. The number of species which should be recognized in this genus is, by far, the most controversial aspect of the classification of salmonid fishes. For many years, controversy has raged in the international literature on char classification. I have contributed my share to this controversy and, looking back, I admit I have often been less than charitable in expressing my disagreements with opposing viewpoints.


Govt. closes area after man-eater swallows swimmers!

35-foot fish eats people and horses!

EXPERTS can't explain the colossal size of giant fish that swallows men and horses alive.

By DEREK CLONTZ

At least 50 horses and a dozen men have been eaten alive by a 35-foot fish that swallows its victims whole, the *New China News Agency* reports.

More than 5,000 tourists flocked to Karas Lake in China's remote Xinjiang province after villagers claimed to have seen the creature feeding on full-grown horses that waded into the lake to drink.

The entire area has since been declared off-limits by Chinese government officials, who believe 12 unsuspecting swimmers were swallowed whole while frolicking in the treacherous water.

"We have absolutely no explanation for the phenom-

Tourists Flock to See China's Monster Fish

PEKING (UPI)—Thousands of Chinese tourists have visited a remote lake in western China to glimpse a horse-eating water monster, the official New China News Agency said Wednesday.

More than 5,000 tourists have visited the remote 16-square-mile lake in China's far western Xinjiang province since sightings were first reported in the press last

HEADLINES in newspapers around the world have told of the giant fish. Clipping above is from the *Los Angeles Times* and tells of the thousands of tourists looking for the monster.

Baffled scientists determined

sents such a threat to livestock and humans, government brass hats initially wanted to blow it to smither-

steel oil drums as bobber

"From a scientific stan point it is crucial that w take the fish alive," he sai "But catching it is going be much more difficult tha we thought.

"The fish weighs a coup of tons at least. So far it h stripped the goats off thre anchors, which we use f hooks, and snapped thre cables that serve as line.

"It's truly amazing

In the realm of science fiction hearsay...

An observation can be noted on the lack of consistency correlating common names of species with their scientific classification. In North America, for example, we recognize lake trout, brook trout and bull trout in the genus *Salvelinus,* rainbow trout and cutthroat trout in the genus *Oncorhynchus,* and brown trout in the genus *Salmo.*

No matter if we call them trout or char, the species of the genus *Salvelinus* can be clustered into three main evolutionary lines within the genus. Two of these lines lead to single species: lake trout and brook trout, native only to North America. Trying to unravel the cluster of species associated with the third evolutionary line which includes Arctic char, Dolly Varden and bull trout is enormously difficult and complex. Besides the three above mentioned species, a fourth "good" species, the Far Eastern char, *Salvelinus leucomaenis,* occurs in Asia *(S. leucomaenis,* is a good species because there is no disagreement on its recognition – only its relationships to other species). I would recognize the stone char, also in Kamchatka, named *S. albus,* as a good species. In my classification, I group the stone char with *S. confluentus,* as species sharing a close evolutionary relationship (more closely related to each other than to other species of char). Only an educated guess can be made on how many "good" species are included among the char currently lumped as Arctic char, *S. alpinus* in Europe, Asia and North America.

In recent times, three new species of char have been described from the Soviet Far East. Two of these new species occur in only one lake on the Chukokst Peninsula (across the Bering Strait from Alaska) and are highly divergent from any known species. How many new species remain to be discovered when the remote char lakes across Siberia are investigated? Until then, I would make a rough estimate that the genus *Salvelinus* contains about 15 species of char, among which is the third largest species of the family Salmonidae, the lake trout, *S. namaycush,* with a maximum recorded weight of 102 pounds. Other species of char that can attain a large size include Arctic char and bull trout which have been recorded at about 30+ pounds.

Also associated with the genus *Salvelinus* in my classification are the genera *Brachymystax* and *Hucho* (species of all three genera lack teeth on the shaft of the vomer bone in roof of mouth and have a highly specialized type of lateral line scale). The genus *Bachymystax* is generally considered to contain a single species, the lenok, *B. lenok.* The lenok is a trout-like fish occurring in river basins across Siberia from the Ob River eastward and south to the Amur River drainage and mountainous sections of the Yellow, Lo, and Han river drainages of China (the lenok of China was described as a separate subspecies from other lenok). It has long been known, however, that two forms of lenok occur: a sharp-snouted lenok and a blunt-snouted lenok. Both forms occur in the Amur River basin. It is likely that the fish called lenok actually represents two distinct species.

Lenok are not known to go to sea. They feed mainly on invertebrates and readily take flies and lures. Their maximum size is about 15-16 pounds.

For anglers, the genus *Hucho* is of interest, because it contains the Siberian taimen, probably attaining the largest size of any salmonid fish. I classify the huchen *(Hucho hucho)* of the Danube River of Europe and the Siberian taimen as two subspecies of one species – *H. hucho hucho* and *H. hucho taimen.* They are very similar to each other, but the taimen appears to attain a greater maximum size than the huchen (perhaps about 150 pounds versus 110 pounds). Exactly how large a size taimen may attain is unknown. They occur in remote areas with little sport fishing and no official record keeping. The taimen is not an important commercial fish so few detailed studies on size and growth can be found in the Russian literature. The largest size I have found documented in the literature (based on specimens weighed and measured) is 123 pounds (which is less than the 126-pound commercially caught Chinook salmon) but the hearsay evidence of much larger fish is enticing.

In the realm of science fiction hearsay, a few years ago, one of the supermarket tabloids had a headline story of a 35-foot-long, 2,000-pound "trout" in a lake of Sinkiang Province, China, which fed on horses and goats. Although I consider such fish stories in the same category of tabloid veracity as the 80-year-old woman who gave birth to a two-headed baby, the name of the lake was given (Hanas Lake). I consulted a Chinese book on the wildlife of Sinkiang Province, and found that taimen do indeed occur in Hanas – where they "attain a size of up to 10 kg. [22 pounds] and more." How much more? I doubt 2,000 pounds more. More substantative hearsay in the

Russian literature includes an 1871 report mentioning that in the Yenisei, Pyasina and Khatanga (rivers of Siberia draining to the Arctic Ocean), "taimen may reach 80 kg [175 pounds] and more."

A 1929 publication recounted testimony of local people on the Uda River (a tributary to the Okhotsk Sea north of the Amur River) that taimen may reach six-pud (a "pud" is an old Russian weight equal to 16.4 kilograms or 36 pounds). There do indeed appear to be large taimen in the Uda River.

In 1989, Larry Shoenborn, producer of the *Fishing the West* television program, visited the Far East to do some angling for exotic fishes. He sent me a photograph of a taimen caught in the Uda River which he estimated to be about 80 pounds – evidently the trophy was cut up and consumed before an official weight could be recorded. Obviously the taimen of Siberia and the Soviet Far East offer a great opportunity to anglers seeking trophy and world record size fish. Be forewarned, however, that there is no transportation network that can easily bring you to a prime taimen river. Accommodations and services typically associated with tourism are nonexistent.

As more foreign anglers fish for taimen, we can expect to learn more about their maximum size. Most sport fishing for taimen is with large spoons and plugs. A size 4/0 Muddler Minnow, though, might really turn them on, or perhaps a horsehair streamer would do the trick on the Hanas Lake monster. Anglers who enjoy tarpon on a fly rod might find the taimen an exciting new challenge.

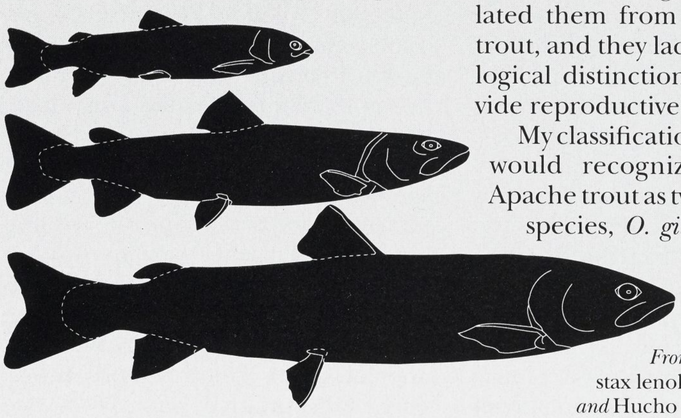
The distribution of taimen is quite similar to that of the lenok, except the taimen occurs farther to the west – to the Pechora River.

A second, quite different species of *Hucho, H. perryi,* occurs in Hokkaido and Sakhalin islands of the Far East. In contrast to the Danube huchen and the Siberian taimen, which are strictly freshwater fish, *H. perryi* spends part of its life at sea.

A fish named *Hucho bleekeri* is known from a small segment of the Yangtze River basin. Virtually nothing is known of *bleekeri.* I suspect it represents a subspecies of *H. hucho* or *H. perryi.*

Moving from the char, lenok and taimen, to the "pure" trout and salmon branches of the family tree, the genera *Oncorhynchus* and *Salmo* can be assessed to determine how many species they contain. As discussed in the winter issue of ***Trout***, the genus *Oncorhynchus* has been expanded to include species of western trout formerly classified in the genus *Salmo.* I recognize six species of Pacific salmon in North America and Asia. The masu or cherry salmon, *O. masou,* is restricted to the Far East; the other five species occur in both North America and Asia. The western North American trouts can be divided into two major evolutionary groupings classified as rainbow trout, *O. mykiss,* and cutthroat trout, *O. clarki.* The American Fisheries Society officially recognizes four additional species: California golden trout, *O. aguabonita;* Apache trout, *O. apache;* Gila trout, *O. gilae;* and Mexican golden trout, *O. chysogaster.* A problem for classifying these four kinds of trout as species or subspecies concerns reproductive isolation, or lack thereof. None of them can maintain its identity when occurring with either rainbow or cutthroat trout. Their original distribution isolated them from contact with other trout, and they lack behavioral or ecological distinctions which could provide reproductive isolation.

My classification is a compromise. I would recognize Gila trout and Apache trout as two subspecies of one species, *O. gilae gilae* and *O. gilae apache.* Species recognition is based on the distinctive chromosomes shared by both Gila and Apache trout, but the extremely close genetic relationships between them argues that they should be classified as two subspecies of one species rather than separate species. The Mexican golden trout is quite different from other trout in several characteristics. I would retain separate species classification for *chrysogaster,* at least until more is known about its evolutionary history. I would classify the California golden trout as a subspecies of rainbow trout, *O. mykiss aguabonita,* based on its close genetic relationship to rainbow trout and lack of reproductive isolation.



From top to bottom, Brachymystax lenok, Hucho hucho taimen, *and* Hucho hucho hucho

In the genus *Salmo,* the Atlantic salmon, *S. salar,* and the brown trout, *S. trutta,* are two well-known species. A well marked, but lesser known, species is the marbled trout, *S. marmoratus,* of tributary rivers to the northern Adriatic Sea. The marbled trout is a large predator, attaining weights to about 50 pounds. It has only light colored, marbled markings on its body, similar to char of the genus *Salvelinus.* The genetic relationship of *S. marmoratus,* however, is close to *S. trutta,* and the two species are known to hybridize when they occur together. Two additional species are commonly recognized in the genus *Salmo*: *S. letnica* of Lake Ohrid, Yugoslavia, and *S. ischchan* of Lake Sevan, USSR, represent ancient invasions of an *S. trutta* ancestor into these lakes and subsequent specializations and differentiation.

There are a few odds and ends of species on the family tree whose connecting points remain largely unknown.

In 1968 I described a new species of trout from Turkey in the genus *Salmo.* This species is known only from three specimens. These specimens are highly divergent from *S. trutta* and I created a new subgenus *(Platysalmo)* to emphasize the uncertain relationships of the species *platycephalus.* Until additional specimens become available, this Turkish species remains in an uncertain position on the family tree. *S. platycephalus* is the only trout on the world's list of endangered species.

In a few rivers on the Adriatic coast of Yugoslavia, at least one – probably two – species of trout classified in the genus *Salmothymus* occurs. As the genus name implies, this fish was originally believed to be intermediate between trout *(Salmo)* and grayling *(Thymallus)*. Undoubtedly, *Salmothymus* belongs in the subfamily Salmoninae, probably close to the genus *Salmo*. They attain a maximum size of only a few pounds, but are loads of fun on a dry fly.

The most distinctive species of "trout" apparently far removed from any other living species, is *Acantholingua orhidanus*, existing as a single population in Lake Ohrid, Yugoslavia. This species has a smelt-like appearance and possesses the most primitive dentition pattern of any salmonid fish. All of its near-relatives are long extinct and its position on the family tree is uncertain.

Now that anglers have at least a provisional list of the known, the good and dubious species of trout, salmon and char of the world, perhaps a phenomenon comparable to the bird watcher's bird list might develop. World travelers who enjoy exploring remote regions might vie with one another to see who can list the greatest number of species fairly captured by angling.

As a final word on conservation, I would point out that controversy over precise classification, and recognition of a particular form of trout as a species or a subspecies, should not be allowed to interfere with conservation programs to preserve the biological diversity within species. The truly significant diversity in life histories and ecological adaptations are not associated with formal classification.

The winter-run Chinook salmon of the Sacramento River, for example, is the only race of this species that spawns in the spring. Because of a highly modified winter flow regime in the Sacramento River, this significant form of diversity within the Chinook salmon species faces extinction. It has been proposed for protection under the Endangered Species Act. The Endangered Species Act defines a "species" to include subspecies and even unique populations (such as the winter-run Chinook population). An effective endangered species conservation program must protect the diversity within a species.

The "world record" size fish of each species of trout, salmon and char typically are associated with a single race or population. The world's largest Chinook salmon is a race which spawns in the Kenai River, a moderate sized Alaskan river. The largest rainbow trout is the summer-run steelhead of the Skeena River drainage, British Columbia, and the Gerrard population of Kamloops trout, spawning in a single tributary of Kootenay Lake.

The world's largest cutthroat trout was the original population native to Pyramid Lake, Nevada (cutthroat trout of the same subspecies introduced into Pyramid Lake do not attain half the maximum size of the original population). The world's largest brown trout is the population of winter-run fish in the Kura River from the Caspian Sea. These examples of significant biological diversity should be preserved no matter how they are classified.

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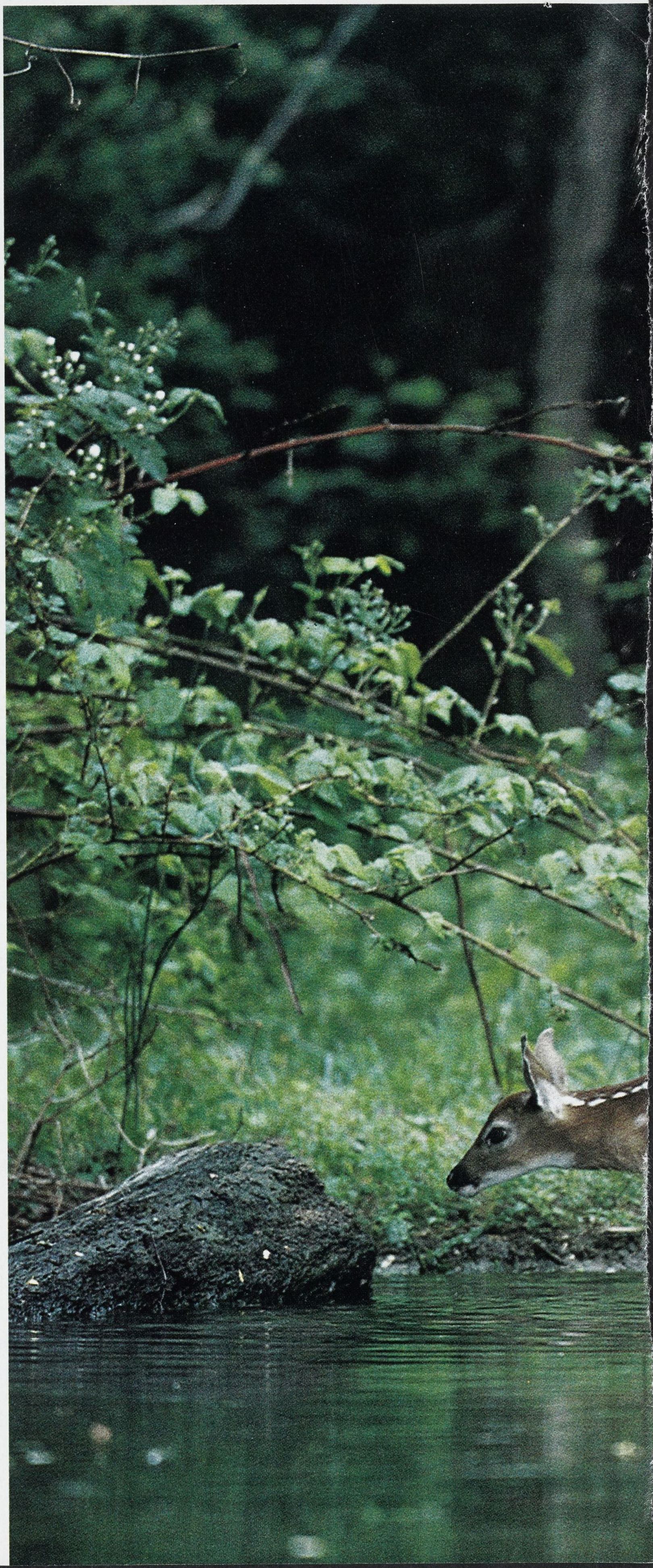


The Family Tree: Origins of Trout and Salmon

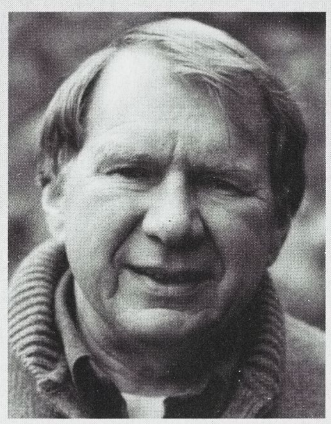
Science, Speculation and 100 Million Years of Salmoniformes

Robert J. Behnke

OUR CONCEPT OF TIME is colored by experience. A human life span of 100 years is perceived of as one of extreme duration. To examine the evolutionary history and origin of the family Salmonidae, a time frame of 100 million years is suggested. The events and changes on earth during this enormous duration, acting to direct the course of evolution, are known only by bits and pieces. Any attempt to recreate a scenario of the evolutionary history of trout and salmon – from the origin of the family to living species – must include considerable speculation.

To place the family Salmonidae in a larger evolutionary context, we must go back about 500 million years to the origin of vertebrate animals.

The earliest vertebrates (animals with backbones – although the primitive "backbone" is a cartilaginous rod, or notochord, without bone) are grouped in the class Agnatha (jawless vertebrates). Agnathas had mouths but no skeletal elements forming jaws. They lacked paired fins – no pectoral or pelvic fins. They had only a single nostril. About 60–70 species of Agnatha still persist which we know as lampreys and hagfishes.



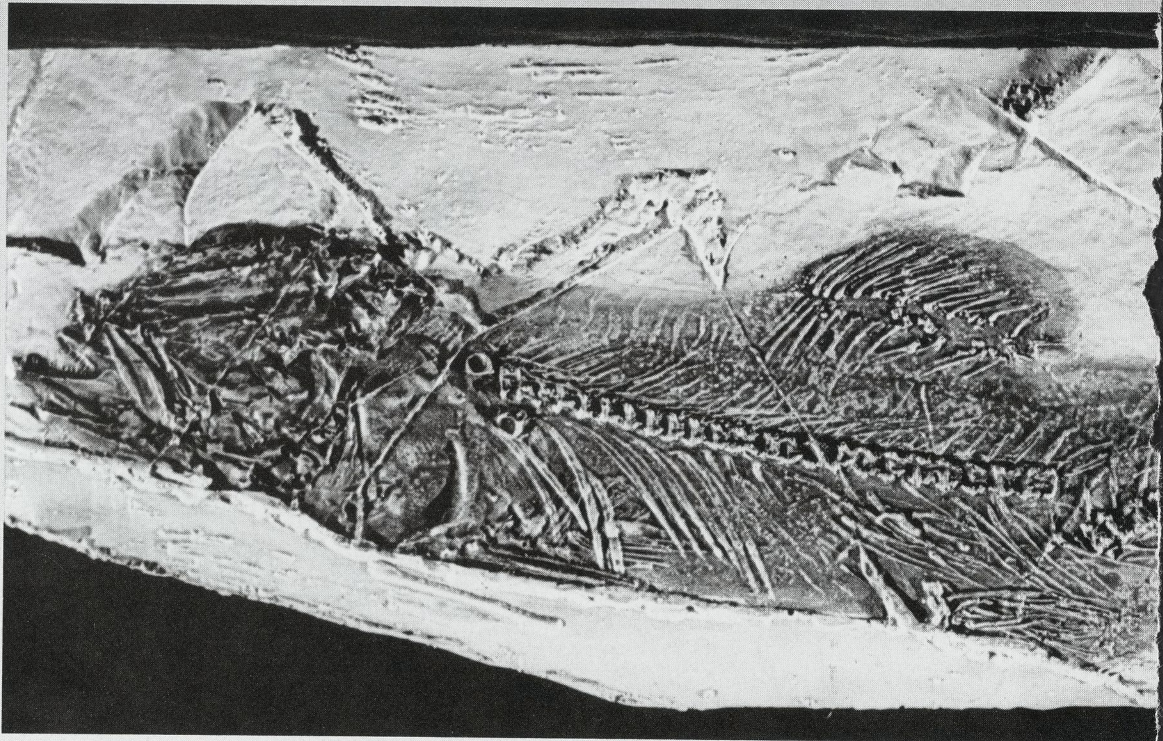
The sabertooth salmon of Pliocene times reached lengths of six feet or more and possessed a large fang at the tip of its jaws.

Evolution is often thought of as new groups of more advanced species replacing more primitive species which become extinct. In this light, it may seem strange that several extremely primitive species, retaining the same basic physiology and anatomy possessed by their ancestors of hundreds of millions of years ago, are still around. One species, the sea lamprey, is not only still around, but it devastated the modern fish fauna of the Great Lakes once it got above Niagara Falls and gained access to the upper lakes. It also has proved highly successful in persisting despite intensive efforts to eradicate it by traps, electrical wires, and chemical treatment of spawning streams. The sea lamprey might be considered as an "evil" species in relation to its impact on the Great Lakes, but it is certainly an evolutionary success story.

The primitive lamprey's success story might, at first, seem analogous to a Model-T Ford winning the Indianapolis 500, finishing ahead of all the most advanced vehicles. Actually it is more analogous to a Model-T, fitted with balloon tires, winning a race across a swamp. Its lightness would give the Model-T an advantage over modern cars in that particular environment. That is, it would fill the "swamp" niche better and win the race in that environment. Living species of lampreys and hagfishes occupy unique niches. They use their jawless mouths for a variety of feeding specializations in different species or different life history stages such as filter feeding, scavenging, and parasitism – feeding specializations for which no modern fish species competes.

An understanding of niche specialization explains the origin and persistence through time of trout and salmon and of all existing species – they do something better in a particular environment, under particular conditions, than other species (which also persist by doing something else better to avoid or reduce interspecific niche overlap).

During the period from about 500 to 400 million years ago, primitive fishes developed many anatomical advancements including jaws and paired fins. These advancements resulted in a proliferation of new "models" to fill new niches. By 400 million years ago, two main trends of jawed fishes became established – the cartilaginous fishes of the class Chrondrichthyes (sharks and rays), and bony fishes of the class Osteichthyes. The bony fishes subdivided into three subclasses – one for lungfishes, one for coelacanths, one for ray finned fishes (subclass Actinopterygii). During the late Paleozoic era to the middle of the Mesozoic, or from about 250 to 150 million years ago, the ray finned fishes evolved many further advancements leading to the origin of modern body fishes, or teleosts, which gained overwhelming dominance in the world of fishes.



There are about 750 living species of sharks and rays, six species of lungfishes, and one living coelacanth. The more primitive Actinopterygii persist as about 30 species of sturgeons and paddlefish, about 11 species of African bichirs or reedfish (order Polypteriformes), five species of gar and one species of bowfin. In contrast, there are about 20,000 known species of teleostean fishes, with about 100 or more new species described each year. The teleosts dominate in numbers and biomass in virtually all freshwater and marine environments. Once a certain combination of evolutionary advancements in jaws, fins and skeletal structure was attained, teleosts proliferated with great evolutionary success.

During the early to mid Cretaceous period of the late Mesozoic era, from about 100 to 130 million years ago, several divergent lines of teleost evolution became established which have persisted to the present. These include groups we recognize as the orders Clupeiformes (herrings, shad, anchovies, sardines), Osteoglosiformes (bonytongues, including the mooneye and goldeye of North America), Elopiformes (tarpons and bonefishes), and the very successful superorder Ostariophysi which includes all the minnows, suckers, catfishes and characins. All of the above teleostean orders possess some specialized features which indicate they were not in the mainline of teleost evolution leading to the modern spiny-rayed fishes (such as perch and bass).

The order Salmoniformes includes a Southern Hemisphere group exemplified by the families Galaxiidaeand Retropinnidae of Australia and New Zealand, a Northern Hemisphere group including Salmonidae and Osmeridae (smelts) plus several families of deep-sea fishes. The general, primitive features exhibited by various families of salmoniform fishes indicate that the mainline of teleost evolution went through the Salmoniformes (or via a common ancestral branch). Thus, the order Salmoniformes most probably had its origin well over 100 million years ago. This ancient evolutionary heritage can be readily observed in living species of salmon and trout. Primitive characteristics include the smooth (cycloid) scales, fins without spines, position of the pelvic fins under dorsal fin rather than under pectoral fins (as in perch and bass), upper jaw formed by maxillary bone (premaxillary in perch and bass), rays of caudal fin (tail) supported by three upturned vertebrae, vestige of spiral valve intestine, absence of oviducts, presence of abdominal pores, etc.

There is little doubt that the combination of these primitive traits denotes a very ancient origin for the family Salmonidae. Until the fossil record is better known, however, the timing of this origin is a matter of educated guessing. An origin of about 100 million years ago appears reasonable in relation to the great antiquity of the order Salmoniformes. It is probable that trout-like fishes of the family Salmonidae, not vastly different in appearance or in ecology from living species, inhabited coldwater streams when dinosaurs still roamed the earth.

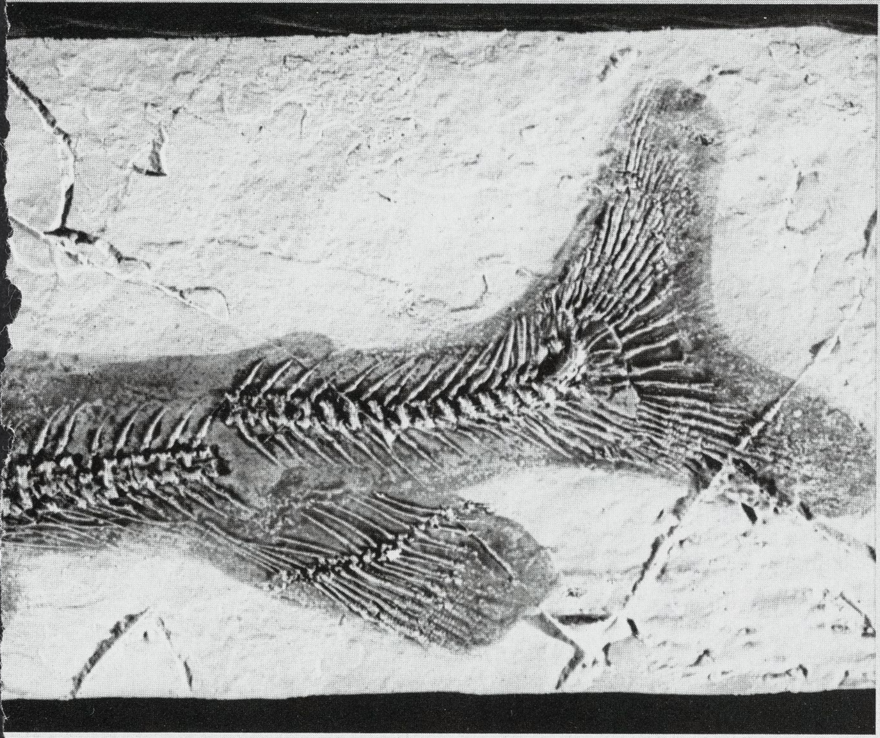
The origin of the family was likely the result of a polypoid event (doubling of chromosome numbers) in a common ancestral species. All three subfamilies, Coregoninae (whitefishes), Thymallinae (grayling), and Salmoninae (trout salmon, char), have about twice the amount of DNA in their chromosomes as do species in other families of the order Salmoniformes. Thus, it can be assumed that this polypoid event occurred in a common ancestor prior to the divergence into evolutionary lines we now recognize as subfamilies.

The earliest documented fossil definitely classified as Salmonidae was found in Eocene deposits of British Columbia (45-50 million years old) and named *Eosalmo driftwoodensis. Eosalmo* was a trout-like fish, apparently of the subfamily Salmoninae. If further research confirms subfamily classification, it would demonstrate that the three subfamilies had diverged from each other by at least 50 million years ago; this would lend credence to an estimate of about 100 million years since the origin of the family.

The question of habitat of the original ancestral salmonid fish – freshwater or marine – has been long debated but never fully resolved. The evidence that all living species reproduce in freshwater argues for a freshwater origin. The fact that many whitefish species and most species of salmon, trout and char have anadromous populations is evidence that the physiological adaptation for osmoregulation in the sea (ability to retain water and excrete salts) has been passed on from the earliest ancestor.

It is probable that, from the earliest ancestor to the present, salmonid fishes have always been coldwater species, restricted to the cold waters of the Northern Hemisphere. During the early periods of salmonid evolution (Eocene and earlier) the Northern Hemisphere was one great land mass (Laurasia = North America, Greenland, Europe and Asia) which became separated by continental drift and the intervening area filled in by the Atlantic and Arctic oceans. Such geological events are typically associated with evolutionary divergences. For example, with living species of trout and salmon we can trace a Pacific basis origin for Pacific salmons, rainbow and cutthroat trout, and an Atlantic basis origin for brown trout and Atlantic salmon (why rainbow and cutthroat trout are now classified in the same genus, *Oncorhynchus,* with Pacific salmons as discussed in the last issue of ***Trout***).

During the history of the earth there have been many alternating periods of global warming and global cooling which would shift the distribution of salmonid fishes. During warming periods the distribution shifted from south to north and vice-versa during cooling periods. During the Eocene period, when *Eosalmo* inhabited waters of British Columbia, a series of large lakes (the Green River lakes) occurred in southwest Wyoming, northwest Colorado and northeast Utah. The fossil fishes of the Green River lakes have been well studied. The fish fauna inhabiting the Green River lakes of 40 to 50 million years ago was typically of warmwater fishes – species of gars, bowfins, paddlefish, suckers, ancestors of mooneye and goldeye, herrings and catfishes. But no salmonid fossils have been found. Evidently the climate was too warm for coldwater fishes in this region during that period.



Rare, near perfect fossil of earliest known salmonid in North America, *Eosalmo driftwoodensis*, alive 45–50 million years ago.

photo courtesy of the University of Alberta

The fossil record for Salmonidae is spotty. There are two reasons. First, the preservation of an organism as a fossil is a rare, chance event and the finding of fossils is also largely a rare, chance event. The second reason concerns the number of people who study fossil fishes (paleoichthyologists) and who have a particular interest in salmonid fossils. Currently, most research on salmonid fossils is centered at two universities – the University of Michigan (Dr. Gerald Smith and associates) and Ohio State University (Dr. Ted Cavender).

In recent years, an increasing number of salmonid fossils have been discovered in the western United States, representing species which lived during the Miocene to early Pleistocene times or from about 20 million to about two million years ago. I must emphasize again that the fossil evidence is sketchy; an evolutionary scenario presented now is likely to change in the future as more fossils are found and studied. Attempting to envision how the family tree of Salmonidae was constructed during a distant time period from the evidence of a very few terminal branches (fossil specimens) is analogous to a blind person describing the morphology of an elephant from assessing a few parts of the animal – a rough approximation might be possible.

With this reservation in mind, the following approximation is given.

After *Eosalmo*, a gap of about 25 million years in the fossil record of Salmonidae occurs which obviously leaves a large blank area on the family tree. The early Miocene fossils suggest that a major branching in the subfamily Salmoninae had become well established with one branch leading to the present genera of *Brachymystax* (Siberian lenok), *Hucho* (European huchen and Siberian taimen), and *Salvelinus* (chars), and the other branch leading to the trouts and salmons of the genera *Salmo* and *Oncorhynchus*. Evidently, both ancestral char-like and huchen-like species occurred in western North America during the early to mid-Miocene period.

By the late Miocene, species we now classify in the genus *Oncorhynchus* were widely distributed in western North America. Three major groups have been distinguished. Besides the ancestors of the living species of Pacific salmon (*Oncorhynchus* in the strict sense as limited by former classification), there were two groups of trout-like species. Among northern fossils (Oregon and Idaho), a trout with a rod-like upper jaw bone predominates. This type of fossil trout was originally described as the genus *Rhabdofario*. In Nevada, late Miocene fossils of trout, evidently ancestral to rainbow and cutthroat trout, have been more commonly found. Some of these fossil species apparently were anadromous. Some lived in lakes and some lived in streams, similar to the present types of life histories.

Many of the ancient species were probably not vastly different from living species in size, appearance or ecology. Some fossils, however, represent rather bizarre evolutionary models highly divergent from the mainstream of evolution. The sabertooth salmon of Pliocene times reached lengths of six feet or more and possessed a large fang at the tip of its jaws. The great development of gillrakers in the sabertooth salmon, however, indicate it fed by straining plankton, probably in the ocean.

Ancient southward distribution of trout during periods of global cooling are documented in the fossil record from the Lake Chapala basin of Mexico, about 250 miles south of present distribution of living species. In other parts of the world, populations of living species exist as glacial relicts. Because these relict populations do not exhibit significant divergence from more northern populations of their species, it is assumed that they attained their southern distribution in relatively recent times. Perhaps this occurred during the last glacial epoch (10,000 to 50,000 years ago) when ocean temperature were cooler. Such examples include the masu salmon of Taiwan, the taimen of the Yangtze basin of central China and the brown trout of North Africa. For Europe and Asia, the fossil record of Salmonidae is virtually unknown and there are no paleoichthyologists studying Eurasian salmonid fossils.

Today about all that can be done to backtrack on the family tree, to assess the times and places of branching leading to all living genera and species, is to compare various types of characters denoting the different genera and how they change through evolutionary time. This is essentially how ichthyologists arrive at a system of classification that reflects evolutionary relationships. Admittedly, the evidence is often inconclusive and calls for professional judgment to arrive at a classification of all living species and their assignment to genera. Because of this uncertainty, disagreement exists among ichthyologists regarding which classification is "best" – which most accurately reflects evolutionary relationships and branchings of the family tree. With this warning of hazardous authenticity, I plan to present my classification of salmonine fishes (subfamily Salmoninae) in the upcoming summer issue of ***Trout***.

A look at the native cutthroats of the West

The Trout of the Shining Mountains

ERNEST SCHWIEBERT

OUR FIRST KNOWLEDGE that the Rockies existed is recorded in the journals of Jonathan Carver, written before the American Revolution. Carver left Fort Mackinac, on the Great Lakes, in the melting snows of the spring of 1766 with the mission of charting the upper Mississippi and making contact with 175 frontier Indian tribes. His expedition logs later were published as *Travels Through the Interior Parts of North America.*

Like the Spanish expeditions that searched through the North American West for cities of gold, Carver listened to rumors in the Indian villages about the "Shining Mountains." His party concluded excitedly that there must be glittering mountain summits covered with diamonds and other precious stones. Carver was obviously wrong for the Shining Mountains turned out to be the Rockies, but his journals were our first account in English of the frontier that waited beyond the Indian's Father of Waters, the Mississippi River. Jonathan Carver attempted to mount a second expedition into the high plains and the Shining Mountains, but his dreams were shattered when a tribal war broke out between the Chippewa and Sioux in 1767. Meriwether Lewis and William Clark did mount such an expedition, however, in 1804 when their party, under orders from President Thomas Jefferson to explore the West, set out for the Pacific from Saint Louis. Captain Lewis sighted the Rocky Mountains the following spring when he climbed the bluffs along the Missouri River to establish the expedition's position with his sextant. The sight of the snow-covered mountains erased any thoughts of cartography, and Lewis later recorded his feelings in his logbook:

> *These points of the Rocky Mountains were white with snow, and the sun shone on them in such a manner as to give me the most plain and satisfactory view. While I viewed these mountains I felt a secret pleasure in finding myself so near the headwaters of the heretofore conceived boundless Missouri.*

Although Lewis and Clark were not fully trained naturalists, their journals described 122 species and subspecies of flora and fauna that were still unknown at the threshold of the 19th Century. Their logs were bound in soft elkskin, and included extensive observations on the birds, plants, animals and fishes of the frontier. The beautiful black-spotted cutthroat is described in those worn elkskin journals carried by Meriwether Lewis. His notes are complete with a rudimen-

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As the fly completes its drift and swings to shore, a very slow retrieve will occasionally produce a strike. But most strikes will occur as the nymph tumbles with the current close to the streambed. Setting the hook at any pause in the line's drift will usually hook the most trout, and unfortunately the most snags as well. Always keep some slack available at the end of the swing to prevent a fish from striking on a taut line against the reel. Because stonefly nymphs swim poorly in fast currents, any holding water in or below quick riffle areas is a good place to fish imitations.

Large suggestive nymphs seem to work as well as or better than exact imitations in fast-water situations. Many Western anglers seem to choose the impressionistic Woolly Worm in a dark color or the Montana-style stonefly nymph instead of exact patterns tied in the flat-body style of the natural insect. Fish feeding in turbulent current situations — where stonefly nymphs are usually available — have little time to examine the drifting fly. Tumbling with the current, Woolly Worms or other generally suggestive patterns present much the same form as an exact-imitation nymph does. Using heavy hooks and tying nymphs with several wraps of lead wire beneath the body material help sink the flies in heavy water. Shallow riffles and slow-current areas require lightly weighted patterns — and sometimes even lighter hooks with no extra weight for a productive drift.

In streams with heavy stonefly populations, a large nymph imitation is usually the most consistently productive fly, especially for large fish, throughout the season. The nymph is best during preemergence, when many nymphs are available to the trout, and it is less effective when fish are surface feeding on adult stoneflies. It is a rare day on stonefly-populated Western rivers when a large stonefly nymph fished in heavy holding water doesn't produce at least a few strikes.

THE ADULT STONEFLY emergence starts slowly each year with a few winged adults appearing on the river bank. On a warm afternoon you might see an occasional stonefly ponderously flying over the river. At this time there are not yet enough adults to interest the trout, and an adult on the water might float over many fish without being taken. But then, over a three- or four-day period, more and more adults emerge, climbing along the banks, mating, and making short flights over the river. Quickly taking notice of these large morsels of food, the trout will usually move into position near overhanging trees from which the stoneflies are most likely to fall.

Little activity takes place each day until the sun evaporates the morning dew and warms the air. On windy days most of the adult insects avoid flying, clinging tightly to grass or tree branches. But on calm days many stoneflies start mating flights near the river by 10 A.M. The adults move most actively during the warmer parts of the day, and this is when dry-fly fishing is best. Usually the flight activity and the number of flies available to the fish will decline as the sun drops, but an uncommonly warm and calm evening can trigger a huge flight of stoneflies, with some soaring hundreds of feet into the air.

A heavy emergence of stoneflies will encourage even the largest trout in a river to surface feed. For example, there is a mixed population of brown and rainbow trout in a fascinating stream north of Bend, Oregon. Beginning small in size but growing quickly from large springs flowing from the lava-rock canyon walls, the river holds a sizable number of large browns. The big brown trout are mostly nocturnal feeders and very difficult to take on a fly during much of the season. At the peak of the giant stonefly hatch, however, they lie like shadows at the tails of the pools waiting for the egg-laying female insects to land or flutter on the water. The trout take the large adults in a splashy rise. They seem to know that a deliberate approach would let many escape; when the females deposit their eggs they are on the water only for a few seconds, if at all. Also, a stonefly falling onto the water will usually swim or attempt to fly to shore as quickly as it can. Only late in the emergence, as the adults weaken and begin to die, do they become easy pickings for the trout. But at that time the trout, with stomachs bulged by large numbers of stoneflies, show a diminishing interest.

Fishing stonefly adults is comparatively easy dry-fly fishing. The large patterns normally used are good floaters and easy to see, and a delicate presentation is unnecessary. A natural drift produces the most strikes, although as long as the fly is floating trout may strike at it. Natural stoneflies often flutter on the surface and move contrary to the currents; a dragging fly probably imitates this. When trout concentrate beneath overhanging trees, which they often do in order to wait for falling insects, accurate casting is needed to present the fly. Sometimes it is productive to float a stonefly imitation downstream by feeding out extra line and letting the current take the artificial under the trees.

The giant stonefly adults are imitated best by flies tied on long-shank, #4-#8 hooks, with the wing attached flat along the top of the hook. Many patterns are satisfactory, with the hair-winged Sofa Pillow and the quill-winged English Stone among the more popular. Hair-winged patterns have superior floating qualities and are better in fast water. My favorite imitation has both a dark elk-hair and turkey-quill wing and works well under varied conditions. On the Deschutes River the darker *Pteronarcys* and the yellow *Acroneuria* emerge at the same time, and artificials resembling either insect normally work. Several species of smaller stoneflies emerge before or after the primary hatch, but rarely in quantities sufficient to excite a general rise of trout. These limited hatches can usually be matched with artificials tied on #10-#12 hooks. Many of the larger caddis patterns are as adequate as small stonefly imitations and can be doubly effective during simultaneous emergences of caddisflies and stoneflies. Frequently trout will switch from stoneflies and begin feeding on a mayfly or caddisfly hatch even though substantial numbers of the larger insects are available. It pays to be observant and to be as flexible with fishing techniques as trout are with their feeding habits.

Common cutthroat (Salmo clarki)

Yellowstone cutthroat (Salmo clarki lewisi)

Illustrations by the author

Jackson Hole cutthroat (Salmo clarki carmichaeli)

Lahontan cutthroat (Salmo clarki henshawi) tary drawing and a description of its coloring and taxonomy.

Since the frontiersmen with Lewis and Clark were from the Appalachians and American Northwest Territories, the only trout they knew were brook trout, *Salvelinus fontinalis*, the bright-spotted little native found throughout colonial America. The pale, black-spotted trout of the Shining Mountains were as exotic to these explorers as the forty-five-foot dinosaur skeleton they exhumed along the Missouri. Lewis christened these unfamiliar fish *Salmo clarki*, honoring his fellow expedition leader, and that designation persists today as the genotype of all cutthroat strains.

When the explorers traveled back across the mountains to Saint Louis, the company split into two parties in Western Montana, and Clark led a portage from Three Forks to the Yellowstone. His party discovered a second cutthroat in that drainage, this one more brightly colored and with a spotting pattern concentrated toward its caudal fin. It has since been designated *Salmo clarki lewisi* in honor of Meriwether Lewis, and because of modern federal stocking programs, these Yellowstone trout are perhaps the most widely distributed of our cutthroats today. Although they did not know it, Lewis and Clark had discovered the genotypes of a widespread group of trout, for subsequently during frontier times some twenty cutthroat species were found from the mountains of northern Mexico to the Alaskan rivers of Prince William Sound.

Considerable argument and confusion still exists among experts in the biology and taxonomy of trout, and our perspectives on the cutthroats are still changing. Many experts argue for the single-species concept with a widespread distribution of subspecies — the conservative view of cutthroat taxonomy — while others have evolved a more radical position based upon our growing knowledge of genetics. This latter group contends that the designation of species cannot be based solely on physical structure, since we can use other new biochemical techniques that give precise genetic coding to define species in genetic terms. Science resolves such disagreements slowly, but it seems likely that several cutthroat subspecies will ultimately be granted the status of fully separate species, based upon our knowledge of their chromosome counts and genetic coding.

Several cutthroat strains still exhibit thriving populations, particularly in the river systems first explored by Lewis and Clark, and among the so-called harvest cutthroats of the Pacific Coast. Prudent management and husbandry of their habitats should protect these populations in the future. But other cutthroat populations have been less fortunate. Three of the original strains are extinct, and five strains still lack formal Latin names, although some taxonomists argue that several do not belong with the cutthroat group. Several others have been pushed to the threshold of extinction in the past century.

The decline of the cutthroats closely parallels the opening of the frontier. These black-spotted trout were easily caught, and market fishermen supplied them by the wagonload to railroads, mining camps and hotels. The mining camps were rapacious in their lumbering, cutting the forests for fuel, mine timbers and smelters. Toxic seepages drained from the mines themselves, and lethal tailings collected below the smelters. The railroad builders cut their roadbeds along the rivers, and the forests along their rights-of-way were laid low by the trestle crews and whackers. The roadbuilders were no better, and the siltation that followed their work smothered fly life and buried spawning gravel. Cattle and sheep stripped the streams of sheltering vegetation, raising midday water temperatures and cropping the range so closely that unnaturally large silt loads were carried downstream. Modern lumbering still threatens many watersheds, and agriculture and irrigation are also sources of life-smothering silts and thermal problems throughout the West. Dams that block spawning migrations or enlarge existing cutthroat lakes have so changed the aquatic ecologies that the cutthroat can no longer survive in many of them. In fact, few of the great cutthroat lakes that existed in frontier times have escaped man's rapacity. And population growth has also contributed its sewage and industrial waste to our surviving watersheds. Each of these factors has hurt the cutthroat trout.

But perhaps the most unhappy factor in the cutthroat's decline has been poorly conceived fisheries policy. Our public agencies have seldom been content to work with our fisheries as they found them, and the temptation to tinker with nature has left us with some unfortunate consequences.

Exotic species have been part of the problem. Brown trout have been mistakenly introduced into some prime cutthroat habitats, although they are often too cold for the European species. Our hatchery strains of rainbow are such genetic mixtures—hybrids composed of both riverine and steelhead strains—that planted rainbows will often crossbreed with existing wild cutthroats. Such crossbreeding seldom occurred between wild rainbows and cutthroats in their native Pacific drainages, but the widespread stocking of hatchery rainbows has virtually erased our original cutthroat strains through hybridization. And even some well-meaning federal programs for supplying hatchery cutthroats have had tragic results.

During the past half-century, Yellowstone cutthroat eggs were also widely distributed throughout our Western states. Yellowstone Lake and its spawning tributaries were a bountiful source of eggs and milt, and its cutthroat is a particularly handsome and vigorous strain. Unfortunately, stocking Yellowstone fish in other cutthroat habitats in our Western mountains has also resulted in crossbreeding with other distinct cutthroat populations, and the unique coloring and other characteristics of these populations have been lost. Sometimes we have lost unique species and subspecies through such careless stocking programs before we realized that the existing fish were unique.

THE ORIGINAL *Salmo clarki* cutthroat described by Meriwether Lewis is still widely distributed. Populations are found in the headwaters of both the Missouri and the Columbia rivers, where habitats of cold, unpolluted water still exist.

The Yellowstone strain, *Salmo clarki lewisi*, is relatively common in the headwater drainages of the Yellowstone River. It is less spotted and more brightly colored than the common cutthroats, particularly in the late fall. Perhaps the finest populations are found in Yellowstone Park, because extensive mixing with hatchery rainbows has only occurred elsewhere in the watershed. Perhaps the finest populations exist in the Yellowstone itself, particularly above its famous waterfalls. Specimens taken there are virtually free of mixing with other stocks, and the catch-and-release fishery at Buffalo Ford has displayed remarkable success. Park studies demonstrate that in only five seasons the average cutthroat from this reach of river is as much as three inches longer than previously, and the catch-rate has improved fourfold. Superb Yellowstone cutthroat fisheries also exist in Pelican, Slough and Hellroaring creeks, and in the swift-flowing Lamar River.

THE JACKSON HOLE cutthroat strain is similar anatomically to the Yellowstone subspecies and was once widely distributed throughout the Snake River drainage above Shoshone Falls. Good populations still exist in the Teton, Bechler, Grays, Hoback and Upper Snake rivers. The Henrys Fork was once a superb cutthroat fishery, and Henrys Lake is still one of the finest cutthroat lakes left, although its fish are hybrids having obvious genetic influences from both rainbows and stockings of the Yellowstone cutthroat strain. The most obvious difference of this Snake River subspecies is its relatively orangish coloring and its rather dense pattern of fine spots, which are heavily distributed across its dorsal and lateral surfaces. It has been difficult to protect this subspecies because of extensive rainbow-trout plantings in its habitat in Wyoming and Idaho and the widespread stocking of Yellowstone fish in Teton National Park.

The fine-spotted cutthroat of Jackson Hole, Wyoming, still lacks a formal Latin designation, although one name proposed is *Salmo clarki carmichaeli*, after the late Wyoming guide Bob Carmichael. Carmichael loved these fish and believed them to be members of their own cutthroat strain years before the attention of scientists focused on them. Perhaps the finest stocks of these fine-spotted trout are found in the spring creeks of Jackson Hole, where no other strains have been planted in the past.

ALTHOUGH THEY ARE not actually in the Rocky Mountains, the desert-cutthroat strains found in Nevada and eastern California recall for us the Shining Mountains

Homboldt trout (Salmo clarki humboldtensis)

Piute trout (Salmo clarki seleniris)

Bonneville cutthroat (Salmo clarki utah)

Colorado cutthroat (Salmo clarki plueriticus)

Rio Grande cutthroat (Salmo clarki virginalis)

Green-backed trout (Salmo clarki stomias) of the Old West as evocatively as the names of mountainmen Jedediah Strong Smith and Joseph Reddeford Walker.

Unfortunately, there is no more tragic story than our careless destruction of the finest desert-cutthroat fishery that ever existed. Pyramid Lake in northwestern Nevada was a remarkable habitat, its slightly saline waters among the last echoes of the sprawling seas that once covered the arid country east of the Sierra Nevada. Its Lahontan strain of cutthroat was named for the primordial lake, called Lahontan Lake, that followed the last Pleistocene glaciers, and its fish were baitfish feeders of unusual size. The subspecies was designated *Salmo clarki henshawi*, and the world-record cutthroat of forty-one pounds was caught at Pyramid in 1925. Its spawning runs ascended the Truckee watershed until the Derby Dam was built thirty miles above the lake. Its big cutthroats were denied access to their spawning grounds, yet the fish survived thirty years until irrigation projects began to siphon off the entire flow of the river. The last great spawning run occurred in 1938, and its fish averaged better than twenty pounds, but so little water was left in the river that this strain of remarkable trout became extinct.

Subsequent attempts to restore the Pyramid Lake fishery have been made with relatively pure strains of *Salmo clarki henshawi* from Summit Lake in Nevada, along with hybrids of various cutthroat and rainbow origins. Although an excellent sport fishery has evolved in recent years, it is not based upon a pure Pyramid Lake strain. Efforts are under way to restore stream flowages and access to spawning grounds in the Truckee watershed, but the fishery has yet to produce trout of maximum size that equal the average fish that thrived in Pyramid a half-century ago.

Since the Environmental Policy Act of 1969, field research into rare and endangered species has revealed a unique cutthroat subspecies that has evolved in the same basin as Pyramid Lake. These unique cutthroats are found in the desert drainages of the Humboldt River, and the name *Salmo clarki humboldtensis* has been proposed. Its evolution in a harsh environment has led these unique cutthroats to survive levels of alkalinity that would prove toxic to other trout, and populations are found in desert watersheds that survive both intermittent flowages and temperatures well past the ceiling tolerated by either brown or rainbow trout. These Humboldt trout have been observed at temperatures above 77 degrees Fahrenheit in late summer. Such ability to resist high levels of toxic alkalinity and such high temperatures offers some intriguing opportunities for future management in habitats of marginal quality.

The Piute trout is a third unique cutthroat that evolved in the drainages of the Lahontan Basin. It was first discovered in Silver King Creek, a small alpine tributary of the Carson River in eastern California. It is designated *Salmo clarki seleniris*, and typical specimens totally lack spotting on their bodies, although some spotting is found on the dorsal and caudal fins. It is a beautiful trout, but ill-conceived fisheries policies have brought it to the threshold of extinction. Thousands of rainbow fry were stocked inadvertently in Silver King Creek in 1949, and some other cutthroat strains were stocked later. The pure Piute trout were lost there through subsequent crossbreeding and the subspecies no longer exists in its original habitat. However, small populations of pure Piute cutthroats exist in isolated streams where they have been introduced.

UTAH ONCE HAD remarkable lake populations of its unique Bonneville cutthroats, but those fisheries were soon lost to irrigation development. The Bonneville cutthroat's taxonomic name is *Salmo clarki utah*, and although it is a unique subspecies, and pure populations exist in remote drainages, there is apparently little local sympathy for either restoration or protection of these fish.

COLORADO ONCE HAD four unique strains of cutthroat, but it has already lost *Salmo clarki macdonaldi*, the beautiful yellow-finned trout of Twin Lakes. Small populations of the Rio Grande and Colorado cutthroats remain in tiny alpine tributaries that have escaped either stocking or other fisheries management, and considerable effort to protect the remarkable green-backed trout has met with some success. It is one of our most beautiful fish.

Salmo clarki virginalis was abundant throughout the Rio Grande system at the time of the Santa Fe Trail, but irrigation in the San Luis Valley and the mining-camp tailings above Wagon Wheel Gap have virtually erased the subspecies from the river itself. Limited populations of Rio Grande cutthroat still exist in remote tributaries of Colorado and New Mexico. The subspecies is highly colored at spawning time, and it deserves both protection and restoration wherever possible.

The indigenous cutthroat of the Colorado River and Green River watersheds is *Salmo clarki pleuriticus*, and like the other subspecies, it has fared poorly in recent times. It is a beautiful trout that has suffered extensive rainbow and Yellowstone cutthroat stocking, but good populations still exist in wild tributaries of the Colorado in western Colorado, and in the Green in both Colorado and Wyoming.

The little green-backed trout is the subspecies originally found in the Arkansas and South Platte watersheds. It is *Salmo clarki stomias*, and it was abundant when gold and silver were discovered in mining camps such as Cripple Creek, Telluride and Central City. Market fishermen supplied thousands of green-backed trout to frontier hotels such as the Brown Palace in Denver, and The Antlers in Colorado Springs. Unfortunately, such widespread stocking of rainbow and other cutthroat fry has occurred in its original range that virtually no pure populations of *Salmo clarki stomias* exist today. The green-backed trout is both beautiful and rare, and it must be saved.

Our growing knowledge of the many cutthroat species and subspecies has not come too late, although many populations of unique strains have already been lost. The Endangered Species Act of 1973 defines its jurisdiction with singular taxonomic accuracy, so the legal framework for protecting our dwindling stocks of pure cutthroat strains exists, although we obviously lack an agency for the certification of genetically pure populations. Programs of restoration, preservation and management are mandatory in the future.

Although I took my first cutthroats in the high lakes of Colorado, it was the late Bob Carmichael who really taught me to love them in Jackson Hole. His reputation was fierce, stemming in part from his irascibly good-natured dialogues, which were so formidable that I never dared engage him in conversation until after my college years. His world was not fishing for the brightly colored natives of my boyhood Colorado ponds, but the big current-loving cutthroats of the Gros Ventre and the swift, many-channelled Snake.

It took me several summers to develop enough courage for a sustained conversation with Carmichael, and that one was clearly a mistake. The old man always sat like some magnificent bulldog near his mahogany fly chest, glaring balefully at the summer people who bought snelled hooks and salmon eggs. When I mistakenly expressed my disappointment at the lack of brown trout in the Teton country, the old man glowered and cleared his throat.

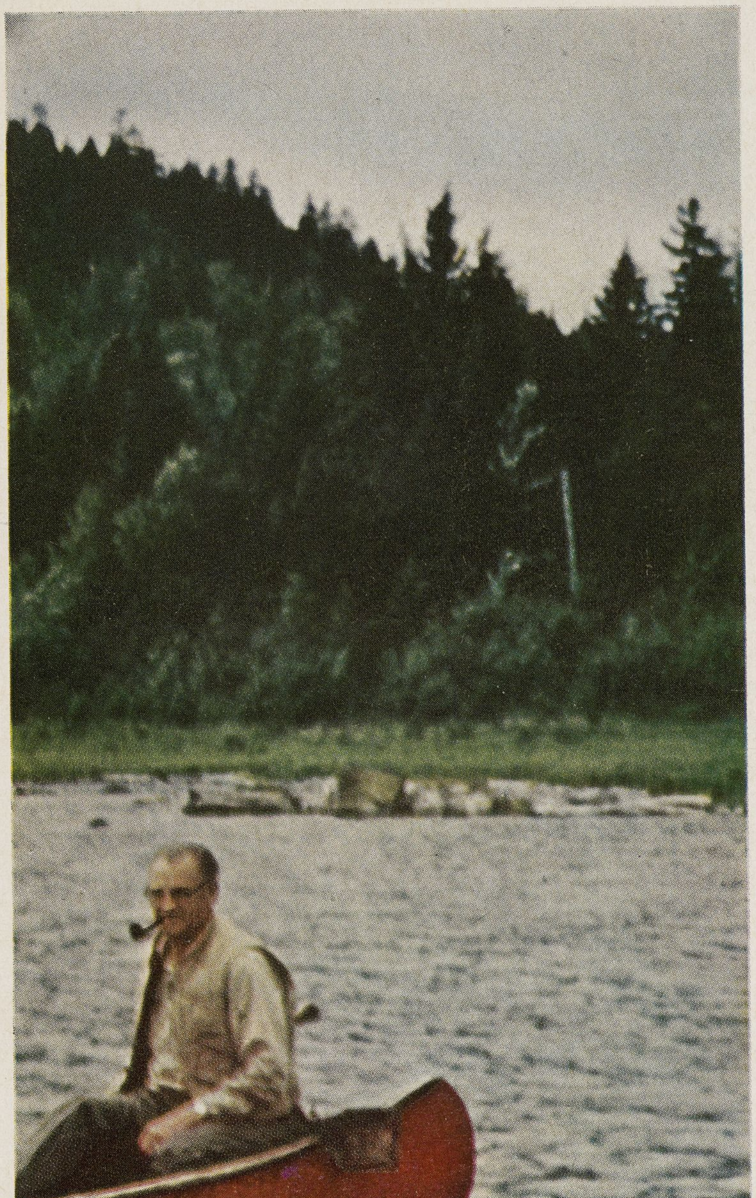
"Young man!" Carmichael rumbled with failing patience. "When you finally know enough about this country to have an opinion about the fishing—maybe you'll come to understand there's cutthroats, and there's cutthroats!"

Our beautiful black-spotted trout survive today, almost in spite of our poor husbandry and greed. The rivers teemed with them in frontier times. Their history is part of our folklore, from Lewis and Clark to John Colter, who fished them when he discovered Jackson Hole and the Yellowstone country, and Zebulon Pike, who found them when he crossed the buffalo-grass prairies of Colorado. Cutthroats were there when Andrew Henry held the first trappers's rendezvous in Wyoming in 1825 and explorers like Jedediah Strong Smith and Benjamin Bonneville and Joseph Reddeford Walker forged trails across the wastes between Wyoming and the Pacific. Jeremiah Johnson caught them from the Little Snake when he wintered with his Indian mate in northern Colorado. Other trappers loved them, too. Their names are legend now, and their roster includes Jim Bridger, Davey Jackson, Bill Sublette, Joseph Meek, Zenas Leonard, Tom Fitzpatrick, Hugh Glass and Kit Carson. Such men left their footprints on the trackless country and their names in the history books that followed.

Our cutthroats are among the most beautiful fish in the world, and that alone would make them worth saving. But their extinction would be particularly tragic, since these brightly colored trout are literally biohistory, living echoes of the frontier that existed when Meriwether Lewis first sighted the Shining Mountains.

BLUEBACK TROUT

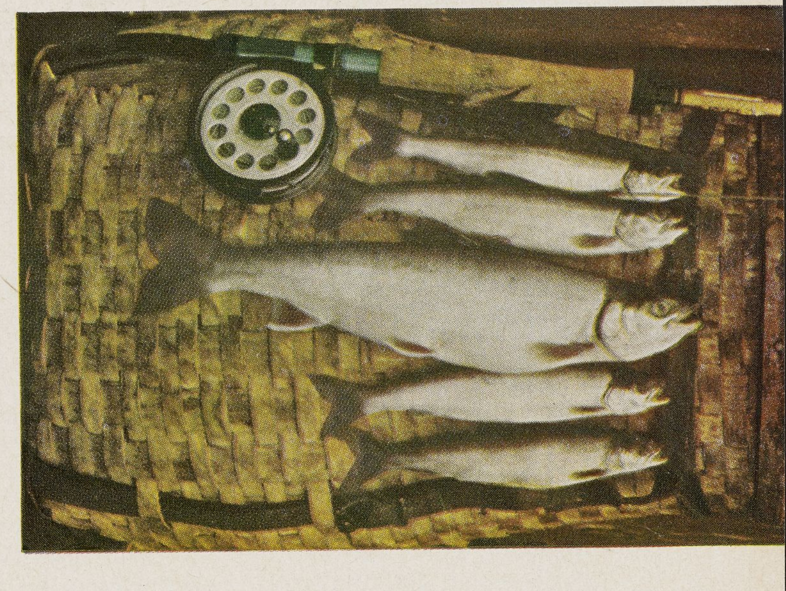
learn that catching one requires a special technique BY NICK KARAS



Once upon a time, in the green and forested state of Maine, there lived a small and silvery fish called the oquassa trout by some and the blueback trout by others. It was first discovered in Oquossoc Lake and was abundant in only a few of the small lakes among the Rangeley Chain. The blueback, unlike its cousin charrs, was a shy and seldom-seen trout. It preferred to look for its food in the deeper and colder parts of the lake rather than make a commotion by jumping for flies on the water. It came to the surface and along the shore late at night, when most of the fishermen were gone.

It was seldom caught by fishermen of old throughout most of the year; but come October and November, the bluebacks would begin congregating along the shallow beaches and near the mouths of creeks, preparing for a spawning migration upstream. Then in stepped man with his nets and spears and a total disregard for the future of the delicate little fish. The bluebacks, intent on the business at hand, became easy prey to the netters. Every year they were taken by the bushel and even wagonloads, to be used only as fertilizer in the nearby farm fields. This practice continued until the turn of the century, when the bluebacks suddenly became scarce. The farmers turned to other fertilizers; but it was too late as far as the fish were concerned. By 1904, the blueback

(*Continued on page 74*)



Here is my limit catch of bluebacks, including a 14-inch male that walloped a small bucktail on a sinking fly line.

←"Sleepy" steadies the canoe while I bring in a hot-tempered blueback trout on my ultralight spinning outfit.

SPORTSMAN'S HAWAII

BY JANET H. ALEXANDER

No matter which island you go to, you'll find an abundance and variety of fish and game, and splendid scenery

PART III

The slogan *Maui, no ka oi* (meaning "Maui is the best") is firmly believed by every one of the 40,000 residents on that island. You will find it the greatest for camping, good for hunting pigs and game birds and shore fishing. It's only fair for deep-sea fishing (you have to go out too far), but the scenery—just you wait!

Aside from its growing tourist business, Maui's industries include sugar (the world's largest plantation), pineapples, ranching, cut flowers, thoroughbred horses and field-trial dogs. It takes 40 minutes by air from Honolulu to reach the principal airport of this second-largest Hawaiian island, and when you land you'll be swamped with U-drive agents. There is even an Alaskan Camper for rent by the day or week. Unless you insist on driving clear around the island, where you'll run into miles of old wagon trails that are nearly impassable, you will do all right with a high-clearance Volkswagen or Jeep.

Maui is called the "Valley Isle" because of the seven-mile-wide, isthmuslike valley that joins its two volcanic mountain areas. The western mountains reach a peak of 6000 feet, and in the east, Haleakala (Hawaii's third-highest mountain) rises to a summit over 10,000 feet high. The two principal towns, charming old Wailuku and the newer Kahului, are on the flat isthmus—your starting point from Kahului Airport.

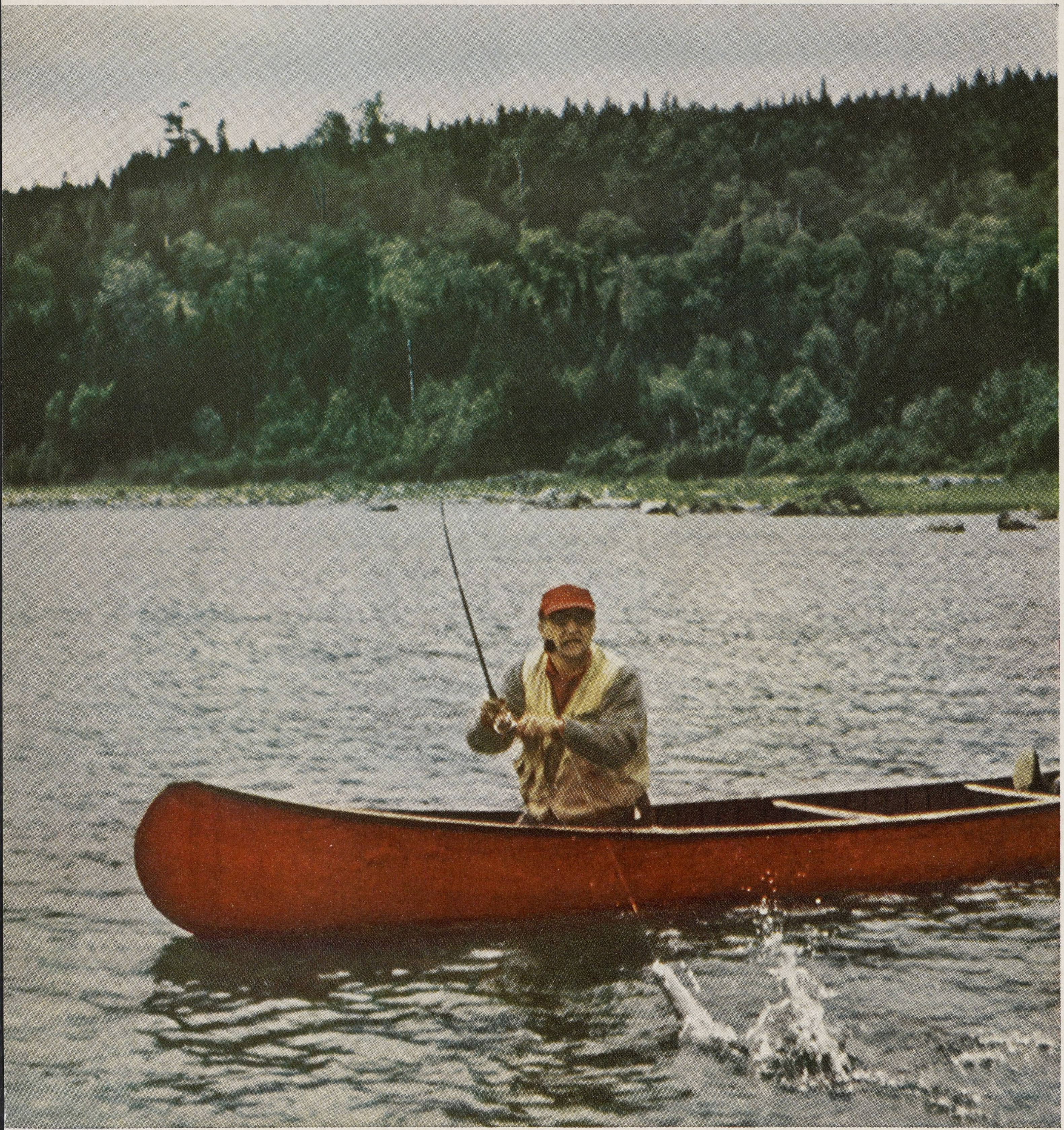
The shootable population of deer and goats is nil, but there are plenty of pigs. For these, you will need a guide and dogs. Try contacting Emanuel Freitos (at Haiku), an old-time Portuguese pig hunter and the long-time president of the Maui Sportsmen's and Hunting Club. There will be no fee, but you'll want to give your guide something, particularly if he loses a dog. One pig hunter told me wild boars had killed 21 of his dogs during one hunting season. However, he didn't appear to feel too bad about it. "The dogs I have left are smarter now!" he said.

(*Continued on page* 85)

Goat-hunting country on Lanai. Least known of the islands, it's probably the best for hunters. Steep cliffs and deep gorges make the going rugged.

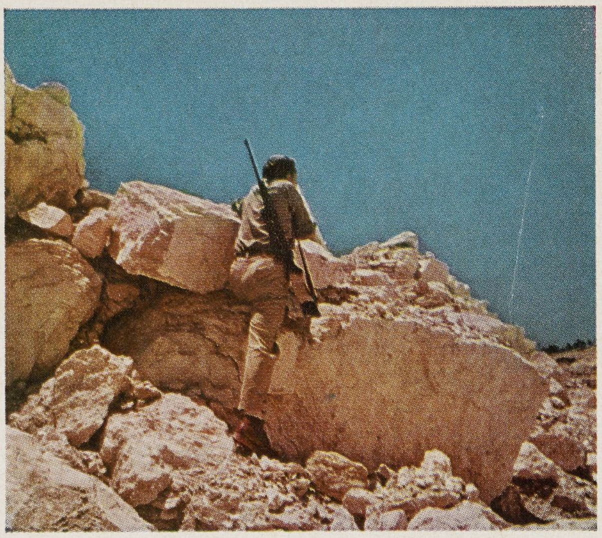
—A TALE OF THE

Once considered extinct, this rare fish is again available—but I had to



Fruit of the prickly pear is popular with animals and birds. Good in a pinch for hunters, too.

Caution is the rule when retrieving birds from thorn- and spine-covered thickets like this.



Look before you reach when in rocky terrain like this. Snakes lie in crevices and shadows.

Always mark spot where you down deer. Toilet paper wrapped on tallest bush marked this site.

People who ask what portions of the United States I most like to hunt are always startled when I reply, "The deserts."

Hunters commonly think of mountains and lake country as our game paradises. Actually, desert areas have the greatest variety and abundance of game and varmints. It is a paradox of nature that the more appealing the forest scenery, the less game and fewer species we find. Conversely, the more grim, tangled and arid the desert terrain, the more it teems with highly varied wildlife.

Last fall I hunted a desert where you'll find whitetails, mule deer, javelinas, three species of quail, three varieties of rabbits, two of doves, waterfowl on small ponds, bobcats, coyotes, mountain lions and a host of lesser animals. To the eye accustomed to forest or mountains, it is a gruesome panorama. Yet it is a hunter's paradise, and when one comes to know it intimately it grows in beauty and appeal.

When they think of deserts, most hunters envision endless stretches of empty, burning sands. The United States has little of such desert terrain. Our deserts are for the most part densely colonized by a tremendous variety of plants, shrubs and trees adapted to arid conditions. They are rich in all the needs of less tenacious vegetation except water. That lack is what makes them deserts. Most, when irrigated, are prodigious crop producers.

Any area with 10 to 20 annual inches of rainfall is semiarid, classed as "steppe." Areas with rainfall seldom exceeding 10 or 12 inches are true desert. These are found in large masses all across the Southwest almost to the Pacific Coast. They reach broad offshooting tongues far into the more northerly heart of the West and occur spottily far up toward the Canadian border. If we include "steppe" areas, we encompass most of the West except the Pacific Slope and islands of high timbered mountain country, and we reach eastward into the Dakotas and parts of western Nebraska and Oklahoma.

Altitude has little to do with it. Some deserts are

(*Continued on page* 118)

A Tale Of The Blueback Trout

(Continued from page 49)

had disappeared from the Rangeley Lakes.

So ended the tale of the blueback trout, a sad tale of how we again abused a natural resource. As late as 1940, when Maine conducted a biological survey of all its lakes and streams to determine what fish inhabited them, the blueback was still apparently an extinct species. Soon thereafter, however, reports from the far northern part of the Penobscot and Red river headwaters told of catches of an odd-looking trout. Sure enough, a lingering population of the blueback trout had been found.

Due north of Mount Katahdin and just 20 miles south of Quebec, a group of small mountain lakes form the headwaters of the Red River. The country here is wild and isolated and has been held in trust by lumber companies for many years. Until a few years ago, the only way to reach the area was over a wet and winding logging road. But this isolation helped protect the trout. Today these ponds—Black, Gardner, Deboullie and Pushineer—along with three or four others on the headwaters of the Penobscot River provide the last sanctuary of the blueback trout.

Bluebacks aren't noted for their growth potential; while still in the Rangeley Lakes they were seldom reported longer then ten inches, with the average fish nearer to eight inches. But the newly discovered bluebacks are giants compared with their ancestors, with some specimens from Pushineer Pond topping 15 inches. The size of the blueback is largely controlled by the availability of food in the waters it inhabits. It is a dweller of the deep, oligotrophic lakes of Maine. In these lakes, where the food is sparse, the fish are forced to feed on plankton and microscopic organisms. In lakes where food is plentiful, the landlocked salmon

★ converse

Nylon Parka
Fishing Shirt
about $19.95

Rod & Reel
Hip Boots
about $21.95

Rod & Reel
Chest Wader
about $29.95

thrives, and the blueback can't compete against this more aggressive fish.

I had caught almost every kind of trout and charr, but I had never seen a blueback. I guess I was much like the big-game trophy hunter who, after collecting all the more common heads, starts looking around for something new to shoot. I wanted to add the blueback to my list of trophies. Luckily, there is a hunting and fishing camp located in the blueback country—on Island Pond. It is operated by a retired game warden, Wilfred "Sleepy" Atkins. His Red River Camps were first built near the turn of the century and are located only a half mile from Pushineer, the lake that has produced some of the larger blueback catches.

The Red River Camps are some 30 miles west of Presque Isle, and Joe Drahos of Binghamton, New York, and I reached it by traveling north through Maine on Route 11 to the village of Portage and then turning west and driving the last 29 miles through the dense woods on a newly cut lumber road. Sleepy, true to his name, was in the sack when we arrived, even though it was only 9:30 in the evening. Traces of light were still on the horizon, and brook trout were rising everywhere on Island Pond. Eventually, we got Sleepy out of bed and he found a cabin for us.

The next morning dawned bright and clear and typically cool for northern Maine, even though it was the end of June. Joe and I tried Pushineer alone the first day, since Sleepy was involved in getting some sports rigged for fly fishing—spinning gear is prohibited on several of the trout ponds near camp. Pushineer was just over the hill from the camp, and we embarked in a canoe Sleepy had cached in the bushes on shore. The lake isn't large—a half mile at its greatest length and roughly triangular in shape.

Even though the series of lakes—Gardner flowing into Deboullie, Deboullie flowing into Pushineer and then Black Pond flowing into the Red River just below Pushineer—are all connected, they receive little runoff water to maintain their levels. The ponds are mainly spring-fed and deep. This accounts for their lack of the acid-tan-colored waters typical of this part of Maine. Without inlet creeks, the sedimentation that has shallowed so many lakes is missing. The lakes have remained deep since the last glaciers deposited their rubble some 5000 years ago. Pushineer is almost 60 feet deep and Deboullie near 90 feet; thus, they are ideal for the bluebacks, which prefer to range the depths.

We spotted a boat in the southwest corner of the lake and worked our way toward it to see if the occupants had caught anything. As we approached they started to leave, each with his limit of trout. One of the men held up his stringer, and among the brook trout hung one long, silver blueback.

"Well, Joe," I said, "the bluebacks are here. All we have to do is catch one." From research reading, I knew that the blueback was a deep-water trout and that it liked its food small. All we had to do, I reasoned, was find the deepest part of the lake and use small lures and we'd take fish. An old log slide planked a high bank on the south shore of the lake, and Sleepy had told us earlier that there was deep water just a few feet offshore at that point. The other fishermen had been trolling over the area, so we figured it had to be a good spot for bluebacks.

I rigged a small gold spinner on the end of my spinning line with a bit of garden hackle on the hook and then added a dropper line with a small dipsey sinker to take the lure down deep. Joe did the same as we moved the canoe upwind and then let it drift back over the deep water. A quick sounding showed that the water only 50 feet offshore was nearly 35 feet deep.

We made countless drifts and even trolled at a creeping speed against the wind with our small outboard, but nothing happened.

By noon, we were sure that the blueback we had seen on the fisherman's stringer must have come out of another lake.

We trolled all afternoon, after dinner until 10 o'clock and then the entire next day and even the whole third day —and still we didn't catch a blueback. We tried everything—spinners, flies, spoons, plugs and even more garden hackle in big balls — but nothing worked. We fished at all times of the day, from early morning to late in the evening. We caught some good brook trout—the only other fish, excepting a few perch, that inhabit the lake. We must have been doing something wrong, but what? With one more day left for fishing, we were becoming desperate.

That evening, back at Sleepy's, we met John Crabtree, the game warden from Eagle Lake who has this part of the state as his district. John suggested that we try Deboullie, even though the bluebacks there had in the past run a bit smaller than those from Pushineer. And he even agreed to spend his one day a week off fishing with us.

We had high hopes for Deboullie the next morning, and with John to guide us, we felt confident we'd find our first blueback. Launching again on Pushineer, we motored to the north shore and into the outlet from Deboullie. The connection between the two lakes is less than a hundred yards long. The stream is only ten feet at its widest, and most of the way our aluminum boat scraped bottom. Joe and I walked the route. Deboullie's level is less than two feet higher than Pushineer's, and an increase in the height of the small logging dam on Pushineer's outlet could easily make one lake out of two.

Deboullie is a pretty lake nearly two miles long. A large stone slide, off the face of Deboullie Mountain to the north, slopes into the depths of the lake. It is the only break in the dense green mantle of spruce and hemlock that covers the mountains surrounding the lake. The water is exceptionally clear and deeper than in Pushineer. We found the depth of the water near the slide to be over 50 feet and easily filling the requirements for bluebacks. The three of us worked over the hole all morning—but, again, no trout.

I put the fish locator to work once more and we ran a course at right angles to the rockslide. The deeper water was farther into the middle of the lake and near 85 feet. We concentrated our trolling here for most of the afternoon and even anchored and still-fished, but still no luck. Joe caught a squaretail from just under the boat as he was pulling up his line to check the bait, and for a moment we had a scare thinking that at last it might be a blueback.

Sleepy has a large bell in front of the main cabin, and we heard it toll over the hills. Dinner was ready. We had the length of Deboullie to cross, and John, never late for a meal, started the motor before Joe's line was in. Joe hauled faster, but on the first few cranks the line wrapped around the bail. The accident saved the trip. The fast troll caught us a fish. Joe hardly knew it was on at first, the drag was so slight. Finally, John stopped the motor and I netted the fish—though it hardly needed netting; it was only six inches long. At first glance, it didn't look like a trout but resembled a chub.

Then John yelled, "It's a blueback!"

We wolfed down dinner that evening, eager to get back onto Pushineer. We had the trick of catching bluebacks all figured out, we hoped. All we needed was a faster troll through about 30 feet of water and we'd catch bluebacks.

The sun was already hiding behind some of the higher peaks when we returned to the lake, and the western shore was in shadow. We started dropping our lures into the water just as the canoe trolled past the now-familiar log-slide landmark. At that point, the depth fell off from 30 to 50 feet over the bottom. This time, however, we kept the little three-horse motor purring at a faster rate, and as we passed a white birch stump Joe had the first strike. He hauled in another blueback, this one a little larger than the six-incher of the afternoon. I made the turn at the end of the lake and we made another pass across the same water. This time my rod bobbed as we passed the birch stump and a fish hung on. I cut the motor and settled down to catch my first blueback.

The fish fought well, and when I brought it alongside the canoe, it made a desperate effort to be free. The first jump was magnificent as the little blueback cleared the water by a foot. One more jump and it was finished. Joe netted the trout and we had a ten-incher. We scurried back to the end of the lake to make another pass at the deep-water hole. Earlier, I had removed the dipsey sinkers that we had used during the past three days; three or four large split shot were all that was needed for weight.

The bluebacks must have been schooled in one spot, because just as we passed the lone birch stump again, Joe's reel sang out. The fish broke water a hundred feet behind the boat and then settled down for a tussle.

"It must be a brookie, from the size of it," I said to Joe.

The fish leaped out of the water again before it made a deep dive under the boat. Joe slowly worked the fish out of the depths and into the clear water, where I got my first good look at it. It was a big fish, but too lightly colored for a brookie. Moments later it was near the surface. It was a deep-bellied blueback. It was big, and as Joe swung it toward the net I held in readiness I saw that it wouldn't easily fit—it was at least 18 inches long.

And then Joe suddenly goofed. In his desire to land the blueback, he tightened up too much on the line and lifted the trout's head out of the water. That was all the fish needed. It rolled over once and was free. For a moment, the trout just lay there, unaware that the hook was gone. I made a pass at it with the landing net, but it was just inches too far away. The movement was all the scare the fish needed. It headed for the bottom.

Steadily, we picked up more fish until it was too dark to see. When we returned to camp, we had eight bluebacks in the pack basket. I couldn't believe it. We had fished so hard for the three previous days and missed them consistently—then we found that a simple trick like a faster troll was all that was needed.

To make sure it wasn't just luck, Joe and I squeezed in a few hours of fishing the next morning before we left Sleepy's. We were on Pushineer before breakfast and promptly went into our fast-trolling routine. Two more bluebacks were all that we needed to fill the limit of five fish per man, either daily or possession limit. The troll past the white birch was almost magical, and Joe landed his first fish on the spinner-worm combination. I had switched to a fly rod to see if I could take them on artificials and trolled a small bucktail at the end of a nine-foot leader and 35 yards of sinking fly line.

After Joe's fish, we turned and trolled across the middle of the lake, and I slowed the motor somewhat to allow the lure to sink a little deeper. We approached the white birch, but this time a hundred yards or so farther out on the lake. The strike came almost when we expected it, and I set the hook. Just as I cut the motor, the fish broke the surface, and I thought I had a squaretail because of its size.

The fish yanked the bucktail from side to side and then jumped. It headed for bottom and pulled desperately at the line. Gradually, the trout weakened until I could see it swishing back and forth beneath the boat in 20 feet of water. The flashes of light from its sides were too bright for a brookie, and we knew it had to be a blueback. Joe grabbed the net as he cautioned me not to lift its head out of the water. The fish jumped beside the boat and stayed on its tail for several moments. Joe lunged for it and hauled in the trout. It was a blueback all right, a beauty that measured 14¼ inches and weighed a pound and a quarter. The lower jaw was starting to assume the characteristic hook of the salmonids, and we knew it was a male.

"Blueback" is a poor name for this fish, because it acquires the deeper, bluish hues only late in the fall, when spawning is near. It is a late spawner, becoming active in late November and December. The rest of the season, the fish is more of an opalescent salmon color, with metallic hues shifting color in the light. The fish we caught graduated from gold along the sides to tan or dark brown on the back. The large male had the white stripes along the leading edge of the fins that are characteristic of all the charrs.

In shape, the fish is delicate when compared with a brook trout and closely resembles a salmon. The head is often small in proportion to the rest of the body and the tail deeply forked, even more so than in lake trout.

The blueback is perfectly compatible with the brook trout, and the two species coexist in the waters at the head of the Red River system. The blueback, being a deep-water fish, usually claims the stratum from 30 to 50 feet. The brook trout is seldom found below 30 feet. Foodwise, the blueback feeds on small crustaceans and plankton found in the depths. It does rise to the surface during the evening and will take flies, but this type of feeding accounts for only about ten percent of its diet. The lakes aren't extremely fertile at these depths, and this is one reason why a blueback is usually shorter and lighter in weight than a brook trout of comparable age.

The lakes and Sleepy's Red River Camps are easily reached over a new logging road just completed by the Great Northern Paper Company. The state maintains several campsites on Pushineer, which fishermen can reach by fording the shallow Red River at the outlet of the lake. Several other campsites are located on Debouillie, but you need a canoe or boat to reach them unless you come in on a back road that is passable only with a four-wheel-drive.

According to several icthyologists, the blueback trout, *Salvelinus oquassa*, is a landlocked Arctic charr that was isolated from the more northern Arctic charrs after the last glacier moved north. Since that time, it has developed on its own and given up the yen for salt water of its bigger cousins. Though the species was exterminated in the Rangeleys, the bluebacks in the north are holding their own. Wise bag limitations and strict enforcement are helping the bluebacks stay around. This time, we've been lucky and have been given a second chance to perpetuate a rare fish. ■ ■ ■

SPORTS AFIELD DATA LIST

A TALE OF THE BLUEBACK TROUT

By Nick Karas

March 1967 Issue

LOCALE:

North-central Maine.

TRANSPORTATION:

Type used by author—camper from Kings Park, N.Y., to Portage, Me.
Approximate cost—$55 for gas and tolls.

LICENSES:

License required—yes.

Type—fishing.
Where available—sporting-goods stores, fishing lodges or village clerk's office.
Cost—resident $3.75; nonresident season $9.75, 15-day $6.75, 7-day $5.25, 3-day $4.50.

WEATHER CONDITIONS:

Average temperature at time of article (late June)—55°F.

EQUIPMENT:

Fishing
Type of rod and reel—Garcia ultra-light spinning; fly rods and reels.
Type of line and weight—spinning: 4-lb. Stren; fly line: Cortland sinking line.
Type of fish-recovery gear—landing net.
Lures used—willow leaf spinners, Mepps spinners, No. 14 Mickey Finn bucktails.
Protective clothing used—rain gear.
Electronic gear used—Lowrance Fish Lo-K-Tor.

Camping
Trailer used—Dodge Family Camper.
Pack used—Adirondack pack basket.
Cooking gear used—Coleman stoves.
Foods used—canned and fresh.
Illumination—Coleman lanterns.
Sleeping bag—Utica-Duxbak.

CLOTHING:

Type needed at time of article—medium and lightweight (cool nights, warm days).
Type of material for outergarments—cotton.
Undergarments recommended—summer-weight.
Type of footwear used—Bean boat pacs.
Type of headgear used—wide-brimmed hat.

PHOTOGRAPHY:

Camera—Pentax-Photomic.
Lenses used—33mm, 50mm, 135mm.
Film used—Anscochrome D22, D50.

OUTFITTER OR GUIDE:

Name—Wilfred "Sleepy" Atkins.
Address—Red River Camps, 15 Yale St., Presque Isle, Me.
Services offered—boats, motors, canoes, guides, food and lodging.
Total guide cost—varies with services required.

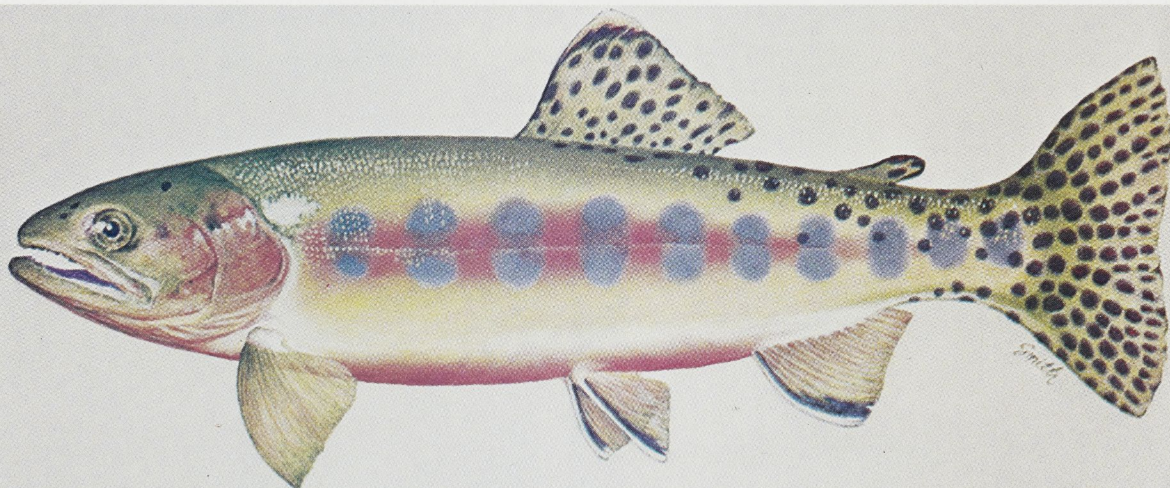
TOTAL TIME OF TRIP:

5 days.

TOTAL COSTS OF TRIP:

Transportation, lodging, etc. for two men, $140.

GOLDEN TROUT OF THE HIGH SIERRA



TEXT AND ILLUSTRATIONS BY
LOREN G. SMITH

It is not known for certain when the first trout came to the bright streams of the southern High Sierra, but it must have been long, long ago as men measure time — when melting ice filled the desolate granite valleys and the parched deserts of Saline and Panamint with sweet waters. Long before that time, trout had found their way into the Rio Colorado, and, when the ice came, it was not difficult for them to push westward to certain headwaters of the San Joaquin. Among the first to come were those who made their home in the

Great Kern — a wild, strange river whose sources are among the highest of California's lofty mountains. From this clear, cold waterway these trout (essentially the original Gilbert Rainbow) would traverse their way upstream, entering the tributaries and even penetrating the little rivulets that trickle from the flanks of the great mountains and from the banks of snow that never completely melt.

But the forces of nature intervened. Geologic upheaval, hydraulic erosion, and volcanic activity created impassable falls, preventing any subsequent invasions of fish from the main river. Isolated colonies of these creek trout, thus prevented from any further intermingling with the river fish, evolved separately and uniquely into the brilliantly-colored species justifiably referred to as the golden trout.

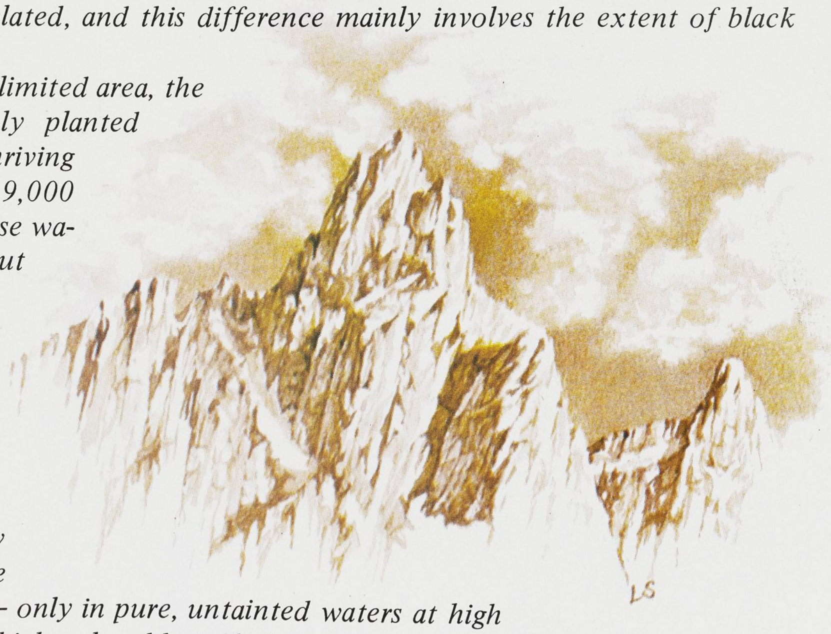
The remarkable coloration of the golden ranges from a delicate olive on the head, back, and upper parts of the side, to a clear butter-yellow along

and below the lateral line, overlaid by a striking rose-tangerine lateral band with eight to ten parr marks of an iridescent Payne's gray, and a vivid swatch of cadmium red on the underparts.

The tributary streams that confined the ancestral goldens evidently had much to do with this richness of hue. These waters differed radically from the main river. The Kern was deep and large, with a bed of boulders, fine sand and even mud in many areas. In contrast, the isolated headwaters were small, turbulent streams with bottoms of yellowish and blackish lava and rust-colored volcanic rocks. In time this unique environmental condition effected a metamorphosis in the coloration of these cloistered fish — finally giving rise to the brilliant markings of the contemporary golden.

Most icthyologists recognize two groups of goldens: Salmo whitei, *indigenous to the Little Kern drainage, and* Salmo aguabonita, *native to the South Fork of the Kern and Volcano Creek. It would seem that at one time the two sub-species shared a common stream bottom, but were isolated from* *each other by additional geologic forces, causing them to evolve slightly differently. (The two types are very closely related, and this difference mainly involves the extent of black spotting on the back.)*

Although native only to a limited area, the golden has since been widely planted throughout the High Sierra, thriving in lakes and streams between 9,000 and 12,000 feet. Many of these waters were originally barren but have proven to be ideal homes for this piscine recluse.

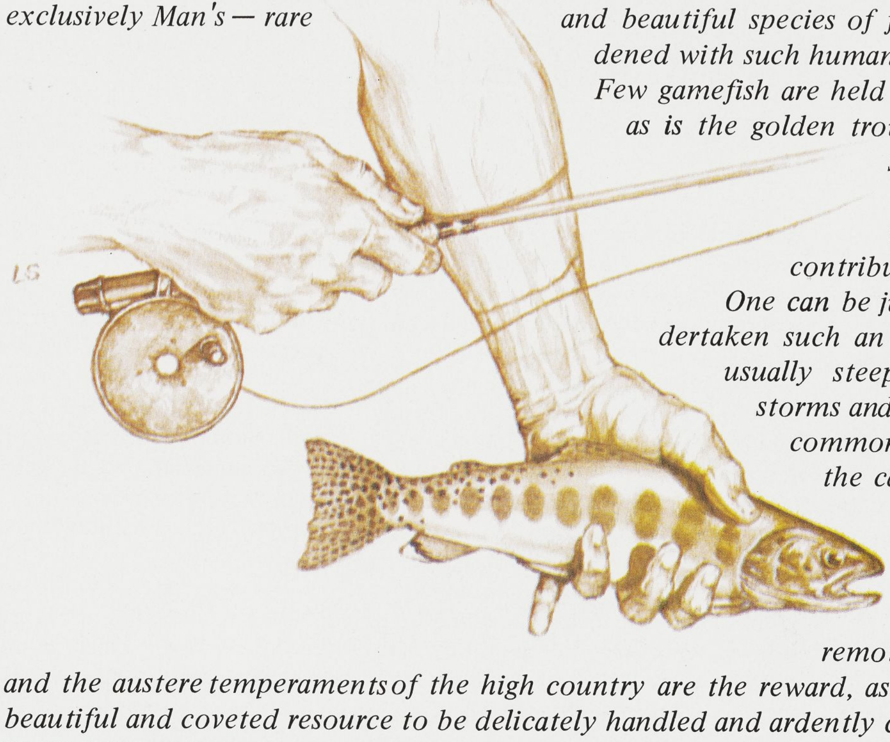


The golden does not fare well at lower elevations, and cannot (or will not) subject itself to tepid, over-fished waters or to the degradations of pollution. They will never be found where the multitudes infest the streams — only in pure, untainted waters at high altitudes, the remoteness of which only adds to their seductive nature.

The goldens reach their greatest abundance and most vivid coloration in stream environments, but here they rarely attain a length greater than seven or eight inches. Their lake-dwelling brethren, on the other hand, can grow much larger, but are never as strikingly hued as those found in the bright, tumbling streams.

Like the rainbow, the golden spawns in the spring, the lake residents moving into the tributaries shortly after the ice melts. (However, spring in such high elevations often occurs in July and August, and many waters are ice-free for only three to four months of the year.) If they cannot reach flowing water — many golden lakes are merely high altitude, granite "bathtubs" with no inlets or outlets — they may spawn in gravelly areas along the shore. The stream inhabitants choose gravel-bottomed riffles.

Whereas the golden and rainbow can (and do) co-exist in many of the Sierra's alpine lakes, they hybridize readily. Their offspring range from "pure" golden to "typical" rainbow in coloration and markings. Although there is nothing inferior about the golden-rainbow cross, many anglers (this writer included) believe that the pure golden strain should be kept pure. (The indignities of an "identity crisis" must remain exclusively Man's — rare and beautiful species of fish should not be burdened with such human aberrations.)

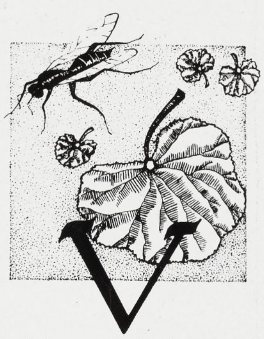


Few gamefish are held in such lofty reverence as is the golden trout by the anglers who seek them. Certainly the inaccessibility of their secluded habitat contributes to this sentiment. One can be justly proud to have undertaken such an expedition: trails are usually steep and arduous, snowstorms and frigid temperatures are common in mid-summer, and the capricious nature of the goldens themselves does anything but guarantee angling success. But the remote mountain expanses and the austere temperaments of the high country are the reward, as is the golden trout — a beautiful and coveted resource to be delicately handled and ardently conserved.

KEITH BILBY

Elevated Angling

By Keith L. Bilby



Virtually thousands of small sub-alpine and alpine lakes are easily accessible to the industrious angler, yet most are virtually untouched by today's standards. While some high country lakes are void of fish for various reasons, most contain good populations of trout and char.

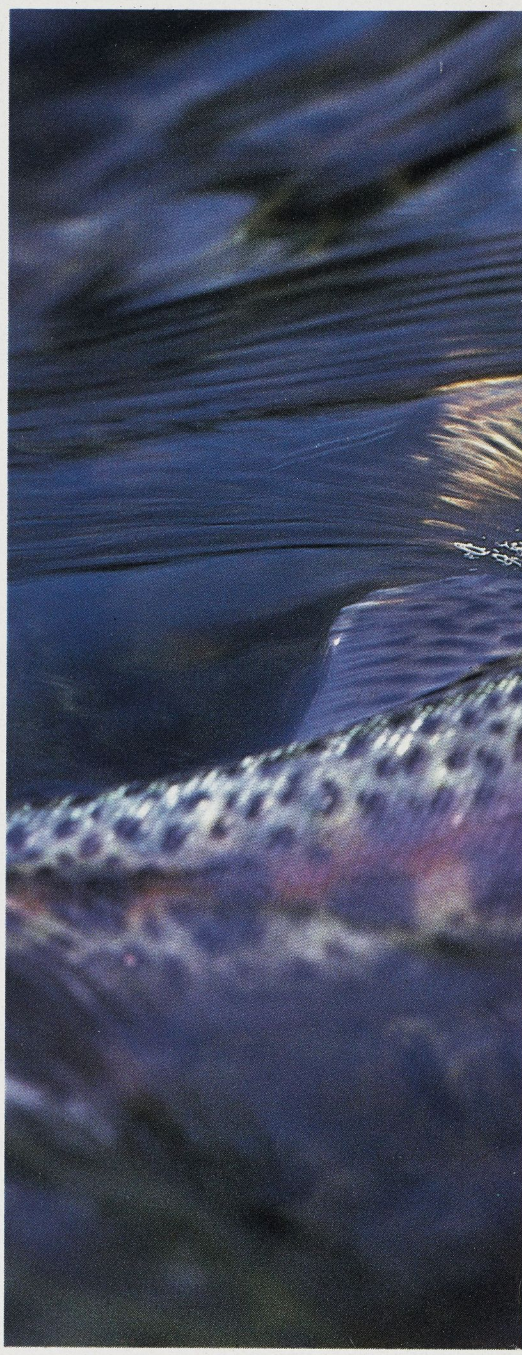
Anglers familiar with the typical moderate elevation stream environment will quickly discover upon entering the high country scene why alpine fly fishing is considered to be one of the ultimate challenges. It's a whole new ball game where many of the patterns and techniques suited to lower altitudes become useless.

I was taught fly fishing by my dad on the Manistee River of Michigan. Many of the knowledgeable types in that area don't bother getting their waders wet during a hot July day until nine or ten in the evening, when they know the large "caddis" (*hexagenia limbàta*) will emerge and cause the big browns to come unglued. This same technique is employed at lower altitudes in the West, but it is mostly a futile gesture in the high country where the possibility of the evening hatch is shut off completely once the sun slides behind the mountains. Rapid decline in air and water temperatures signals thumbs down on hatches. The sole exception to after dark fly fishing involves large brook trout which may occasionally be taken on over-sized flies at nightfall. (I might add that wading after dark in an alpine lake is a dangerous practice due to the sharp rocks and equally sharp dropoffs, plus the numbing cold of the water.)

Evening hatches in the mountains have a tendency to be brief by low altitude standards. Thirty minutes or less is the norm, with a lesser number of hatches lasting one to two hours. This severely

Rare Natives

The Paiute, redband and greenback are just three of the obscure species of trout that still inhabit North America. Some of them are even thriving. by Worth Mathewson



Worth Mathewson

In retrospect, I'm sure that the situation was somewhat out of the ordinary. As I made my request, the landowner stood on his front porch in the chill of the April morning and listened with interest and a degree of amusement. At first he had been taken aback when I told him that I had come all the way from Oregon to the mountains of western North Carolina just to see a little trout.

"Well, I let a few people fish the big creek, but I just don't allow anyone to fish way up there, on the branch above the falls," he told me.

"All the trout above the falls are natives," he continued, "and no one has fished for them in years. I go up a couple times a year to check on them. The creek is full of them.

"But since you came from Oregon, you go on up. I'll let you catch a few for pictures, but be careful about letting them loose again. When I was a boy, all the creeks in these mountains had natives in them; they are kind of hard to find today, though. You really don't have to fish for them, just slip along the bank. You can see them plainly," he said.

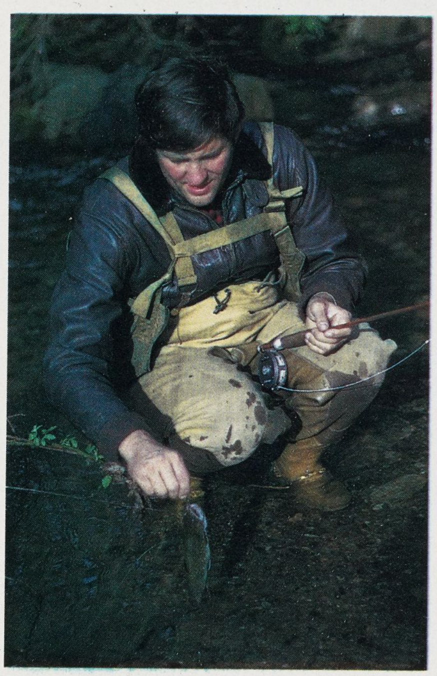
His creek turned out to be quite small—quite a shock to me after the large steelhead and trout rivers I am accustomed to. And as I walked, I passed a couple of other anglers. They were fishing for brown trout, "natives" of sorts to the creek because they reproduced naturally. But they weren't the true "natives" of the watershed that I had come to see.

I was still walking half an hour later. The stream had grown even smaller and the laurel thicker. No other anglers were present up there. And when I reached a point at which another flow—really a branch, in southern colloquialism—entered the stream, I followed this. There was no longer any trail, and I had to pick my way on hands and knees in places. After I climbed around a waterfall, I rested and started to look for trout.

There was no place on the little creek that I could not jump across. The trout were there, too, in greater numbers than I would ever have guessed. I *could* see them. Some would quickly dart under an overhang of the bank or into a pocket by a rock, while others would flash around wildly in attempts to find cover, finally swimming off downstream to escape. Some looked to be fully five inches long.

I stopped at a point where a huge old section of chestnut log lay across the creek. I didn't cast, but just dabbled a barbless fly over a deep pocket formed by the log. A trout hit almost immediately.

I caught 30 or more of those Appalachian brook trout that morning. Most were three or four inches long, although one giant went almost eight. The trout I am likely never to forget, however, was a male that pushed five inches and boasted a fully



Worth Mathewson

Appalachian brook trout (left) are found in Virginia, North Carolina, Tennessee.

Fishing the Madison. Although the lower part of the river produces bigger browns, the author prefers the beauty of the upper stretches.

kyped jaw, red-tipped fins and belly, perfectly aligned pink dots with deep blue halos, and a vermiculated back as perfect as any brook trout that ever swam. That particular trout, and all the rest in that little creek, collectively represent a part of North America's lifeforms that are as fragile, as beautiful and as dependent upon their unaltered habitat as any living creature imaginable.

On another April morning, my wife, son and I stood by yet another little stream. We were in Oregon. The sun was out, but a hard numbing wind was blowing across the expanse of sagebrush-covered desert. We had no fishing rods, as we were trout watching instead. We really didn't notice

The redband, in all likelihood the forerunner of all rainbows, is now found only in Oregon. It can live in water temperatures as high as 85°F.

the cold, either, because in places the stream was jammed with redband trout, some of them 20 inches long. It was hard for us to believe that such large trout in those vast numbers were in such a small flow of water.

A few had already dug their redds; males were fighting, others struggling up the flow through shallow water. When they came to a place where their passage was blocked by a willow jam, they swam ashore, over a dry gravel bed, around the jam, and then back into the stream. We found a male of about three pounds that had actually worn the skin off his belly by doing this. A thin, transparent membrane was all that remained to prevent his intestines from falling out.

The Appalachian brook trout and the redband trout are just two of a surprising number of salmonid races and species which are most often referred to as "rare trout." In almost all cases these trout were historically localized to one geographical region, endemic to a confined watershed—in some cases a single stream or lake system. Most had healthy populations at one time, but today are greatly reduced due to the introduction of hatchery trout into their habitat, poor land management and overfishing.

The majority of these rare trout are found in western waters, and most belong to one of the beautiful and varied races of the cutthroat trout. Although many might not be well known to the average angler, the rare trout are now, in varying degrees, watched and managed by both state and federal agencies. A few enjoy a "threatened" classification from the U.S. Fish and Wildlife Service. Populations of most, while greatly reduced from former numbers, are stable and in some cases even increasing.

Sorting out North America's salmonid species and races prior to human intrusion is a complex and difficult task. After more than 100 years of man's tampering—in particular, the stocking of trout not native to specific watersheds—the situation is muddled indeed.

Perhaps the foremost expert on North American native trout, and the person who has done much of the sorting, is Dr. Robert J. Behnke of Colorado State University. By "native trout," Dr. Behnke has written: "I mean trout historically occurring in a specific geographical area and not originally introduced by man."

Thus the term "native trout," used in this context, means the *first* trout that evolved in a watershed—not ones that may have followed and spawned successfully over several generations.

Dr. Behnke is known as a gifted, incisive taxonomist. His work with trout provides a fascinating look at how things must have been at one time. Greatly simplified: In the age of unaltered, pristine trout populations, all watersheds evolved with a well-defined species or race. Many of these races, or strains, were found in only a single stream or lake while in close proximity would be found yet another race, perhaps very similar, but genetically distinct.

The rare trout that survive today are the remnants of this once highly specialized, eons-in-evolving, order of salmonid. A good example of this is the Lahontan cutthroat trout found in Pyramid Lake, Nevada. This trout once grew larger than perhaps any other North American species. The world record stands at 41 pounds, although larger specimens are rumored to have been caught by Indians. The Lahontan is still found in Nevada, California and Oregon in good numbers; but the common Lahontan of today is usually a hybrid cutthroat/rainbow instead of a purebred. From 1940 until 1960, in fact, pure Lahontans were thought to have vanished. And while the hybrid Lahontans do reach appreciable sizes, they do not reach the giant proportions of pure Lahontans.

In 1960 Dr. Behnke reported four pure Lahontan populations, and since that time more have been found. It is hoped that stock from these finds will provide the nucleus for a new age of pure Lahontans and that fish from this new generation will reach the size of the Lahontan trout of antiquity.

All rare trout are remarkably interesting. Following is a rundown on notable ones found in North America.

GREENBACK CUTTHROAT:

This small, beautiful trout was largely responsible for the focusing of national attention on the plight of all rare trout when it was declared an endangered species. Today that classification has been changed to threatened.

The greenback rarely exceeds 14 inches at full maturity and has the largest spots of any of the cutthroats. It was once found over a wide area of Colorado, especially near Boulder and Denver, as well as in a small area of Wyoming. Its population was quite large when the settlement of Colorado began, but by 1937 pure greenbacks were thought to be extinct.

Pure greenbacks have since been rediscovered, and an organization known as the Greenback Recovery Team has made good progress in reestablishing the trout in Colorado. In 1982 anglers were allowed to fish for greenbacks on a catch-and-release basis in some areas of Colorado's Rocky Mountain National Park.

APPALACHIAN BROOK TROUT:

This was once the only trout found in the southeastern mountains of Virginia, North Carolina, Tennessee and Georgia. It is the little "native" of angler's tales in the region 50 or more years ago.

The Appalachian brook trout is the smallest race of brook trout. It becomes capable of spawning at four inches, and rarely grows much larger than 12 inches. (My grandfather, before his death, often spoke of a 17-incher that he caught in North Carolina in 1905.)

Though abundant at one time, this little trout is quite fragile, and its numbers have been greatly reduced. Pure Appalachian brook trout can still be found in Virginia, North Carolina and Tennessee. They are entirely confined to the headwaters of a few remote, mountain streams, especially those that have a natural barrier such as a waterfall. This trout has proved hard to raise in hatcheries, and its existence will depend on wise land management and public concern for its welfare. It disappears almost immediately if other trout are introduced into its habitat.

REDBAND TROUT:

The redband trout emerges as a "favorite" rare trout to all who know of it. To date, "redband" is only a temporary name given the trout pending more taxonomic work. Dr. Behnke believes that the redband

The only member of the cutthroat family that is almost totally devoid of spots, the Paiute has greatly benefited from the attempts to save it.

The much-publicized golden trout is presently found in California's Kern River drainage, up to the 10,000-foot elevation. A similar trout lives in Mexico.

Very rare in its pure form, the Rio Grande cutthroat is marked with a multitude of heavy black spots that grow thicker down the body past the dorsal fin.

Perhaps the rarest trout on the continent, the Alvord Basin trout is currently known from only two creeks in Oregon's Great Basin. Overfishing is the biggest threat to its future.

Robert A. Smith

Robert A. Smith

Robert A. Smith

Worth Mathewson

is probably the ancestor of all rainbow trout races. "They represent an early divergence from an evolutionary line leading to the rainbow trout."

The redband demands respect due to its ability to survive in conditions that no other trout can. It does well in daytime summer water temperatures of up to 85°F, while in winter some streams it inhabits form anchor ice. It faces yearly flashfloods and the consequent siltation, and does well in water with high alkaline content. It is one of the few salmonids that can base its diet almost exclusively on other fish, with small desert chubs being preferred forage.

This hearty trout was once thought to be widely distributed over the high desert region of Idaho, Nevada, Washington, Oregon and California. Today pure redbands are thought to inhabit only a few remote creeks of Oregon's Great Basin region.

ALVORD BASIN TROUT:

Perhaps the rarest of North American trout, this strain is known from only two creeks in the Great Basin region. The Alvord Basin trout is a cutthroat, with a maximum size of about 12 inches, and like the redband, it has adapted to harsh desert conditions. Water temperatures in midsummer in the two creeks it inhabits can reach nearly 80°F.

The greatest threat to the Alvord Basin trout comes from potential overfishing. The remoteness of its habitat makes enforcement of laws difficult. The trout is easy to catch, and the few people who happen onto it seldom, if ever, have any idea what it is.

PAIUTE TROUT:

A small cutthroat native to the Silver King Creek watershed of California's Sierra Nevadas, this trout was first described in 1933. The Paiute is the only member of the cutthroat species that is almost totally devoid of spots. At one time it was also an adaptable trout, having switched to clear, cold running streams after the gradual disappearance of the ancient Lake Erie-sized Lahontan Sea.

As with the greenback cutthroat, the Paiute has benefited from large-scale attempts to save it. It is currently found in a few creeks isolated by waterfalls. Pure Paiutes have also been established in several formerly barren creeks in the Silver King Creek watershed.

GOLDEN TROUT:

It is doubtful that any other trout species has been more romanticized or sought after by anglers than the golden. Brood stock from this fish was captured, reared domestically at an early age of fish propagation, and released in suitable and unsuitable habitat over much of the United States.

(Continued on page 128)

Bass Notes

Over the years, a number of thrilling experiences have convinced me that smallmouth fishing is very special sport indeed. by Jim Tabor

It started a long time ago, at the end of a decrepit pier that leaned out into a simmering Virginia lake. There was no wind. Flies buzzed; the stagnant heat encased me. Out on the glistening lake surface, my bobber sat as though stuck. I was perch fishing . . . lowly stuff—worm and hook and fat cloth line. Then I heard a motor's sound, coming up the dirt road; it was a pickup hauling its tail of red dust. Abreast of the lake, this truck stopped. Two men— country men, wearing T-shirts and jeans—got out. From the truck bed they hauled a heavy cooler and walked toward me. I watched them, they watched me, and they stopped at the end of the pier.

"Hey, boy. Come here a second."

I did.

"Lookee here," one of them said, pointing to the cooler. He pulled the lid up and I looked. The cooler was full of water and there was a fish, so much of a fish that it could not straighten itself out. Huge, thick, barely alive, floating in gallons of water stolen from the same lake where they had poached the fish. They were not the kind of men who lined up to buy fishing licenses.

"This your lake?" one of them asked.

"My daddy's."

"You want this fish here?"

"What is it?"

They looked at each other, then up the road behind, where their dust was still falling from the air. I sensed this clearly: They had something others should not see them with. Except, maybe, a kid.

"Bass. You want him?"

"Yes."

"Okay." They went to the water's edge and settled the fish in shallows. The bass rolled over on its side. "Damn," one of them said. They moved it back and forth, back and forth. Then it moved and batted the water with its tail. Disappeared.

They stood up, relieved, hefted their cooler, and walked off. "All yours now," one said, the voice loud and cracker sharp again, lighter by the weight of guilt.

I barely heard them. That fish, immense, longer than my arm from elbow to fingertips. How heavy? Five pounds? Six? Ten? In my pond now, waiting.

I spent the summer trying to catch that bass. I used spoons and spinners, creamy worms and real worms, crawlers and crayfish and frogs, minnows and doughballs and Velveeta cheese. I fished at sunrise and sunset, under the hot noon sun and full-moon midnights. Once, just once, I may have hooked him. On one retrieve, the hook simply stopped coming, as though it had snagged the submerged bumper of a wrecked car. But there were no wrecked cars in that pond. Then—maybe—it moved the other way. Not suddenly, but with immense force. And I, not knowing how bass feed, yanked that line up with both arms, yanked like a man in a fishing boat's fighting chair, sent the line singing up out of the water and the hook slashing past my ear into an unimaginable snarl of cattails and monofilament.

That summer I did not catch that largemouth bass, but I have been trying ever since.

Fishing amid the ruins of the old dam, I hooked a large smallmouth, and then saw a second fish shadow the one I had on.

There is a pull to the hard, sliding waters of spring that is feverish in its intensity, a pull that makes it impossible to concentrate on telephone calls and deals and things of the world. There is only one cure for that fever, and it is to stand thigh-deep in the moving water, dry-wading or, if the cold is bearable, wet-wading, feeling the muscular flow around the legs and against line, feeling the delicate underwater bounce and spin as the lure is carried along.

Springtime is also the time for trout, of course, but I do not much like trout. Listen to what one of the recognized trout experts says about catching such fish: "When I fish with my brother, I am constantly reminded that you can never be too careful when approaching a trout stream. Time and time again I have kidded him about the way he'll frequently fall to the ground and belly crawl up to a favorite pool in order not to scare the fish that are rising there, or the way he'll stalk gingerly along a stream edge to get into position to make the cast. . .God forbid you should get close to him while he's fishing to rising trout if you're not prepared to fall to the ground, crawl up, and whisper or use sign language."

Why in hell would I—or any sane angler for that matter—want to pursue a fish so reticent that one must *crawl* toward it? And *whisper*, for God's sake! I have little interest in such antics. What's wanted is a fish that is gutsy, hard and angry and ready to attack, a streetfighter of a fish. That is what bass are. I think that if bass were people, they would have been, say, marines in Vietnam, or boxers such as Joe Frazier.

I have been drifting a baited No. 10 Mustad hook, on 2-pound-test monofilament, downstream in a bouldery section of Vermont's West River. Because of an impenetrable tangle of poison ivy and briers, I am not at the water's edge but stand on some rocks above

Illustrated for *Sports Afield* by Tom Christopher

Rare Natives

(Continued from page 87)

The golden is the noted trout from high elevations. The fish originally was native to a limited region of California's Kern River drainage, found up to the 10,000-foot elevation. There are still pure golden trout within the Kern River drainage, while a similar Mexican golden trout is found in three Pacific drainage river systems in Durango and Sinaloa, Mexico.

RIO GRANDE CUTTHROAT:

Found in limited areas of Colorado and New Mexico, the Rio Grande cutthroat is similar, yet separate, from the also-rare Colorado River cutthroat of Colorado, Utah and Wyoming. Both the Rio Grande and the Colorado River cutthroat are very striking trout. Some specimens have a multitude of heavy black spots that grow thicker down the body past the dorsal fin until the tail appears almost black.

The Rio Grande and the Colorado River cutthroat are very rare in pure form.

BLUEBACK TROUT:

The blueback trout, found only in Maine, is officially listed as a form of landlocked arctic char. In 1914 William C. Kendall wrote that the blueback was probably extinct in Rangeley Lakes, although he had found them in Rainbow Lake and believed there were other lakes with populations. No one got around to verifying this until 1948, when the trout was brought to light by a writer for a Bangor, Maine, newspaper.

The blueback inhabits about ten deep lakes near the Maine-New Hampshire-Quebec border. More than 100 years ago, early settlers in this region netted bluebacks by the thousands for smoking. The Rangeley Lakes system was especially known for this.

Much of the decline in blueback numbers was caused by the introduction of landlocked salmon into their habitat. Today the fish are considered rare only in context to their limited distribution. They still maintain healthy populations in some lakes.

SUNAPEE TROUT:

The Sunapee trout is similar to the blueback, and it too is regarded as a landlocked arctic char. The Sunapee was historically found over a wider range than the blueback, inhabiting lakes in New Hampshire, Vermont and Maine, but it was limited to fewer actual lakes.

Much of the attention that has long surrounded the Sunapee originated from the char's best-known habitat, Sunapee Lake in New Hampshire. For many years intensive hatchery programs were formed to restock Sunapee Lake with these char. Unfortunately, predation from lake trout and hybridization with both lake and brook trout have forced the lake's Sunapees into extinction.

A refuge for Sunapee trout was established in the mid-1950s in Tewksbury

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Pond, New Hampshire, but it is thought that the Sunapee char there are really hybrid fish. At present there are only two known populations of pure Sunapee chars, and these are remarkably distant from one another. One is found in Maine's Floods Pond, and the other in two lakes in Idaho's Sawtooth Mountains. The Idaho Sunapees came from a 1925 stocking with fish from Sunapee Lake.

APACHE AND GILA TROUT:

Both of these southwestern trout owe their recognition to Robert R. Miller of the University of Michigan, who first described them as a totally new species in the 1950s. They had previously been treated as Colorado River cutthroats.

The Apache trout, with the largest dorsal fin of any American trout, was historically native to the headwaters of the Salt River drainage of Arizona. It is currently found in streams on the Fort Apache Indian Reservation. Reservation residents have worked closely with state and federal agencies to assure the trout's preservation.

The Gila trout was once found in both Arizona and New Mexico, but its range today is limited to streams in New Mexico's Gila River watershed. One of the main reasons for its decline in numbers over the years has been the introduction of rainbow trout into its original habitat. In 1976 a totally pure population of Gila trout was discovered in an isolated tributary in its former range, and stock from this find is now being utilized for future propagation.

The outlook for most rare trout is bright. Many have been saved from the brink of extinction in the past 15 years and only the Gila trout is still listed as endangered.

Efforts by a few dedicated individuals have contributed largely to this remarkable turn of events. Public concern, interest and constant vigilance will prove invaluable to assure stability in the coming years. Many of the rare trout are still exceedingly vulnerable. One blunder or disaster could erase the work that has been done.

The search for rare trout is still continuing, too. The yellowfin trout of Colorado's Twin Lakes is presumed extinct. Historically, both the greenback cutthroat and the yellowfin, also a cutthroat, were reported from this region. The greenback is a small trout, while the yellowfin grew to weights of ten pounds.

Today there are a few yellowfin specimens in scientific collections, a large amount of documentation regarding the trout, and an enigma surrounding whether it still remains today or not. Although doubtful, it's remotely conceivable that an overlooked population still exists. It has happened before. We can certainly hope. SA

Special thanks to Robert H. Smith for the use of his photos on page 66. For more on rare trout, don't miss his book, Native Trout and Char of Western North America, *to be published this spring by Frank Amato Publications of Portland, Oregon.*

Just One More

(Continued from page 160)

hook was buried well beyond the barb. Shaking my head, yet glad to be alone and unwatched in this wonderful display of streamside expertise, I sloshed out of the water and back to camp. First I cut the fly from the leader, then probed the hook to test the damage.

I know one infallible, painless way to remove a barbed hook from flesh. You simply loop some strong fishing line around the bend of the hook, just where it enters the skin, and while pressing down on the eye of the hook with your other hand, give a sharp jerk on the line. The hook pops right back out of its entry hole without causing further injury. The only drawback is that you need two hands for this procedure. With the hook in my wrist, I could neither press nor pull with that hand.

I sat brooding for a moment. My evening of fishing was ruined, that was certain. I'd only gotten in ten or so actual minutes on the water, and dusk was already falling. By the time I could find help getting rid of the hook, it would be dark. At least, I thought, I could then cook a leisurely camp dinner and be ready to hit the water bright and early tomorrow.

I drove back down the dirt road to find help. There was a small bar and grill right where the road met the main highway, and somebody was sure to be there. I knew it also had various brands of anesthetic on tap to facilitate the operation.

The place was empty except for a lone bartender, who was hunched over the bar, chin in hands, watching a Superman rerun on the elevated TV. He didn't look at me until I plopped down on a stool.

"Howdy," he said tonelessly. No one had ever packed so much boredom and career disillusionment into a single word. And his "What'll it be?" carried with it all the existential mournfulness of a wolf baying at the moon.

I explained my predicament, showed him the fly bloodying up my wrist. He peered at it. "Tie it yourself?" he asked.

"Yeah."

"Thought it looked kinda sloppy."

I began to understand why the place was empty. I pulled out a length of fishing line and asked for his help, explaining the method of extraction. He shook his head.

"Can't do it," he said. "We'd be responsible if anything went wrong. I got strict orders not to get involved. The boss got sued once for something like this."

It was my turn to shake my head. "Look, it'll just take a second. It's no big deal. Just pull on the line when I say to. I've done it lots of times."

"Sorry. Can't. We'd be responsible."

I argued against this thesis. I offered to sign a statement waiving their involvement. I offered to pay. I offered a sacrificial trout in their honor. But the bartender's head kept shaking back and forth in automated negation. When I left, his head was still shaking and "can't do it" was still dribbling over his lips.

My wrist was beginning to ache a little, and the vein was puffing up. I drove back to my campsite, lit the lantern and sat on a log. Possibilities flitted through my mind: I could leave the damned hook where it was, simply ignoring it. What about blood poisoning? When was that last tetanus shot? I rubbed my jaw, which suddenly felt a little stiff in the joints. Nonsense. Could I really sleep with a hook tearing at my vein? How would I flyfish in the future if the thing became infected and I lost my right arm?

With that thought I knew what had to be done. I took down the tarp, packed up the cooking kit, stuffed the sleeping bag into its sack, extinguished the lantern and dragged the whole pile of gear back to the car.

A half hour later I was back at my house. I walked over to Melvin's place next door and explained the situation. Melvin, a white-haired old pioneer who had spent his formative years homesteading in Alaska and cutting off frost-bitten toes, took one look at the imbedded hook and dragged me into his kitchen. There he produced a butcher knife suitable in size for the canefields of Hawaii.

"We'll get that little sucker out," he said. "Don't you worry."

I gasped as he plunked my wrist down on the cutting board and held the knife over the hook. "Wait!" I cried. "I know a better way! Really!"

"Only way to get out a hook that deep is to cut it out," he said, in the sage tones of one who has performed many such mutilations before. The butcher knife began descending toward the fly.

With my free hand I grabbed it and fairly wrestled it away. "Melvin," I begged, "at least *try* my method. It works, believe me."

He finally agreed to go along with such youthful foolishness, smiling doubtfully the whole time. I pressed on the eye of the hook and said, "Now!" He gave a yank that would have torn an outboard off its transom, and the little fly popped out and into the air. It fluttered down with a delicacy I couldn't help appreciating.

"Well, I'll be ga-darned," Melvin said, scratching his head, "It worked at that. Whattaya know?"

Eventually he roused himself out of his stupefaction over this modern surgical technique and insisted on pouring great burning quantities of iodine and alcohol into the wound.

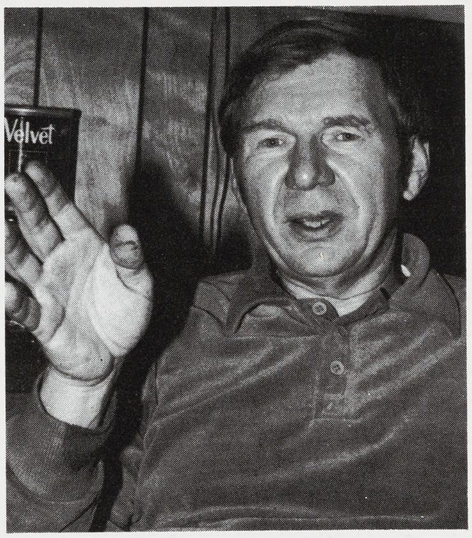
"There ya are," he said at last, "good as new." I thanked him profusely and escaped back to my own house, where I built a drink of monumental proportions.

Slouched in a chair, sipping from the glass, I suddenly realized that my twitch was gone. Remarkable. But fishing is like that. One little trip and the stresses of the workaday world just melt right away. SA

ROBERT J. BEHNKE

ABOUT TROUT

Westslope Cutthroat Trout



The cutthroat trout is a good example of a polytypic species. That is, the species as a whole (*Salmo clarki*) is made up of individual parts consisting of numerous geographical races (subspecies). The cutthroat trout once had the greatest distribution of any trout in North America. The coastal cutthroat subspecies inhabited waters along the Pacific Coast from northern California to southern Alaska and various other subspecies extended inland to the South Saskatchewan River system of Alberta (Hudson Bay drainage) southward on both sides of the Continental Divide to southern New Mexico (Rio Grande cutthroat trout). Despite this once great range, the cutthroat trout is one of the least known of our trouts because the subspecies in the interior regions suffered catastrophic declines soon after our ancesters wrought a civilizing influence on Western watersheds and introduced non-native fishes. In this respect, the cutthroat trout is similar to the canary in the mine — it is typically the first species to go in a disturbed environment.

Salmo clarki lewisi is the scientific name for a subspecies of cutthroat trout that is indigenous to a vast geographical region. Originally, it was the only trout living in the Madison, Gallatin, and Beaverhead rivers and of the whole upper Missouri River drainage above Great Falls, Montana. On the other side of the Continental Divide *S. c. lewisi* is the only trout (considering the bull trout as a char) native to the Flathead, Clark Fork and Bitteroot rivers of Montana. It is also native to the South Saskatchewan River of northern Montana and Alberta, the upper Kootenay River of British Columbia, and Montana, the St. Joe River system of Idaho and the Salmon and Clearwater river drainages of Idaho.

"Despite this once great range, the cutthroat trout is one of the least known of our trouts because the subspecies in the interior regions suffered catastrophic declines soon after our ancestors wrought a civilizing influence on western watersheds and introduced non-native fishes."

How little is known about this particular subspecies of cutthroat trout is illustrated by the fact that it was only during the past two years that I documented the indigenous occurrence of *S. c. lewisi* in the John Day River drainage of Oregon and as the native trout of Lake Chelan, Washington. The fishery agencies of Oregon and Washington had never realized that *S. c. lewisi* (or any form of interior cutthroat trout) is native to their states. I had long heard stories that cutthroat trout occurred in certain tributaries to the John Day River but it was commonly believed that they were the result of stocking. Mr. Robert Smith, an ardent trout angler from Central Point, Oregon, who now attains his ultimate angling experience by fishing for rare, native trout in their native environments, made several collections of fishes and basic information for me that provided the basis for the verification of the native occurrence of *lewisi* in the John Day drainage.

The fisheries for brook, brown, and rainbow trouts and for lake trout and kokanee salmon in large lakes such as Pend Oreille, Priest, Cour d'Alene, and Flathead, in this vast region of the original range of *S. c. lewisi*, are the results of stocking by man during the past 100

Continued on page 38

WESTSLOPE CUTTHROAT (Salmo clarki lewisi)

From an original watercolor painted for Trout Unlimited by Mike Stidham years. None of these species is native to the original range of the "westslope" cutthroat trout with the exception that rainbow trout are native to the Salmon and Clearwater rivers of Idaho and to the John Day River of Oregon. With the establishment of non-native species of salmonid fishes, the westslope cutthroat trout rapidly declined and it now occupies only a tiny fraction of its original range, mainly restricted to small, headwater tributaries.

It was such remnant populations of westslope cutthroat existing in the headwater of the St. Joe River and Kelly Creek in Idaho that first provided conclusive evident that special angling regulations designed to reduce the numbers of trout killed by anglers can be effective for increasing the abundance and size of trout in a population exposed to angler exploitation. The data gathered by Dr. Ted Bjornn and his students of the Idaho Cooperative Fishery Unit established beyond doubt that, after special regulations went into effect, the native cutthroat trout populations responded by tremendous increases in abundance and in the proportion of older, larger trout in the populations. What is still not generally understood among laymen and biologists, however, is that only the cutthroat trout could have responded so favorably to special regulations in these Idaho waters.

The results of special regulation management of cutthroat trout in Idaho can not be indiscriminately applied to other waters with other species of trout with expectations of similar success. The cutthroat trout is the species most easily caught by anglers. It takes enormously greater fishing pressure to overexploit a population of brown trout or rainbow trout than it does a comparable population of cutthroat trout under comparable conditions. In most trout populations, overexploitation occurs when anglers remove about 50% or more of the catchable-size fish during a year. Brown trout populations are known for their resistance to overexploitation under high fishing intensity. The degree of vulnerability of trout to being caught by anglers, besides hereditary, species-specific differences, also is influenced by the characteristics of individual waters and the degree of expertise of the anglers fishing those waters. Brown trout populations have been known to be exposed to 500 to 800 hours of fishing pressure per surface acre per year with less than 50% exploitation rates. Clear-cut examples where brown trout have favorably responded to special regulations include Hot Creek, California, with angling intensity of 3,800 hours per acre per year and the South Platte River near Denver, Colorado, with more than 2000 hours per acre angling pressure. It has now been documented by U.S. Fish and Wildlife Service biologists that severe overexploitation of the cutthroat trout in Yellowstone Lake occurred at only 5 to 6 hours of angling per surface acre per year even with a 14-inch minimum size limit and a bag limit of three fish. The size-age structure and abundance of cutthroat trout in Yellowstone Lake recovered rapidly after a 13-inch maximum size limit (all trout of 13-inches and larger must be released) was instituted. In the catch-and-release fishery for cutthroat trout in the Yellowstone River below Yellowstone Lake, each fish was caught and released an average of 5-6 times in 1981, with virtually no angler induced mortality according to a U.S. Fish and Wildlife Service study. The total annual catch (and release) of Yellowstone cutthroat trout in the river is about 500 pounds per surface acre per year. No other natural trout fishery in the world sustains such a catch.

Only the cutthroat trout can be expected to respond to special regulations designed to greatly curtail angler kill with a significant increase in the abundance of larger, older fish when exposed to relatively light angling pressure (less than 40 or 50 hours per surface acre per year). Because of this attribute, a stirring of interest and increased recognition of the management potential of cutthroat has emerged in state and federal agencies after a long, sad history of neglect and decline.

I should point out here that the Yellowstone cutthroat trout is not *Salmo clarki lewisi*, but a different subspecies (*S. c. bouvieri*) from the "westslope" cutthroat trout. Most anglers somewhat familiar with fishery literature (and most professional biologists) have learned that *lewisi* is the subspecific name for "Yellowstone" cutthroat trout, but this is incorrect.

Until recently, virtually all references to trout classification were based on the work of David Starr Jordan and B.W. Evermann published by the U.S. National Museum in 1896 and revised for popular consumption in the book, *American Food and Game Fishes*, published in 1902. Jordan assumed that an ancestral trout crossed the Continental Divide from the upper Snake River drainage (Columbia River basin) into the Yellowstone River drainage via two Ocean Creek — a stream on the Continental Divide that forks with one fork becoming the Pacific Creek, a tributary to the Snake River, and one fork becoming Atlantic Creek, tributary to the Yellowstone River (Missouri River basin). Jordan believed that, once in the Yellowstone River, the ancestral trout populated the river downstream to the Missouri and then spread throughout the headwaters of the Missouri. Thus, it seemed logical to Dr. Jordan that the Yellowstone trout and the upper Missouri drainage trout should be similar and the name "*lewisi*" given in 1856 to specimens of Missouri trout from near Great Falls, Montana, was applied to both Yellowstone and upper Missouri cutthroat. Jordan did not realize that trout distribution in the Yellowstone River drainage did not extend beyond the Tongue River, in the vicinity of Sheridan, Wyoming (the main army of General Crook was camped on the upper Tongue River enjoying great fishing for "Yellowstone" cutthroat trout on June 25, 1876, while Custer and his regiment were being annihilated on the Little Bighorn, the adjacent tributary to the Yellowstone River to the west). The cutthroat trout native to the headwaters of the Missouri basin originated from a separate crossing of the Continental Divide by a different ancestral subspecies than did the Yellowstone cutthroat, and the two subspecies never came into contact.

In the 1960s Montana biologists realized that the native cutthroat trout of the upper Columbia River basin in Montana was distinctly different in appearance from the Yellowstone cutthroat trout and they used the common name of westslope cutthroat trout to differentiate it from the Yellowstone cutthroat. Since then, studies by my graduate students established the fact that the cutthroat trout of the upper Missouri drainage is identical to the upper Columbia basin cutthroat; thus, the name *lewisi* was applied to the cutthroat trout on both sides of the Continental Divide and a different subspecies name was designated for the distinctly different form of cutthroat trout native to the upper Snake River and Yellowstone River.

George Suckley, a surgeon-naturalist and avid lover of trout, collected trout specimens during the Pacific Railroad Survey of 1853. Suckley was aware that Lewis and Clark first encountered "speckled trout" in the Missouri River in the vicinity of the "Great Falls." He made a special trip to the site and caught several specimens on flies. He wrote, "I found them a lively, fine fish jumping readily at the fly." Suckley sent two of these specimens to the Smithsonian Institution and they serve as the basis (type specimens) for the name *lewisi*. Suckley also noted that the trout on both sides of the Continental Divide (upper Missouri and Flathead rivers) were identical, but no one paid attention to his remarks. After 120 years had passed Suckley's observation on the identity of these trout was verified.

It took many years of study and the examination of thousands of trout specimens from Western North America before the evolutionary history and distribution patterns of the numerous subspecies of cutthroat trout became reasonably clear. The subspecies *S. c. lewisi* is differentiated from Yellowstone cutthroat trout by possessing smaller, irregularly shaped spots on the body. The size and shape of the spots are comparable to the spots of the coastal cutthroat trout subspecies, but *lewisi* differs from coastal cutthroat trout by having few or no spots anteriorly on the body below the lateral line. *S. c. lewisi* differs from both coastal cutthroat and Yellowstone cutthroat in the development of brilliant coloration, especially in waters where crustaceans (with carotenoid pigments) contribute to their diet. Spawning males of *lewisi* may have their whole ventral region suffused with a bright crimson color.

The westslope cutthroat is probably the least predaceous subspecies of cutthroat trout; it seldom preys on fish even when they are available. This dietary peculiarity is likely the result of a long evolutionary history of coexistence with the predatory bull trout in the upper Columbia River basin. The two species evolved to partition the food resources and avoid direct competition. This proclivity for nonpredatory feeding results in a smaller maximum size typical of *S. c. lewisi* than of other subspecies of cutthroat — about three pounds in all but exceptional cases. However, this hereditary specialization for invertebrate feeding preeminently "preadapts' the westslope cutthroat trout to the expectations of fly fishermen. With the wealth of diversity and specializations for different life history types found among the 15 subspecies of cutthroat trout, it is unfortunate for the devotees of wild trout that the fisheries management programs in those states with native cutthroat trout have, historically, placed their emphasis and priorities with the domesticated hatchery rainbow trout to resolve all problems and mitigation disputes. I doubt that big game hunters in those states would willingly accept so many tons of feedlot fattened Herefords in replacement for the loss of deer and elk range.

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October 22	Beamoc (New York)	Ms. Carrol Darbee (914) 439-4273
October 22	Montachusett (Massachusetts)	Mr. Drew O'Connell (413) 597-5140
November 2	Oakbrook (Illinois)	Mr. Colin Haase (312) 325-5130
November 3	Georgia Council	Mr. John Hoyle (404) 433-0106
November 5	Maryland	Mr. Harris Davis (301) 435-0160
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Heeere's Dolly

I read with interest the letter from John T. Hannah, Houston, Texas, regarding the naming of the Dolly Varden char.

I too had often wondered how this name came about. Most outdoor writers have explained it away by referring to the gaily spotted dresses favored by Dolly Varden, the heroine of Charles Dickens' *Barnaby Rudge*. However, as Mr. Hannah pointed out, a careful reading of this novel reveals no such description.

Dickens was very popular in the U.S., and it is said that his tour of this country set off a craze in "Dolly Varden" dresses, hats, and patterns of fabrics, and this did indeed lead to the common name for the red-spotted western char.

Peter B. Moyle, in his 1976 book, *Inland Fishes of California* (Berkeley, CA, University of California Press) has the actual story. The following is an excerpt from page 145 of his book:

> *Names. Salvelinus* is an ancient Scandinavian word for char. The name Dolly Varden has an interesting origin which was recounted to the author in a letter (March 24, 1974) from Mrs. Valerie Masson-Gomez:
>
> My grandmother's family operated a summer resort at Upper Soda Springs on the Sacramento River just north of the present town of Dunsmuir. She lived there all her life and related to us in her later years her story about the naming of the Dolly Varden trout. She said that some fishermen were standing on the lawn at Upper Soda Springs looking at a catch of the large trout from the McCloud River that were called "calico trout" because of their spotted, colorful markings. They were saying that the trout should have a better name. My grandmother, then a young girl of 15 or 16, had been reading Charles Dickens' *Barnaby Rudge* in which there appears a character named Dolly Varden; also the vogue in fashion for women at that time (middle 1870s) was called "Dolly Varden," a dress of sheer figured muslin worn over a bright-colored petticoat. My grandmother had just gotten a new dress in that style and the red-spotted trout reminded her of her printed dress. She suggested to the men looking down at the trout, "Why not call them Dolly Varden?" They thought it a very appropriate name and the guests that summer returned to their homes (many in the San Francisco Bay area) calling the trout by this new name. David Starr Jordan, while at Stanford University, included an account of this naming of the Dolly Varden Trout in one of his books.

Pat Trotter
Seattle, Washington

pictures and article; how would I order such a custom boat?

I do a great deal of reading and if I find something that I am interested in I want to know whom to call or write to. In my opinion articles without telephone numbers or addresses are not complete. Do the authors feel that every reader should know where to find these items? If every reader did know—then why write the article?

Please offer your readers such as myself a complete article with purchase information. Thank you.

Si Siatos
San Rafael, California

#1—Armed with the information supplied in our reviews, anyone can walk into any bookstore and purchase/order same.
#2—The point of that ad is to alert readers of the presence—or absence—of a sympatico tackle shop in their home town, or in a town they may be visiting. Space does not permit more information, so we suggest Directory Assistance.
#3—Virtually any fly-tackle shop carries or can order any of our Kudo-winners.
#4—See previous letter.

Note however that we do supply particulars in our equipment reviews, such as the float tube feature in this issue.

—Ed.

Another Passing

I want to compliment you on a great Nov/Dec issue. The piece on the Pates [*Tarpon Hunting*] was excellent—terrific photographs.

You may have heard that John Emery died on October 11, following complications from cancer treatment. The Rod & Reel Club held a benefit for him in Miami, and we raised more money for his family at a dinner here in Islamorada.

Michael Callahan
Islamorada, Florida

John Emery, the innovative Florida tackle maker and fishing guide, died of a malignant melanoma, a deadly form of skin cancer. He was 44 years old; he leaves behind a wife and two young sons.

Emery's meticulously crafted big-game fly reels, in production only a few years, became collector's items almost overnight. He had just completed a redesign of the reels, and his wife is reportedly going ahead with John's plan to reintroduce them to the market.

The 51st annual Metropolitan South Florida Fishing Tournament, which began on December 14, was dedicated to John Emery.

—Ed.

Yellowstone Cutthroat

This question was partly answered when Larson introduced me to biological technician Steve Moore, a husky graduate in fisheries biology from Tennessee Technological University. Moore recently completed an intensive four-year trout research project that involved the experimental removal of rainbow trout from six selected brook trout streams in the park.

"We collected trout of both species from the six test streams by electroshocking," Moore explained. "The rainbows were removed and all brook trout were returned to the same stream from where they were collected. These six streams were electrofished for four consecutive years [1976 to 1980] to test the effectiveness of the method in removing exotic trout and to observe brook trout population responses, if any, to the rainbow trout removal.

"While we were not able to remove all of the rainbows from these streams, we did succeed in reducing their numbers substantially," said Moore. "The results were positive. Brook trout populations improved markedly and showed progressive and cumulative increases in both numbers and total weight per area of water."

Ironically, the brook trout's retreat into beautifully inhospitable habitat presents the greatest obstacle to rehabilitation through an electroshocking program. Many of the streams in the Great Smokies are located in steep, rugged terrain inaccessible by roads. Overnight camping in remote areas was frequently necessary, and this meant that the electroshocking equipment—gas-operated devices weighing 18 kilograms each—and food and camping gear had to be carried by backpack. During the course of the four-year study, it wasn't unusual for Moore and his assistants to lug 65-pound backpacks over distances ranging from two to seven miles upstream. And the actual in-stream electrofishing work took eight to ten hours a day for several days until a stream was completely sampled. Selective fish killing was also man killing.

While Moore's studies have indicated the impracticality of using elecrofishing equipment to completely remove rainbow trout from park streams, these studies also suggest that brook trout populations increased when rainbow populations were reduced. In 1980, removal of rainbow on Lynn Camp Prong was attempted using angling. Larson, Moore, and Lee (in press) concluded that *angling is more efficient for removing rainbow trout than electrofishing.* Angling should be considered as a technique for reducing the rainbow in selected streams where rainbow reduction seems feasible. Further testing may show that this technique might be used periodically to maintain rainbow trout populations at levels that have little effect on brook trout populations.

Stuart E. Coleman, the park's Resources Management Specialist, said valuable insights into restoring brook trout populations were gained from Moore's research findings. "The results are applicable to the current interim long-range management plan that has been developed for the recovery of native brook trout populations within the park," said Coleman.

Coleman explained that the plan's restoration program consists of two main parts. The first involves the removal of rainbow trout above natural obstructions (waterfalls and cascades) which are barriers to upstream migration by rainbow. The second phase of the program calls for the modification of selected passable obstructions into impassable barriers and then removing the rainbows upstream of the barriers. The second phase is pending the acceptable completion of the first phase and studies of how the passable obstructions can be modified, as well as an assessment of the physical, chemical, and biological impacts of such modifications.

One future possibility calls for the restocking of native brookies in barren waters above natural barriers when it is known that such waters were historically occupied by brook trout.

The eventual goal, if the interim project is successful, is to remove the competing rainbow trout from selected reaches of former brook trout streams over a four-year period. One future possibility calls for the restocking of native brookies in barren waters above natural barriers when it is known that such waters were historically occupied by brook trout.

According to Coleman, the long-term goal of the program is not to eliminate the rainbow trout from the park. It is to ensure the perpetuation of viable, self-sustaining native brook trout populations. "Many people have the mistaken notion that the National Park Service wants to eradicate all rainbow trout from the park, but this is not true," Coleman emphasized. "Populations of rainbow trout will always remain in the larger, lower elevation streams for recreational fishing. But the brook trout is a 'native son' of the Great Smokies, and we aim to do all we can to enhance its opportunity to migrate into portions of its former range within the park."

As I drove down into the valley away from the shadow of the Great Smoky Mountains National Park, I thought about the brookie I had hooked. By releasing it I had actively contributed to the survival of a colorful denizen, a part of the living heritage of this unique region. It is expected that all fellow fishermen in the Smokies will do the same.

With continued good-sense management by the National Park Service, and an aggressive rehabilitation effort, there is no reason the brook trout—the original occupant of this mountain enclave—should ever recede into the high mists.

ROBERT J. BEHNKE

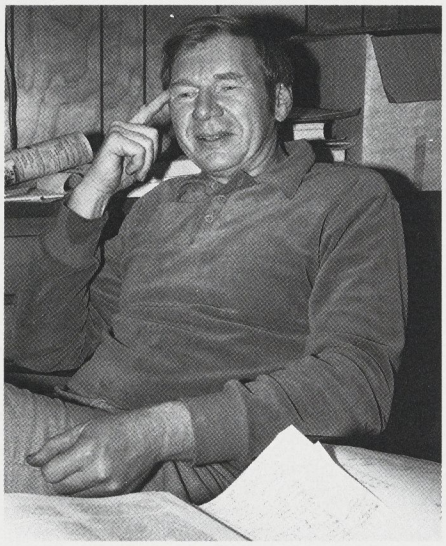
The combination of circumstances that is responsible for the phenomenal fishery in the Yellowstone River is not duplicated anywhere else on earth.

Yellowstone Cutthroat

Yellowstone Lake and the Yellowstone River downstream to the two spectacular falls in Yellowstone National Park contain the greatest concentration of inland cutthroat trout still in existence. Thus, the common name "Yellowstone cutthroat" seems appropriate, although the origins of this subspecies are associated with the Snake River on the other side of the Continental Divide.

The Yellowstone cutthroat trout is characterized by relatively large, roundish spots, less brilliant coloration (in comparison with other subspecies) and 64 chromosomes. The presence of cutthroat trout in the Yellowstone River is due to a crossing of the Continental Divide in recent geological times from the headwaters of the Snake River (Columbia River Basin) to the headwaters of the Yellowstone River (Missouri River Basin). This transfer occurred after the end of the last glacial epoch and the melting of the glacial ice from the Yellowstone Plateau about 6500 years ago.

After the common ancestor to all cutthroat trout became established along the Pacific Coast of North America there was an inland movement of the species in the Columbia River. This inland invasion led to the eventual separation of the coastal subspecies from interior subspecies with the Cascade Mountains forming the line of demarcation. The ancestral inland cutthroat trout soon divided into a northern Columbia River group associated with the Kootenay, Pend Oreille and Spokane River systems, which evolved into the



westslope cutthroat trout, *S. c. lewisi* (see autumn 1983 issue of ***Trout***), and a group associated with the Snake River system, which evolved into the Yellowstone cutthroat trout. Based on the degrees of divergence as interpreted from morphological differentiation, protein patterns, and chromosomes (karyotypes), I estimate that the original separation of a common ancestral cutthroat trout into three major evolutionary lines—coastal, westslope, Yellowstone—may have occurred about one million years ago or more.

The ancestor to the present Yellowstone cutthroat gave rise to all other inland subspecies by successive invasions from the Snake River system into the Lahontan, Bonneville and Alvord Basins (separate desert basins of the Great Basin), and into the Green River drainage of the Colorado River Basin and subsequent radiation into the South Platte, Arkansas, and Rio Grande drainages. The formation of Shoshone Falls on the Snake River near Twin Falls, Idaho, isolated the cutthroat trout in the drainage above the falls and protected them from a later invasion of rainbow trout in the Columbia Basin.

After rainbow trout became established in the Columbia Basin, they completely eliminated the Yellowstone cutthroat from the Snake River drainage below Shoshone Falls wherever they came into contact. Rainbow trout also virtually eliminated the westslope cutthroat subspecies from the Columbia Basin up to barrier falls on the Kootenay, Pend Oreille, and Spokane Rivers. During the past 100 years, stocking of rainbow trout into almost all areas of the upper Columbia Basin and the upper Missouri and Yellowstone drainages has demolished the isolation that had protected the native cutthroats from rainbow trout for thousands of years. Hybridization and replacement by rainbow trout and replacement by brook, brown, and lake trout has resulted in the present survival of pure populations of both Yellowstone and westslope cutthroats in only a tiny fraction of their native range. This same phenomenon of hybridization and replacement has occurred with other inland subspecies so that Yellowstone Park has become the greatest stronghold for any of the interior subspecies of cutthroat trout.

There is a record of 20,000 rainbow trout stocked into the Yellowstone drainage above the falls many years ago. Evidently their survival was very low or nil. No trace of the effects of rainbow trout hybridization can be found in the cutthroat trout in Yellowstone Lake or in the river above the falls today.

In 1985 Eastern brook trout were found in Arnica Creek, a tributary to Yellowstone Lake. Perhaps an angler caught some brook trout in another part of the park and kept them alive in a bucket until disposing of them in Arnica. If so, he couldn't have realized the potential ecological catastrophe his action might trigger.

I doubt that brook trout could successfully compete with the native cutthroat in Yellowstone Lake, but they would be expected to eventually spread to most or all of the lake's 68 tributary streams used by cutthroats for spawning. Their presence could severely impact cutthroat spawning success and recruitment. To head off such a catastrophe, the National Park Service and the United States Fish and Wildlife Service mobilized a counter-offensive by chemically treating Arnica Creek to kill the brook trout and nip the threat in the bud. This treatment was repeated in 1986.

The older literature designates Yellowstone cutthroat trout as *Salmo clarki lewisi* because the name *lewisi* was assigned to cutthroat trout native to the Missouri River near Great Falls, Montana. It was assumed that the cutthroat trout of the Yellowstone and upper Missouri Rivers were the same subspecies. Actually, the upper Missouri River cutthroat trout is derived from a separate crossing of the Continental Divide by westslope cutthroat from the headwaters of the Flathead River drainage. The two subspecies never came into contact, although they occurred within a few miles of each other in headwaters of the Yellowstone and Madison Rivers. The downstream environment of the Yellowstone and Missouri Rivers in eastern Montana is too warm and turbid for trout. This environmental barrier enforced isolation between the Yellowstone and Missouri River (westslope) cutthroat trout.

Several years ago it became obvious that the cutthroat trout of the upper Missouri and Yellowstone drainages represented two distinctly different subspecies.

The subspecies name *lewisi* must be assigned to the cutthroat native to the upper Missouri and upper Columbia River drainages. Thus, a new subspecies name had to be found for Yellowstone and upper Snake River cutthroat trout. I searched the literature to find the oldest available name that described the large-spotted cutthroat of the Snake and Yellowstone Rivers. I decided on *Salmo clarki bouvieri,* a name given in 1883 to the cutthroat trout native to Waha Lake, Idaho. Waha Lake is located near the Washington border, far downstream from Shoshone Falls. The lake is isolated from direct connection to the Snake River. This isolation blocked rainbow trout from Waha Lake and the native cutthroat persisted unmolested until impacted by the influence of Caucasian civilization. The Waha Lake watershed was degraded and rainbow trout and a hodgepodge of non-native fishes, including carp, were stocked. *S.c. bouvieri* has been long extinct in Waha Lake, the type locality for the name, but the name survives to be used for the remaining populations of the subspecies in the upper Snake and Yellowstone drainages.

Fortunately, the native cutthroat persisted in the upper Yellowstone drainage in Yellowstone National Park, although the native westslope cutthroat is long gone from the Madison and Gallatin Rivers in the park. ? Native Yellowstone cutthroat existing in a near-pristine environment have been the subject of many studies to provide a better understanding of population dynamics, exploitation rates and effects of special regulation fisheries.

Knowledgeable and observant anglers familiar with Yellowstone Lake and its cutthroat trout are likely to raise questions based on their experience with other trout fisheries. These questions may seem to lack reasonable answers. For example, where are the young trout? Why are fish less than 12 inches long so rarely seen? Why might two fish of the same size look so different? Why is their flesh red like that of a ? salmon?

Cutthroats in the lake typically reach maturity at four or five years of age and 14–16 inches. They run up tributaries from late May through early July for spawning. Their eggs hatch in about 30 days and almost all of the young move into the lake soon after hatching. Movement of the juvenile cutthroat once in Yellowstone Lake is not well understood. They must spend their early years in deeper, open waters, segregated from larger, older trout. Cutthroat are rarely taken in net samples with large fish and are not found in the stomachs of large fish (though large cutthroat, given the opportunity to intercept the lakeward run of newly hatched fry, will gorge on them; they have no inhibitions against cannibalism). Typically, in their third or fourth year of life, averaging 12 inches, the trout move into shallow water to join the adult population.

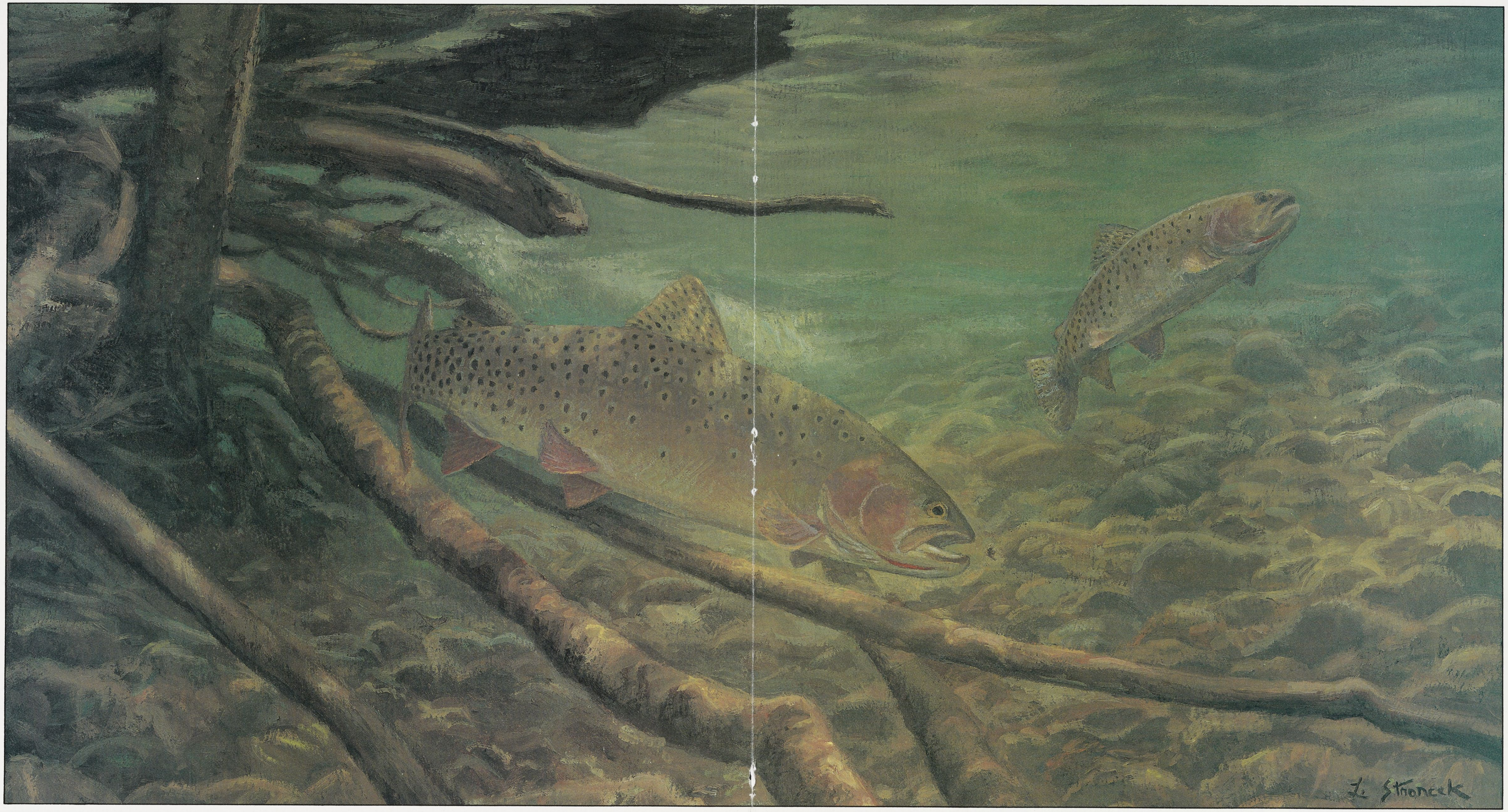
There are insects in Yellowstone Lake—midges, mayflies, caddisflies—but the main cutthroat diet consists of crustacea: water fleas (daphnia) and amphipods (freshwater shrimp or scuds). This diet imparts the salmon- ? red color to their flesh.

Because of a great depletion of energy reserves from spawning and a relatively short growing season in Yellowstone Lake, most of the surviving spawners must wait out a full year before their gonads can mature again for repeat spawning. That is, they wait to spawn again two years after first spawning. This is why some fish, caught in midsummer soon after spawning, appear sickly and emaciated, while others, having spawned the previous year and now fattening for next year, are plump and bright. ?

With a 13-inch maximum size limit to protect the older fish, Yellowstone Lake has experienced a resurgence of older age classes of its cutthroat trout. Formerly, under heavy angling exploitation, fish of more than five years were extremely rare. In recent years trout of seven to eight years have become increasingly common. Some nine-year-olds have been found.

It is now well known that cutthroat trout are extremely susceptible to angling; they are easily overexploited. Because of this vulnerability, however, cutthroat also respond to special regulations much better than other trout species. Although I have a long familiarity with all aspects of cutthroat trout biology, I am still amazed at some of the data developed from studies of the native cutthroat in Yellowstone Park.

Yellowstone Lake has a surface area



YELLOWSTONE CUTTHROAT *(Salmo clarki bouvieri)*

From an original acrylic painted for Trout Unlimited by Lee Stroncek

of more than 87,000 acres. At an elevation of slightly over 7700 feet, it is the largest high lake over 7000 feet in North America. The cutthroat trout and a small minnow, the longnose dace, are the only fish species that crossed the Continental Divide at Two Ocean Pass from the Snake River and became established in the Yellowstone Lake Basin. (Redside shiner and longnose sucker have been established in recent times by illegal introductions). The cutthroat trout essentially had Yellowstone Lake and its tributaries all to itself for several thousand years. They flourished in great abundance.

Until 1970, angling regulations allowed three trout of any size to be creeled from Yellowstone Lake. From 1970-1972 a minimum size of 14 inches was initiated, and the bag limit was reduced to two fish per day in 1973. Despite these restrictive regulations, the population in the lake drastically declined. A most astonishing fact is that this decline occurred when angling pressure was no more than four to five hours per surface acre per year. I have never heard of a documented case of overexploitation—overfishing—occurring at such low angling pressure. I am quite certain it could occur at such low pressure only if cutthroat trout is the species being exploited.

In 1975 a new regulation was instituted requiring the release of all fish of 13 inches and larger, a two-fish daily bag limit, with only flies and artificial lures allowed. This regulation was designed to protect the older, mature fish. It has proven highly successful.

By the 1980s the size of the spawning run in Pelican Creek had doubled from counts made in the 1960s, from 12,000 to 24,000. In Clear Creek, spawning runs had dropped below 10,000 fish by the 1950s, but recovered rapidly under the 1975 regulation; the 1978 run peaked at about 70,000. In regard to trophy-size fish, only three fish per 1000 caught in 1973 and five per 1000 in 1974 were more than 18 inches. In 1983 this ratio had increased to 80 per 1000. The proportion of fish spawning for the second or third time (repeat spawners) increased from only a few percent of the spawning runs to 25 to 30 percent.

From the lake, the Yellowstone River flows for about 20 miles through gentle terrain before plunging over the upper and then the lower falls into Yellowstone Canyon. About nine miles of the river below the lake is presently open to catch-and-release angling. This section supports the greatest cutthroat trout fishery in the world. It is also probably the greatest completely natural fishery for any species of trout in the world as expressed in annual catch of large fish (14 to 18 inches) per unit area of river. A fishery of such quality is only possible because of the susceptibility of cutthroat trout to be caught again and again.

Fishery regulations on the river became increasingly restrictive by the 1950s in an attempt to prevent overexploitation. By the 1970-1972 period, regulations prohibited bait fishing and had a 14-inch minimum size and a three-fish-per-day limit. Yet overexploitation still occurred. Electrofishing sampling made in the fall of 1971 compared a section of the river closed to angling with the open section. The results left no doubt that the cutthroat in the river were severely overexploited. The trout in the closed section averaged 17.6 inches, with fish up to 22 inches. The trout in the open section averaged 14.2 inches, with virtually no fish more than 16 inches—almost every trout was being removed upon attaining (or nearly attaning) the minimum size of 14 inches!

In 1973 the catch-and-release (no-kill) regulation was instituted with only flies and artificial lures allowed. The results were dramatic. Average age and size of fish in the catch jumped. By 1974-1975 the total annual catch was two to two and one-half times the annual catch in the 1970-1972 period. Catch-per-hour had tripled to an average angler catch of more than two trout per hour—which has since declined to slightly more than one per hour in the 1980s due to a great increase in fishing pressure.

In 1980 and 1981, a graduate student at Idaho State University, Mr. Daniel Schill, and his professor, Dr. J.S. Griffith, conducted research on the Yellowstone River fishery to provide some insights into how a finite population of cutthroat trout can consistently sustain such a high total catch.

A section of river about three miles in length in the Buffalo Ford area—which is subjected to the greatest fishing pressure—was selected for critical analysis. During a six-week period from July 15 to August 25, 1981, an estimated 7500 trout provided an estimated catch of 72,698 during six weeks of angling—that is, each trout was caught and released an average of 9.7 times. The total mortality of trout during this period was estimated at 236. If all this mortality was due to hooking or handling mortality, it figures out to be three fish killed per 1000 caught and released, or .3 percent (236 died from 72,698 caught). This section of the river probably contains less than 100 surface acres. The trout caught averaged about 16 inches. Thus, during a six-week period the native cutthroat trout provided a catch (and release) of about 1000 pounds per acre with angling pressure of about 700 hours per acre.

The results from the Yellowstone cutthroat trout fishery should not be cited to indiscriminantly demand catch-and-release trout fisheries all over the country. Thoughtful consideration of a few facts should make it evident that the same results would not be expected in other rivers with other species of trout.

For consideration of catch-and-release regulations a useful comparative indice is the number of hours of angling per unit area it takes to catch each fish in the population an average of two or three times. The Yellowstone River cutthroat trout were caught an average of 9.7 times with about 700 hours per acre angling—or the population was "turned over" with every 70 hours per acre of angling. The rapid drop in total catch and catch-per-hour soon after opening day demonstrates that even cutthroat trout learn from experience—they become progressively more difficult to catch with successive catching. I estimate that only about 20 hours of angling per acre was required to catch each Yellowstone cutthroat an average of two times.

The brown trout stands at the other extreme in angling vulnerability. In the South Platte River, Colorado, it took 1900 angling hours per acre to catch each brown trout in the population an average of two times. To catch each brown trout in Hot Creek, California, an average of three times required 3800 angling hours per acre! Special regulations governing angling in the Madison River in Yellowstone Park have produced no detectable changes in the brown trout population.

Besides considerations of angling pressure and vulnerability to being caught, it is important to know life history characteristics of trout populations considered for special regulations management. Are they relatively long-lived—general maximum age of about five to eight years? Do they continue to exhibit good growth throughout their life (average about three inches per year increase), or do environmental limitations place severe restrictions on growth and longevity?

The Yellowstone River cutthroat trout represent an exceptional situation. Evidently, soon after hatching they migrate into Yellowstone Lake to grow and mature. They do not return to the river until they are adults—about 95 percent of the population in the river are fish of more than 12 inches. Thus, virtually none of the habitat or food supply is utilized by young, small fish. To my knowledge the combination of circumstances that is responsible for the phenomenal fishery in the Yellowstone River is not duplicated anywhere else on earth.

The fisheries research studies in Yellowstone Park have also helped to dispel some long-established beliefs.

Contrary to popular opinion, it is not necessary to restrict catch-and-release fisheries to barbless flies only. A large proportion of Yellowstone anglers have only casual interest in fishing and are not highly skilled or experienced. Many use large treble hook lures. The trout they catch are frequently left flopping on the bank while a camera is dug out and photos taken. Yet survival of the released trout is exceedingly high (99.7 percent) based on the 1981 study. Almost all detailed comparative studies on hooking mortality have demonstrated no significant differences in mortality between trout caught on single, treble, barbed, or barbless hooks. There is, however, a slight but consistent increase in mortality due to barbless hooks.

John Deinstadt, a California Fish and Game Department biologist with long experience with catch-and-release fisheries, believes this is due to what he calls the "stiletto effect." Barbless hooks have the tendency to penetrate more deeply. Although mortality of released trout rapidly increases with warmer water temperatures (especially as temperatures approach 70 degrees), under normal conditions, almost all mortality of trout caught on flies or artificial lures is due to rupture of the respiratory filaments of the gills or puncture of the carotid artery in the roof of the mouth. Because of their greater penetration power, barbless hooks are more prone to puncture the carotid artery. Large treble hooks often cause the least mortality because, unless the trout is quite large, the hooks cannot be engulfed into the mouth.

Another long-entrenched belief is that regulations that promote the selective removal of large trout, such as a 14-inch minimum size limit, will cause dwarfing of the population. That is, the continued removal of larger, faster-growing trout leaves the slower-growing "runts" to breed, and a hereditary change for slower growth will occur in the population. This certainly seems logical. It is theoretically possible or even probable until the matter is looked into in greater depth and the right questions are asked.

For such an effect to occur, the larger or faster-growing fish must be eliminated before they reproduce—otherwise they have already passed their hereditary information on to the next generation. Many, perhaps most, of the Yellowstone cutthroat trout had already spawned before they were removed from the population in former times under the 14-inch size limit. Also, opposing selection factors acting against slow growth must be considered, such as lower fecundity and increased vulnerability to predation. In any event, the adult populations of cutthroat trout both in Yellowstone Lake and River were exposed to extreme levels of exploitation for many years—probably higher than any other major wild trout fishery in the country. If a hereditary change for slower growth and a smaller adult size is a consequence of high exploitation rates of larger adults, then the Yellowstone cutthroat would be expected to show this effect. All of the empirical evidence, comparing the average and maximum size of cutthroat trout caught in "the old days" before high exploitation occurred with what is found in the present populations protected by special regulations, demonstrates that no detectable change has occurred. Edward R. Hewitt, in his book *A Trout and Salmon Fisherman for Seventy-five Years,* recounted a fishing trip to Yellowstone Park in 1881 before the park was open to the public. Hewitt caught thousands of Yellowstone cutthroat trout and commented that none exceeded four and one-half pounds, which is about the present general maximum size.

For history buffs, the Yellowstone cutthroat is richly associated with the lore of the Old West. When documenting the easternmost natural range of Yellowstone cutthroat trout in the Tongue River, a tributary of the Yellowstone River immediately east of the Little Bighorn drainage, I found reference to General Crook's army encamped in the upper Tongue River drainage in June, 1876.

Crook had retreated after the battle of the Rosebud, where his army met fierce resistance from a surprisingly large number of Indians led by Crazy Horse. Crook's army found the streams full of large, easily caught cutthroat trout. The men so enjoyed this wilderness paradise that General Crook decided to spend a few extra days for the morale of his men. When the main army finally moved westward to the Little Bighorn they found the remains of Colonel Custer and his troops. Perhaps if the range of the Yellowstone cutthroat trout had terminated with the Little Bighorn River and not extended to the Tongue River, names such as Little Bighorn, Custer and Sitting Bull would not have such common familiarity today. If the Indians had had their way there would still be native cutthroat trout in the Little Bighorn and Tongue Rivers. The taming of the West was bad news for cutthroat trout.

Fortunately for *Salmo clarki bouvieri*—and for *Homo sapiens*—a large area of the untamed West, including the headwaters of the Yellowstone River, was set aside in 1872 to become our first national park.

ROBERT J. BEHNKE

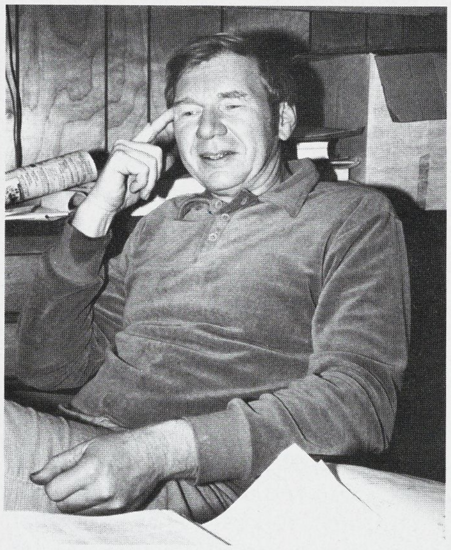
***Fisheries managers must be able to discriminate between special strains of trout as connoisseurs do estate-bottled and* vin ordinaire.**

Kamloops Trout

Kamloops trout can be most simply defined as a form of rainbow trout native to the upper Columbia and upper Fraser River Basins of British Columbia. The problem with such a definition is that it is too simple to be informative. Burgundy can be defined as a form of wine, but such a simple definition is not at all useful to someone seeking an in-depth understanding and appreciation of wines.

My first exposure to the Kamloops trout was in the summer of 1957 when the late Paul Needham and I made a trip from California to Alaska. Our aim was to collect and preserve specimens of rainbow and cutthroat trout which we believed would provide the basic evidence to resolve the confusion surrounding the evolution and classification of Western trouts. I must admit that I had a more naive faith then in the orderliness of nature, in the ability of "research" to provide a clear understanding of how evolution works, and how we could interpret evolutionary diversity for an unambiguous system of classification.

One of the confusing forms of rainbow trout in need of study was the Kamloops trout, which had, at various times, been considered as a distinct species, a subspecies, and a "form" of rainbow trout. (The Kamloops trout was first described by David Starr Jordan in 1892 as *Oncorhynchus kamloops,* under the mistaken belief that it represented a landlocked species of Pacific salmon.) On our return trip, we made several collections of trout from the upper Fraser River Basin to obtain



material to characterize the Kamloops trout. Although nets were sometimes used during our 1957 collecting trip, most of our specimens were collected with a fly rod. The most distinctive attribute I recall about Kamloops trout was their spectacular fighting ability — of all the "forms" sampled, the Kamloops were the most fun!

On our way down the Fraser River, we stopped for a few days to visit Tommy Brayshaw and his wife Becky at Hope, British Columbia. Tommy Brayshaw was a friend of Roderick Haig-Brown (he did the illustrations for Haig-Brown's book, *The Western Angler.*) Both Brayshaw and Haig-Brown represented an extremely rare form of angler: anglers who have an obsession for learning about all aspects of their beloved fish — their biology, life history, evolution, and classification. Haig-Brown and Brayshaw avidly sought out scientific literature on trout biology. They read it, discussed it, and exchanged information.

Tommy Brayshaw was the first person I met who had first-hand, in-depth information on Kamloops trout, and I asked his opinion on the question: What exactly is a Kamloops trout? Much of what we discussed can be found in Haig-Brown's book, *The Western Angler*, and concerns attempts to delineate the relative roles of nature and nurture for a decision on the status of Kamloops trout.

That is, how much of the differences that have been used to characterize Kamloops trout are the result of heredity (nature) and how much are due to direct environmental influence (nurture)? The question of formal taxonomic recognition as a separate species or subspecies concerns the origin of Kamloops trout. Can all the rainbow trout native to the upper Fraser and upper Columbia River Basins be traced to one common ancestral divergence from all other evolutionary lines of rainbow trout? If so, then are there hereditary, identifying characters possessed by these populations that differentiate Kamloops trout from all other forms of rainbow trout? The answer to this question is affirmative if Kamloops trout are regarded as lake-adapted populations of the Columbia River redband trout, as I discussed in my article on redband trout in the autumn 1986 issue of ***Trout.*** Thus, Kamloops trout are part of the subspecies *Salmo gairdneri gairdneri* which also includes anadromous steelhead trout and resident redband trout native to the upper lead ball to stir up the bottom and excite the lake trout. He had more fun fishing with his hands on the rod than when simply watching a set of rods cocked in downriggers. Last year a modern angler challenged him to a contest, the old gear against a boat equipped with downriggers and other modern equipment.

"But, it was no contest! I caught six trout before he had his first."

Anyone who knows lake trout shouldn't be surprised at that. As wonderful as downriggers are, they impose limitations. With a downrigger it is difficult and hazardous to fish in contact with the bottom; yet that is easily done with the old wire-line rig. A downrigger presents a lure with a monotonous, steady swimming action, whereas the

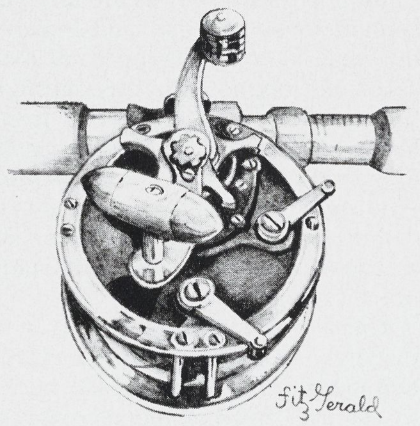


Illustration by Hubert J. FitzGerald

jigged rig has built in up-and-down action and changes of speed.

A VHF radio is a valuable piece of equipment that hurts some fishermen who rely on it too much. I'm thinking of anglers who count on the radio to tell them where the fish are hitting. They then pull rigs and race to the hot spot, often arriving just in time to see the last fish netted from that group. It is better to be the boat which finds the fish than to be a chasing boat that tries to get in the last lick or two on a school that has been torn up by the boats that found the fish in the first place.

Similarly, relying on graphs can crimp your fishing. Some fish — the fish that are so shallow they spook away from the boat and its sonar cone — don't graph at all. Others don't graph well, especially the highly active fish that are often the most catchable ones. The fish you can see so well with a graph tend to be the deeper, less active fish. Seeing where they are and what they are doing is definitely worthwhile, but good fishermen can recall days when they never graphed a fish and yet the net was busy all day.

A charter captain friend on Lake Ontario refers scornfully to "graph fishermen." They have no confidence unless their graph is telling them they're on lots of fish. They avoid situations where fish can be caught but not seen. At other times they'll troll for hours over huge schools of fish that mysteriously won't strike, and it apparently never occurs to them that the warm water they're fishing is bound to be full of carp!

Too many modern anglers are reluctant to deal with gear and techniques that lack the snappy precision of downriggers.

For example, diving planers (such as the Dipsy Diver or Deep 6) can be extremely effective, but they require an apprenticeship which spooks off some modern, high tech anglers. You have to learn how deep a diver will dive when you let out a certain amount of line. Some anglers are simply uncomfortable with the need to count how many times a reel's levelwind cycles as they let a diving planer out. It all seems... *amateurish* and mushy to them.

The same anglers won't put lead on their lines because they don't know how far an ounce or two of lead will take a line down. Yet using lead sinkers intelligently is often extremely useful. Of course, you need to spend a few minutes learning how sinkers affect the depth of your lines.

To repeat, there is nothing the least bit wrong with any of the modern equipment. What *is* foolish is relying on it to do the fishing.

Fishing is fishing. Though sophisticated equipment is extremely useful for anglers seeking trout and salmon in huge bodies of water, there is ultimately no substitute for knowledge. You have to know fish and what spots they use near your port. You have to understand your equipment and lures. You have to know how fish respond to different presentations.

No matter how much modern equipment you own, you have to know how to fish.

Columbia and Fraser Basins.

The vagueness and lack of a precise definition for Kamloops trout in relation to its position in an evolutionary and taxonomic context can be traced to work performed by a Canadian biologist, Charles Mottley, in the 1930s. At the time, the main criterion used to distinguish Kamloops trout from coastal rainbow trout (which I classify as the subspecies *S. g. irideus*) was the number of scales along the body. Kamloops trout were believed to have an average of about 20 more scales than the coastal rainbow. Mottley incubated Kamloops eggs at different temperatures and demonstrated that the fish hatched from these eggs had significantly different numbers of scales in relation to the temperatures of embryonic development. This work led to the unfortunate conclusion that character differences used to distinguish different forms of trout were mainly due to direct environmental influence and not heredity — nurture not nature was considered to be the main determinant of forms of trout.

The conclusion was unfortunate because it led to an unwarranted inductive leap that has long plagued fisheries management. If nurture not nature predominates in determining characters (including life history attributes such as feeding, growth, longevity, etc.), then any generic hatchery rainbow trout can duplicate all the attributes of a Kamloops trout if stocked in a "Kamloops" environment. This is a very wrong conclusion and it has taken many years for fisheries biologists and managers to begin to understand the dangers of a mistaken faith in nurture over nature in relation to forms of trout and salmonid fishes in general.

Haig-Brown is widely regarded as an author *par excellence* of angling literature. I highly admire his work because he was informed and accurate, without sham; his work has authenticity. His writings reflect outstanding judgment or, simply, common sense.

Regarding the status of the Kamloops trout, he wrote in *The Western Angler*: "As we have decided, the Kamloops is, strictly speaking, simply a subspecies of the steelhead. He is a rainbow trout which has certain slight structural differences from the originally-described members of the species, but none that may not be readily modified by change of environment. From the point of view of the scientist and naturalist, this is a thoroughly logical and desirable simplification, and the loophole left by the subspecific rating is all that the angler needs. An angler's view of his fish, though it should be at least related to that of the scientist, is not necessarily identical with it. Differences of habit, of habitat, of those qualities which go to make up what he considers a game fish — even superficial differences in appearance — naturally mean more to the angler than the slight structural differences that separate two closely related fish."

Although Haig-Brown's concept of the Kamloops trout subspecies somewhat differs from my current concept, the point he makes, that subtle differences in "habit and habitat" (life history and ecology) can be very important to anglers, is certainly valid — more so than he realized. The true significance of the notion that intraspecific life history differences, completely unrelated to formal taxonomic recognition as a species or subspecies, can be of extreme importance to fisheries management can be illustrated by using the Kamloops trout as an example.

A useful analogy to help understand the significance of intraspecific diversity in the rainbow trout species, and, also, of the roles of nature and nurture as determining influences on the ultimate product, is to consider wines made from grapes.

Virtually all wine is made from a single species of grape, *Vitus vinifera*. Differences in quality — color, taste, body, aroma — are due to intraspecific differences or varieties in the species *Vitus vinifera* interacting with differences in soils and climate. Thus, the hereditary basis of different varieties of vines determining the basic color, flavor, size, and shape of the grape are not influenced by soils and climate; but subtle flavor differences *are* environmentally induced by soils and climate, resulting in different vintages from the same vines in different years. Similarly, in rainbow trout, there is a strong hereditary component governing life history and behavior attributes such as anadromy, nonanadromy, age at maturity, and maximum life span, but each year-class (or "vintage") of a single population may exhibit different growth rates and mortality rates in relation to climate and food supply.

A "taxonomy" of wines used for precise classification includes the variety of grape, the region where it is grown, and a particular subregion or estate.

To a wine connoisseur, the wine contained in a bottle from a prized estate has a much greater significance and value than the *vin ordinaire* in a gallon jug of "country red" or "mountain burgundy," although all of these wines represent intraspecific diversity in *Vitus vinifera* interacting with environmental differences.

For the intelligent use of intraspecific diversity in fisheries management, we must attain a degree of understanding of the subject comparable to that of a wine connoisseur. For example, consider a goal to produce a new world-record rainbow trout.

The Kamloops trout known to possess the hereditary attributes to attain an extremely large size can be identified as a small "estate" in a particular "region" of intraspecific diversity — namely, the Gerrard strain of Kamloops of Kootenay Lake, British Columbia (upper Columbia River Basin). A "generic Kamloops" won't do; only the Gerrard strain of Kootenay Lake is known to have the evolutionary specializations resulting in older age at maturity, long life span, and capacity for rapid and sustained growth necessary to produce a rainbow trout of more than 40 pounds. Virtually all Kamloops trout of the Gerrard strain in Kootenay Lake spawn for the first time when they are five, six, or seven years old (most generic rainbow trout have died of old age by age five). The average size of spawners is about 10 pounds and the general maximum age and size is 10 years and about 25 pounds in Kootenay Lake. When stocked in other waters with a superabundance of food, the Gerrard Kamloops can reach 50 pounds or more.

The two most obvious examples demonstrating the growth potential of the Gerrard Kamloops are Jewel Lake, British Columbia and Lake Pend Oreille, Idaho. Jewel Lake, in the Columbia Basin, is just north of the British

KAMLOOPS TROUT *(Salmo gairdneri gairdneri)*

From an original acrylic painted for Trout Unlimited by Lee Stroncek

Columbia-Washington State border. It was barren of trout until stocked with Gerrard Kamloops in 1924. Several stories of fish in excess of 50 pounds originated from Jewel Lake. The most authentic report is of a fish weighing 52 pounds 8 ounces caught in 1932. A photograph of this fish can be seen in *The Fisherman's Encyclopedia* (Stackpole, 1950). If this 50-pound-plus fish caught in 1932 originated from the 1924 stocking of Jewel Lake, then it would have been eight years old. Gerrard Kamloops stocked in Lake Pend Oreille in 1942 were exposed to a superabundance of kokanee salmon — their preferred food. In 1946, a four-year-old Kamloops was caught weighing 32 pounds, and in 1947, a five-year-old fish was taken at 37 pounds. The 37-pounder was 40-1/2 inches in length and had a girth of 28 inches. A typical Gerrard Kamloops in Kootenay Lake would weigh about 25 pounds at about 40 inches in length and would be nine or ten years old. An occasional fish can grow much larger. In Steve Raymond's book, *Kamloops*, he states that a 52-pound fish from Kootenay Lake was taken during spawning operations in 1930.

A most interesting aspect of the Kamloops trout of Kootenay Lake, which illustrates the importance of recognizing the specificity between races of trout analogous to estate-bottled wine, is that there are three or more races of Kamloops trout native to Kootenay Lake. One race is associated with the west arm of the lake, another with the south arm; the Gerrard race is associated with the north arm, but may range into other areas for feeding. Although a definitive study is yet to be made on the Kamloops trout diversity of Kootenay Lake, it appears that the other races, which do not spawn in the Lardeau River, can be classified as *vin ordinaire* rainbow trout. They apparently spawn when they are three or four years of age at about two to four pounds and their maximum size is about 10 pounds. No significant structural or quantitative genetic differences are known between the small, ordinary Kamloops and the giant Gerrard Kamloops in Kootenay. The truly significant difference concerns their life histories; each evolved to fill different trout niches in a large lake — these differences are genetically (hereditarily) based.

The Gerrard strain originally spawned in the Lardeau River and in the Duncan River, a tributary to the Lardeau (north end of lake). The giant Gerrard Kamloops was never highly abundant, but its numbers declined after a dam blocked spawning in the Duncan River. In recent years spawning runs have ranged from about 350 to about 950 fish, but only about 1500 square yards of optimum spawning grounds are available in the Lardeau near Gerrard. In 1980, an estimated 1200 trout caught in Kootenay Lake weighed more than 10 pounds, and about 700 of these weighed more than 15 pounds. Considering that Kootenay Lake is 65 miles long and covers 100,000 surface acres, the chances of an angler encountering one of these trophies is obviously slim.

The possible reality of producing 50-pound rainbow trout relates to finding opportune waters such as Jewel Lake and Pend Oreille that could be stocked with the Gerrard Kamloops. Lake Pend Oreille still produces a few trout of more than 20 pounds, but the glory days of the 1940s are not likely to be repeated. The Gerrard Kamloops has hybridized with ordinary rainbow trout stocked in tributaries, thus diluting their purity, and the abundance of kokanee has drastically declined. I suspect that Gerrard Kamloops could have produced specimens exceeding 50 pounds if they had been stocked in Lake Michigan during the boom in alewife abundance and before the lake was overstocked with Chinook and coho salmon.

The Gerrard Kamloops trout is a highly specialized fish for special types of environments; it is not the trout for all seasons or for all waters. Like rare estate wine, it is a fish for special occasions. Effective use of intraspecific diversity — such as the Gerrard Kamloops — in fisheries management, requires that fisheries managers acquire a knowledge and sophisticated understanding of the subject at least comparable to that of wine connoisseurs. They must at least be able to discriminate between estate-bottled and *vin ordinaire,* and appreciate the difference.

Alvord Cutthroat

An 18-inch Alvord cutthroat, caught for scientific purposes.

Bob Smith

When driving across the desert basins of southeastern Oregon, eyes jaded with the monotony of gray-green sage, rabbitbrush and greasewood, you may think longingly of water and your favorite trout stream, cold and clear, bouncing over a riffle. But just raise your sights a little; look up at the bordering slopes and you may see signs of water. Water long gone to be sure, prehistoric water, fossil shore lines etched along the sides of buttes and rolling uplands hundreds of feet higher than the flat you are now crossing.

These wave-cut terraces and beaches are mute reminders of the Pleistocene lakes of glacial times that once filled many of the intermontane valleys of the Great Basin, most of them without outlets. Two of these lakes were huge, Bonneville and Lahontan, but there were many more smaller ones and many contained trout. In Nevada and Utah these trout were cutthroats, while redbands were predominant in most of the Oregon lakes. But there were two of these pluvial lakes in Oregon that had cutthroats, too, Alvord and Coyote, adjacent but separated by a low divide, and each with its own subspecies of cutthroat still formally undescribed.

When the glaciers melted, the climate warmed and the lakes disappeared, some completely, others leaving remnants in low sumps. Great Salt Lake is a sump of Bonneville, while Pyramid and Walker Lakes are sumps of Lahontan. Alvord and Coyote Lakes left only playas and so the cutthroats there survived in the tributaries, at least some of those that were perennial and cold enough. There may have been many of these in Oregon flowing off the east face of the Steens, the Pueblos and the north and west slopes of the Trout Creek Mountains, while in Nevada there were perennial creeks draining the west slopes of the Pine Forest Mountains and the high plateaus to the south and west. Probably most of these streams contained cutthroats until the early part of this century when some of the ranchers and the state fish and game departments thought to improve upon the natural order of things and planted hatchery rainbows, even though the native trout were abundant and perfectly adapted to their harsh environment. Consequently, most of the native populations were hybridized out of existence.

The original trout of the Alvord Basin, the native cutthroats, were unknown to the scientific community until 1934 when Dr. Carl Hubbs, the renowned ichthyologist, collected specimens from Virgin Creek in Nevada and Trout Creek in Oregon. While he made no formal description, he referred to these cutthroats in his notes as *alvordensis,* a subspecific name. Even at that time Hubbs detected a rainbow influence in the Trout Creek fish, and rainbows had been planted in Virgin Creek the year before. After that the native trout disappeared from the scientific world. None could be found—at least none were found by the scientists and others who searched for them. They found only rainbows or obvious hybrids and concluded that the Alvord cutthroat had probably joined the Dodo in the never-never land of extinction. But Harry Wilson, a Virgin Valley rancher, knew better. Harry was born and raised in the Virgin Valley and had fished for these trout since his youth. He not only knew where they were but owned land on the headwaters and controlled access to the creek. The only trouble was nobody asked Harry. "They probably figured I was just a dumb rancher who didn't know one fish from another," he told me. In any event,

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for over fifty years these trout were lost to the world of science.

Then in 1984 Jim French and a colleague, biologists with the Nevada Department of Wildlife, got into the headwaters of Virgin Creek and fired up their electrofishing gear. They caught some amazing looking trout from this tiny creek, big cutthroats 18 to 20 inches long, red as fire trucks along the sides from maxillary to tail; even the fins were red. Jim took some color photos of these "unique fish" and sent them to Pat Coffin, Chief of Fisheries, with the Department of Wildlife in Reno and Pat in turn sent prints to Dr. Bob Behnke, internationally known trout authority, at Colorado State University.

Dr. Bob was excited to say the least. After years of futile search he suspected that these might be the long lost Alvord cutthroat, but he needed specimens for verification and so he sent the photos on to me. I was excited, too, for here was a cutthroat different in spotting pattern and color from all other supspecies of cutthroats and it came from ancestral Alvord trout water. On the surface it appeared that these fish just had to be the real thing. The only cloud on the horizon was that there were rainbows in Virgin Creek, too, and if the cutthroats were to be salvaged, it would have to be soon. But first we had to get specimens to Dr. Behnke for positive identification.

It was April 1985 when I first saw the pictures, so I started making arrangements in all haste. I got in touch with Pat Coffin and Jim French, and then with Jack James I flew over the Virgin Creek area to get an aerial overlook. Then we went to see Harry Wilson but found that the upper meadows on Virgin Creek wre being irrigated and were thus impassable, so we held off until things dried out.

It was mid July when Jack and I finally headed up the Virgin Valley to Harry Wilson's ranch. Harry gave us the key to the gate, permission to use the old Alkali Ranch as our headquarters and promised to have his son, Walt, join us in the morning to guide us to where the trout were. Although the mouth of the Virgin Creek Gorge was but a short distance from the Wilson Ranch, we had to come in from the other end, and this meant climbing up to the top of the tableland and going around. We got lost only once, but this gave us an opportunity to see more of the country—spectacular to say the least. This area had been mighty hot in the geological past, with great flows of rhyolite and abundant signs of explosive volcanism. Rimrocks were everywhere about and peaks and domes loomed up well above the general level. These tablelands were high, over 6000 feet, and dry as a chip, but a few spring seeps nurtured aspen groves and small boggy meadows. Through all this the Virgin Creek Gorge was a deep rupture in the earth's crust, separating Rock Spring Table from the tabelands to the west. We saw little wildlife—horned larks fluttered out along the track, a lone antelope drifted across a ridge and five sagehen cocks, looking big as turkeys, stepped sedately through the low sage. Finally we dropped down to Alkali Reservoir, churned through a boggy ford and arrived at the old ranch house at the head of a long meadow. That night the coyotes voiced a protest to our intrusion.

Walt arrived with his father-in-law early in the morning and led us down through the meadow, soft and boggy in places with no discernible track. Virgin Creek here was a muddy slough with water only here and there, and as we drove slowly along, the meadow narrowed, then ended abruptly as the Gorge closed in. From here on it was shank's mare, and the creek flowed again from springs—not much but a little, maybe a half cfs, with a temperature of 60%F and slightly opaque. There were a few old beaver workings and here and there long, narrow pools with flowing water in between. This was the area where Jim French had found his big red fish, so I sent a fly out wherever there was room for a cast, but didn't raise a fish or see a sign of one. As we walked on down I mostly looked, intending to fish on the way back, mentally noting a few good pools and the beaver ponds. Finally I saw Walt fishing where the creek swept around a bend, and I stopped to watch. Walt was fishing his fly as one would fish a worm, just letting it hang in the current, and he hooked a trout. I hoisted it out of the water for him and looked it over carefully. It had the long jaws of a cutthroat and vivid red slash marks, but the spotting pattern was rainbow, an obvious hybrid.

At least there were fish here so I started back up and shortly I ran into Jack, busy changing a fly. He pointed to the creek, "Drop a fly right down there," he said, "there's a big one just behind that log." I looked where he pointed and sure enough, a trout longer than the creek was wide was holding just under the surface. There wasn't room enough between the trout's nose and the log to place a fly so I waited until the fish dropped back a little, then dropped a nymph a few inches above its nose. I couldn't see the take, but when the fish moved over and turned back I tightened and all hell broke loose. The fish couldn't go any place, there being no place to go, so it thrashed and splashed, flinging great gouts of water around. When it quieted down some, Jack grabbed a net, scooped it out and laid it on the bank. I made a quick measurement spreading my hand along the side, nose to tail. Eighteen inches from water a foot wide. It would have had to double up to turn around!

After getting a film record of this amazing fish we took a closer look. A female, lean in the flank, she had probably spawned not long ago. She was brick red along the sides, almost purplish, from her maxillary to her tail; even the lower fins were a dark purple. The black spots were large and round, evenly distributed on the back above the lateral line and on the caudal peduncle but not concentrated there as on most interior races of cutthroat. The slash marks were vivid red and the pelvic and anal fins were white tipped. The dorsal fin was orange tipped, a feature I have never seen on any other race of cutthroat. In fact, I had never seen a cutthroat such as this, and I have seen all the living subspecies—all thirteen of them, including this one. Therefore, this would almost have to be an Alvord cutthroat—at least it was different from all others and was in the right place.

Again I worked on up the creek. I needed at least one more specimen to send to Dr. Behnke for positive identification, so I dropped a fly in every nook and cranny where I thought a fish might lurk. Then in a pool no bigger than a bathtub I saw a giant form materialize and a white maw open for my fly but when I tightened there was nothing there. I tossed the fly back in and as the fish came up again and turned back I raised my rod and it felt like I had hooked the bottom. Then things began to happen in that confined space — thrashing, twisting and chugging around. It couldn't make a run—there just wasn't room enough. The bank was steep and, having no net, I waited until the action slowed, then led the fish up a tiny shallow channel and slid it out on a gravel bar. This also was a female and a quick "rule of thumb" measurement along her side came out to 20 inches. She was identical in coloring and spotting to the other except that the spots were smaller. About that time Walt showed up and allowed that was as big a fish as he had ever seen come out of the creek.

". . . Alvord cutthroat had probably joined the Dodo in the never-never land of extinction."

We sat there on the bank admiring the fish and I ticked off in my mind the possible explanations for its exceptional size. Here was a fish that would do credit to a large river or lake yet was taken from a tiny stream, really a rivulet. That fishing pressure was minimal was obvious, thanks to Harry's control of the access. That food was adequate was also obvious – trout don't grow that big anywhere without a plentiful food supply – therefore, the only alternative left was genetic. These fish had to be programmed to grow big in a miniscule hostile environment – grow to almost two feet where one would expect an 8-inch trout to be a big one. Here was a resource to be saved, if possible, not only for future generations of trout fishers, but for its own worth as a unique genetic resource.

We caught up to Jack near the springs where the creek began to flow. He had another good cutthroat of about 15 inches without the red coloration, so it appeared that only the old big fish became red, the males a brilliant red and the females more of a brick red. We preserved the fish right there, slitting them open and stowing them in a jug of formaldehyde, the three good ones and a few hybrids, all to be sent to Dr. Behnke at Colorado State University. He later reported that the three good cutthroats were meristically and phenotypically identical to the specimens that Hubbs collected in 1934, that is, anatomically and structurally they were the same and they were look alikes. He also aged these fish at 5, 6, 7 or 8. On the evidence, therefore, he identified the specimens as pure or essentially pure Alvord cutthroats – *Salmo clarki alvordensis*.

That these cutthroats probably had some rainbow genes in their makeup would seem inevitable since they had been exposed to rainbow influence for half a century, and this was verified by electrophoretic analysis of other Virgin Creek specimens at the University of California, Davis. This analysis also turned up strong evidence of Lahontan cutthroat ancestry and a unique allele found only in Alvord trout. There was also evidence of an ancient rainbow influence dating back thousands of years – strange echoes of the past indeed. Now I was suspicious of those white and orange tipped fins of the Alvord trout from the beginning for these are redband characteristics, not cutthroat, and redband rainbows occurred in pluvial Lake Catlow only a short way across a low divide from Alvord Lake drainage. By a headwater transfer a few redbands could have gotten into Alvord Lake, and if this ancient rainbow introgression is true, I suggest that this was how it happened. But the important thing is some of these trout look like the original Alvord genotype and have been identified as such, and to save these from complete hybridization and oblivion a brood stock of the best fish would have to be moved to a stream where they could breed in isolation.

The sooner this could be done the better, but it was not until the summer of 1986 that a recovery program was initiated, and this involved a major effort by the Nevada Department of Wildlife. Under the direction of Jim French, who found the fish originally, a team was assembled on Virgin Creek in early August. Involved were three electrofishing crews, several fisheries biologists with student helpers and representatives from other agencies. I was there to help identify and select the brood stock. We were to have a helicopter to move the fish from the gorge to the transplant site.

It was hot in the gorge in August and water temperatures soared to 80°F in the afternoon, and although these fish are adapted to a daily range between 60°F and 80°F or more, when under stress of being caught and held in pens there just wasn't enough oxygen to sustain them. Had we been able to airlift them out, as planned, we could have saved them, but our helicopter made one brief appearance, then left not to show up again. As a result, over 20 people milled around in the gorge for two days waiting in vain for air support and then the effort was aborted. From this first try we backpacked three fish out in a plastic bucket, kept alive with bubbling oxygen from a bottle.

A slightly smaller crew assembled again at Virgin Creek on October 3, and when we arrived at the old Alkali Ranch headquarters we were heartened to find a helicopter parked in the horse corral with a pilot standing by. This time the operation went off without a hitch. Two electrofishing crews and two anglers combed the creek and the fish were airlifted out as they were caught and collected at the landing pad. All fish caught were saved and held in an oxygenated tank truck at the line camp. The following day the fish were sorted to select the best for brood stock based on phenotype characters and morphology – spotting pattern, coloration and conformation. A small tissue sample was taken from each fish saved for electrophoretic analysis, and the fish, 26 in all, moved to the transplant site. These, with the three moved before, were enough to insure some degree of genetic diversity.

The quality of the brood stock saved was not as good as I had hoped for. Most were good cutthroat types but there were only two of the big red ones. Hopefully, some of the smaller ones may turn red with age. A few submarginal fish were saved, the consensus being that the aberrant spotting pattern was due to individual variation within a subspecies. We all know, of course, that no two fish are exactly alike and that there is considerable variation, even among siblings from the same redd, but there are parameters beyond which variation is the result of hybridization and in a few instances these limits were exceeded. It was also evident that the whole population is hybridized to a greater or lesser degree as these cutthroats have been exposed to rainbow influence too long to have escaped it. The only thing that is remarkable is that there are any fish left that still look like Alvord cutthroats at all for in the same time span the Alvord cutthroats in Trout Creek, Oregon, were completely replaced by rainbows.

Anyway, the first step in the recovery program has been taken. More good type cutthroats will be moved from Virgin Creek in the future, providing some can still be found. The transplants will be monitored, along with their reproduction, to select the best types for brood stock. The Nevada Department of Wildlife is committed to this, and they put on a tremendous effort in manpower and equipment to take the initial step. As of right now the transplants must survive in their new environment and if they do, spawn in the spring. So if you have any influence with the Powers Up Yonder, you might offer up a short prayer, chant and rattle beans in a gourd or do whatever you think appropriate, for the future of the Alvord cutthroat hangs by a very thin thread.

Beating Time

Marty Sherman

With this issue of *Flyfishing* we begin our tenth year of publication. This brings up the topic of *time.* Several weeks ago I was re-reading Ben Hur Lampman's *A Leaf from French Eddy* and he gave me a good slap across the face concerning the notion of *time.* In Chapter V there is an essay entitled "A Driftwood Fire by the River" and Lampman quotes a couplet:

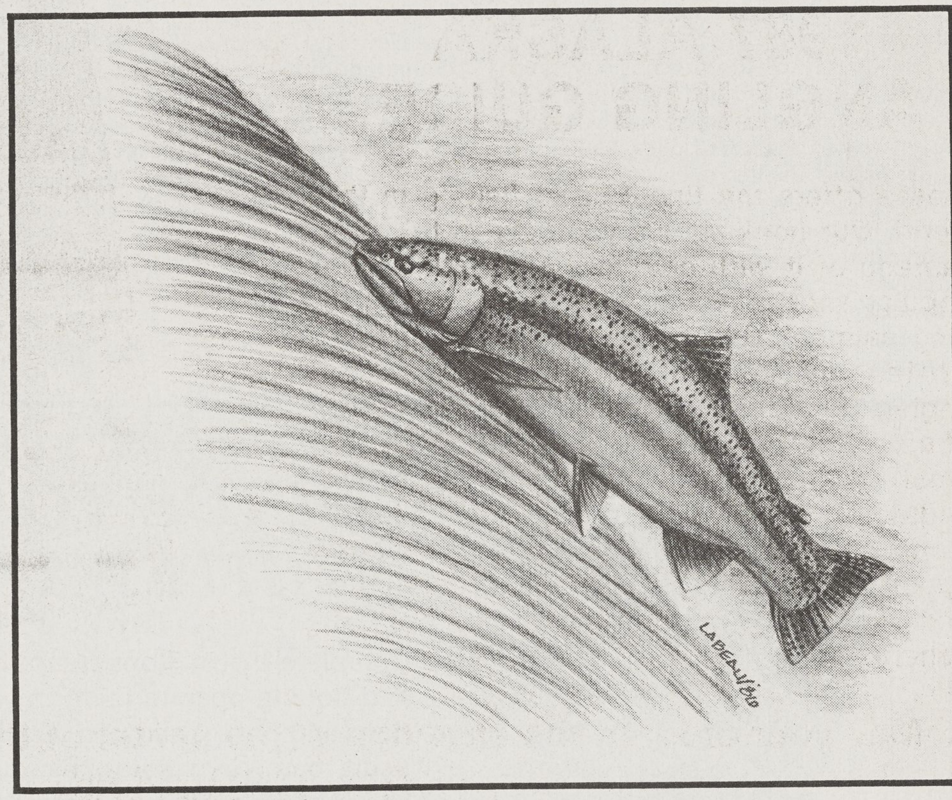
"Time goes, you say? Ah, no;
Time stays—we go." *Austin Dobson*

In *Alice In Wonderland* Alice tells the Hatter that she "beats time" in her music lesson. "Ah! That accounts for it," said the Hatter, "He won't stand beating."

Regardless of how many different ways time may be perceived, we can say that *Flyfishing* is embarking upon the successful completion of a decade of publication. It may sound trite, but our continued success is due, in large part, to you, the readers and subscribers. I like to think that you have continued to support the magazine because we have given you good, thought-provoking, interesting and entertaining articles to read.

I believe that the long range (that area of time that we are now entering) success of a magazine is established by a strong foundation. The strength of *Flyfishing's* foundation is evidenced in the very first issue of the magazine. The columns "Fly Wrap Up" and "Concepts-Contrivances-Contraptions" were both a part of the original *Flyfishing the West* magazine. These two columns have not only endured; they have become two of the most popular parts of the magazine.

In Vol. 3, No. 6, the January-February 1981 issue, we started our Annual Fly Tying Issue. This too has become widely popular. Vol. 4, No. 6 (Jan.-Feb. '82) was to become the issue which brought the biggest change to the magazine. With that issue the name and scope of the magazine was altered. *Flyfishing the West* became *Flyfishing,* and the editorial coverage went from western to nationwide and eventually worldwide.



JON LABEAU

The success of any magazine is the result of the effort put forth by the staff. In our case I know that our staff works hard to produce a magazine that we feel will be enjoyed by a large cross section of readers. There are two people in particular who deserve acknowledgement for the fact that *Flyfishing* has endured. Original editor, Don Roberts, established a strong foundation for the magazine to grow on, and Joyce Sherman has worked tirelessly from the very beginnings of the magazine to make it a quality product.

When I became the editor in March of 1984 most of the hard work had been done. In the past three years I have felt that my primary objective has been to respond to the wishes of the readers and to attempt to satisfy their requests if at all possible. I think that this has been accomplished for the most part. The reason I feel this way is that I seldom receive negative letters. Usually the mail is a positive response to the articles and the magazine in general. As I stated in one of my early editorials I always welcome remarks from the readers. Without reader input I am just guessing at the direction which you want the magazine to travel.

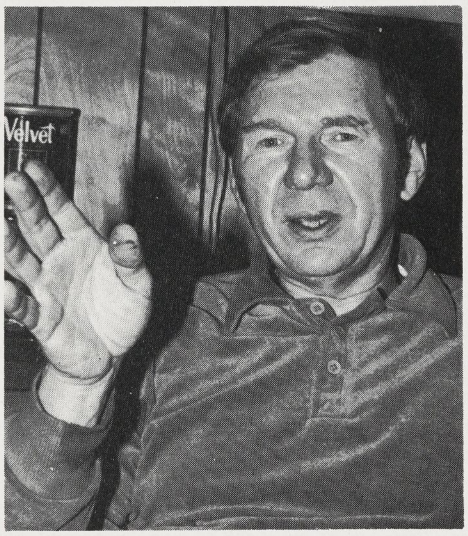
And so we proceed forward into the tenth year of publication attempting to provide you with the kind of publication that you will look forward to finding in your mailbox or on the newsstand, filled with articles, photos, fly patterns and information that will help make your fly fishing experience more complete and enjoyable as we continue on through time, trying to "beat time" with those magical wands we call fly rods. □

Redband Trout

ROBERT J. BEHNKE

ABOUT TROUT

Redband Trout



I once caught one redband after another on dry flies in Chino Creek, Nevada, when the water temperature was 83 degrees.

The redband trout has long confused ichthyologists, fisheries biologists, and knowledgeable anglers. In the past it was recognized as several different species or subspecies, sometimes aligned with cutthroat trout, *Salmo clarki*, sometimes with rainbow trout, *S. gairdneri*. I did not designate a scientific name for the redband trout in the painting for this article because the redband trout, in my assessment, consists of several distinct evolutionary lines. It is not a single entity.

The 1980 edition of the American Fisheries Society's *List of Common and Scientific Names of Fishes* includes an annotation for rainbow trout (*S. gairdneri*) that reads: "The redband trout has been recognized as a species distinct from rainbow trout and has been included on recent published lists"—several citations are then listed—"The systematic status of this species is unresolved and no specific scientific name was applied to it by the authors cited above." The Endangered Species Committee of the American Fisheries Society has designated the redband trout as a "species of special concern."

Some readers may recall the redband trout featured on an *American Outdoors* television program or may have read about them in magazines, especially their ability to thrive in waters too warm for other trout. The late Ted Trueblood, an outdoor writer widely recognized as well above the average in his ability to accurately observe and interpret nature, once wrote a story for *Outdoor Life*, "Cutthroats of the Cattle Country." The "cutthroat" trout he wrote about from southwestern Idaho were, in reality, redband trout. In the 1969 edition of *True's Fishing Yearbook*, Mr. Trueblood provided a color photo of the southwestern Idaho "cutthroat" with the caption: "Native throughout the interior West, cutthroat, like these offer some of the most exciting small-trout action." The photo illustrates three beautiful redband trout which I recognize by their distinctive parr marks, yellowish colors, spotting pattern, and fin markings. I would point out that for many years I tracked down sources of "native cutthroat" reported to me by professional biologists in this same region (Owyhee River drainage and other tributaries to Snake River below Shoshone Falls), and they all turned out to be brightly colored redband trout.

Is the redband trout for real? If so, why hasn't it been properly classified?

To regular readers of this column, confusion regarding trout classification should, by now, be accepted as a fact of life. The redband trout, however, is a special case—not only in regard to the level of complexity and controversy, but also because, among the diversity of forms I include as redband trout, there are some unique adaptations potentially of great value to modern fisheries management.

The confusion concerning redband trout classification began in 1892 when the U.S. Fish Commission sent C.H. Gilbert and B.W. Evermann to survey the fishes of the Columbia River Basin. In the upper Snake River drainage of Wyoming and Idaho, above the great Shoshone Falls, typical cutthroat trout (Yellowstone subspecies) were the only trout found. From the mouth of the Columbia River to the Cascade Mountains, both rainbow trout (coastal rainbows) and cutthroat trout (coastal subspecies) were found together; each was perfectly distinct. Between Shoshone Falls on the Snake River and the Cascade Range, the Columbia River Basin produced a confusing array of native trout that seemed to bridge the gap between the rainbow and cutthroat species. Gilbert and Evermann wrote: "With every additional collection of black-spotted trout it becomes increasingly difficult to recognize any of the distinctions, specific or subspecific, which have been set up....we think it not unlikely that the coastal form should be recognized as *Salmo mykiss gairdneri*, though the question is sadly in need of systematic and thorough investigation." The cutthroat trout at that time was mistakenly classified as *Salmo mykiss*. Gilbert and Evermann suggested that all rainbow and cutthroat trout might be lumped into a single species (*mykiss*) because the trout of the middle Columbia River Basin appeared to represent a complete intergradation between the two.

In their 1896 classic text *Fishes of North America*, Jordan and Evermann classified the middle Columbia River redband trout as a subspecies of cutthroat, *S. mykiss gibbsi*.

In 1872 Livingston Stone set up the first salmon hatchery for the U.S. Fish Commission on the McCloud River, California. He pondered over the question of how many species of trout occurred in the McCloud. Besides the large, silvery trout (steelhead), Stone mentioned smaller, more colorful trout that lived in headwater areas and tributary streams. He called this trout the "red-banded" trout. I adopted the name from Livingston Stone, modifying it to "redband" (as there is only one band). D.S. Jordan proceeded to describe two subspecies of rainbow trout, *shasta* and *stonei* for forms of redband trout sent to him from the McCloud River by Stone. Jordan also described the two basic forms of golden trout from the Kern River drainage, California, *aguabonita* and *gilberti*. At first Jordan classified *aguabonita* as a subspecies of cutthroat trout, then changed it to a subspecies of rainbow trout. He finally concluded that the California golden trout represented a transition from the cutthroat species to the rainbow species.

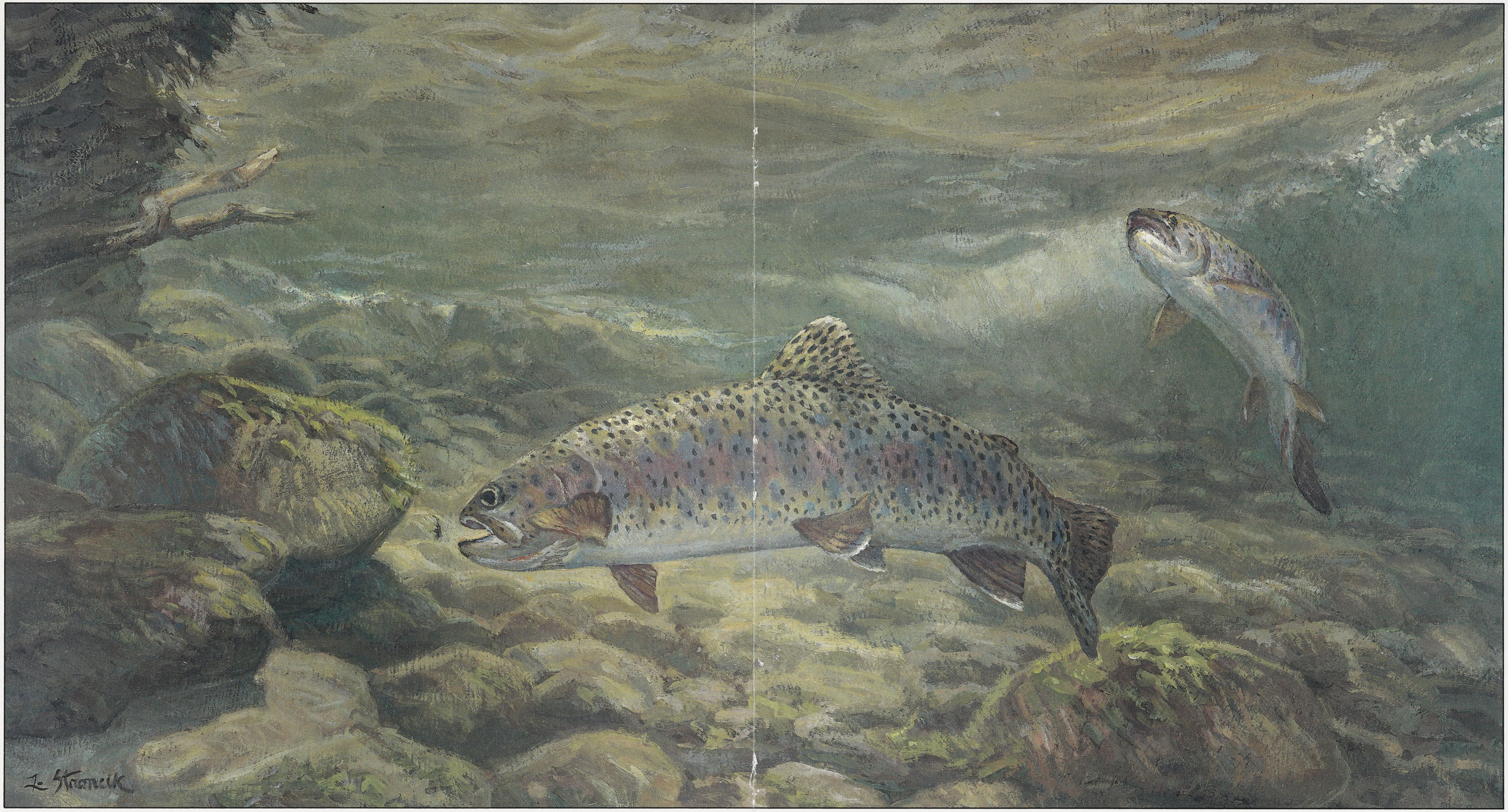
Around the turn of the century, J.O. Snyder, an associate of Jordan, studied the trout in a series of desert basins in southern Oregon that lie between the Columbia River and Sacramento River Basins. Snyder expressed uncertainty about the origins of these desert trout but he classified them as cutthroat trout. About 25 years ago, aware of the confusion in the literature, I began to study the museum specimens collected by the surveys and expeditions mentioned above. Most of the specimens did indeed appear to be quite intermediate between cutthroat trout on one hand and rainbow trout on the other. In my first publication on the subject I concluded that the origin of redband trout was from an ancient hybridization between rainbow and cutthroat trout in interior waters. Such a conclusion certainly seemed logical to me at the time. But I was wrong.

After many years of additional studies, supplemented with new evidence based on chromosomes and protein comparison, it became clear that redband trout represent a diversity of primitive evolutionary lines associated with the ultimate evolution of the typical modern rainbow (coastal rainbow trout).

Although all the details are far from complete, my explanation of redband trout, in an evolutionary sense, is as follows. In the early stages of evolution leading to the typical rainbow trout, various side branches appeared. One of these early branches became established in the Sacramento River Basin, another in the Columbia. They were characterized by traits possessed by a primitive common ancestor to both rainbow and cutthroat trout. Within each basin diversification occurred; for example, the evolution of golden trout in the southern end (Kern River) of the Sacramento Basin, and the more typical red trout in the northern end (McCloud and Pit Rivers). In the Columbia River Basin, redband trout spread inland as far as all the major barrier falls on the Kootenay, Pend Oreille, Spokane, and Snake Rivers. Above these falls, the cutthroat is the only native trout. Below the falls, the redband trout replaced the earlier established cutthroat westward to the Cascade Range. The redband trout also invaded the Oregon desert basins during a glacial epoch when these basins contained large lakes.

In the Columbia River Basin the ancestral redband trout evolved into lake-adapted populations (the Kamloops trout, which is also found in large lakes of the Fraser River Basin), anadromous populations (steelhead trout native to tributaries east of the Cascades, such as the Salmon and Clearwater Rivers of Idaho), and resident stream populations. Many of these resident stream populations have evolved for the past several thousand years in hot, desert-like country of nothern Nevada, southwestern Oregon and southwestern Idaho (Ted Trueblood's "cutthroats" of the cattle country). As such, many populations have evolved adaptations to survive and thrive in extremely harsh and highly fluctuating environments.

In each of several separate desert



REDBAND TROUT

From an original acrylic painted for Trout Unlimited by Lee Stroncek

basins in southern Oregon the redband trout evolved differentiated populations. In the Upper Klamath Lake Basin, Oregon, the redband ancestor evolved into two distinct forms—a specialized lake form which attained a size of 20 pounds or more, and a resident stream fish restricted to the smaller tributaries.

With such diversity, the problem of devising a classification scheme that would accurately reflect evolutionary reality—and still encompass all of this diversity—is enormously difficult. The problem of classification is further compounded by mixing and hybridization between the diverse evolutionary lines. The more recently evolved coastal rainbow trout later invaded the Sacramento and Columbia Basins and hybridized with the earlier established redband trout. Today no sharp line of separation between interior redband trout and coastal rainbow trout is possible. Only in areas isolated from the later invasion by coastal rainbow trout, such as the Kern River and the headwaters of the McCloud above barrier falls, did the original ancestral redband trout persist, more-or-less, in its original form. In the Pit River, California, mixing of "Columbia redband" (via Goose Lake to Pit River headwaters), "Sacramento redband" (the original native trout of Pit River), and the later-invading coastal rainbow trout evidently occurred to produce a mosaic of diversity that defies any attempt at logical classification. The famous Eagle Lake rainbow exemplifies a trout which cannot clearly be classified as either a coastal rainbow trout or a redband.

The human mind seeks orderliness. Nature, however, is seldom orderly.

Bureaucracies may need a classification of rainbow and redband trout to base decisions in regard to the protection of rare native fish. For such purposes they can arbitrarily declare any population to be a coastal rainbow trout or a redband trout by *fiat*. It must be recognized, however, that, in many cases, all diversity within a species cannot simply be pigeon-holed into categories in a manner that accurately reflects ancestral origins and relationships. My advice concerning the classification of rainbow and redband trout is that we must learn to accept and live with a certain amount of natural disorder—and eventually learn to appreciate and enjoy it. The problems created for classification by disorder or "noise" in nature extend beyond the classification of organisms (taxonomy). The philosophical and logical limitations of classification of any aspect of nature equally applies to models of habitat classification. Biologists who do not comprehend these limitations are susceptible to entrapment by the illusion of technique and seduction by mindless methodologies.

I have recommended that the coastal rainbow trout (both steelhead and resident populations) be classified as *Salmo gairdneri irideus*, and the redband trout of the Columbia and upper Fraser River Basins (steelhead, Kamloops, and resident stream trout) should be *S.g. gairdneri*. Under this broad scheme, the California golden trout would be *S.g. aguabonita* (South Fork Kern) and *S.g. gilberti* (Kern and Little Kern golden trout).

The trout native to the McCloud and Pit Rivers (northern Sacramento Basin) and to the Oregon desert basins reflect a hodgepodge of differentiation for which I can envision no simple breakdown into neat subspecific units. The common name "redband trout" as here discussed implies a more inclusive name of "golden-redband-Kamloops complex" which encompasses diverse evolutionary lineages. As such, the term "redband" can be applied to Sacramento redband, Columbia redband, or Oregon desert basin redband.

Much more important, however, than any debate over scientific and common names is the fact that the natural diversity produced during redband trout evolution is a natural resource of great potential value. Such traits as specialized lake predation (some Kamloops trout or upper Klamath Lake trout), or survival under extreme environments (some desert lands redband), offer opportunities to utilize these resources in fisheries management. This is especially true in situations where stocking of domesticated hatchery rainbows gives poor results.

Several years ago, the Oregon Department of Fish and Wildlife established a broodstock of redband trout in a small impoundment. The original source of this broodstock was Three Mile Creek, a tiny stream draining the west slope of the Steens Mountains into Catlow Valley, one of the Oregon desert basins. The U.S. Fish and Wildlife Service obtained eggs from this broodstock for propagation, and Catlow Valley redband trout have been sent to Texas and Missouri in expectations of establishing a trout resistant to high temperatures in waters unsuited for other trout.

A problem I find with the current propagation of redband trout concerns the "typological" approach to fisheries management, whereby all redband trout are considered to be similar—if some populations of redband trout thrive in warm water, any redband trout can do the same. My personal experience with redband trout that live in streams where daily summer water temperatures may reach 85 degrees Fahrenheit concerns the Owyhee River drainage of northern Nevada and southeastern Oregon. I once caught one redband after another on dry flies in Chino Creek, Nevada, when the water temperature was 83 degrees. These trout put up a good fight and appeared to be in excellent condition. In these desert areas, nights are cold, and stream temperatures may drop 25 to 30 degrees below the daytime maximum.

In an experiment performed at a Texas hatchery, Catlow Valley redband trout, rainbow trout from the Firehole River, Yellowstone Park, and a standard hatchery rainbow were subjected to constant warming of their water by one degree (Fahrenheit) per day until they perished. The redband trout perished at 81 degrees and the two groups of rainbow trout perished at 82 degrees.

Perhaps the Catlow Valley redband trout is less heat-tolerant than some rainbow trout, at least under the conditions of this experiment, but I would raise a question concerning the pertinence of such experiments to natural conditions. What must be kept in mind is the selective pressures exerted by the environment during the evolutionary history of a particular common group of fish. No fish, in nature, is subjected to constantly increasing temperatures, but rather to daily and seasonal variations. Evolutionary survival adaptations reflect the natural conditions of the evolutionary environment. Thus, the heat-tolerant redband trout I caught in the Owyhee River drainage might not demonstrate survival at higher temperatures than ordinary rainbow trout in laboratory studies. But I would expect that they evolved physiological adaptations to allow normal functioning for a few hours per day at temperatures that would severely stress other trout. Such a temperature criterion might be called maximum functional temperature—the maximum temperature (with diurnal variation) at which the fish continue to feed and do not lose weight.

Another problem in the use of desert redband trout is that, for the past several thousand years, they have been confined mostly to small, intermittent streams, essentially subjecting them to selection for life history traits similar to Eastern brook trout. They tend to spawn at a small size and die at an early age; few live to spawn again. In small, highly unstable environments such a life history is advantageous for the survival of a population, but not favorable for stocking into waters where it is desirable to have the life-span extend five or six years or more.

Life history traits such as age at maturity and maximum life span can be artificially selected for by continually choosing the oldest spawners and repeat spawners for propagation. Artificial selection may be difficult with the present stock of Catlow Valley redband trout, which were derived from a small population native to a tiny rivulet. They can be expected to lack a broad base of genetic diversity (heterozygosity) needed for selection or to adapt to new environments.

Yet mixing of several distinct stocks should provide the diversity for "improvement" and increase adaptability to new environments.

There is virtually unlimited diversity for life history types and specializations among the redband trout as I define them. In Kootenay Lake, the giant Kamloops trout (Gerrard strain) has specialized to feed on kokanee salmon. It does not sexually mature until it is four to six years old. One of these Kootenay Kamloops stocked in Lake Pend Oreille, Idaho, weighed 37 pounds when it was caught at five years of age. Another, from a broodstock in Jewel Lake, British Columbia, attained a weight of 52 pounds. The Eagle Lake, California, trout derived from the Pit River specialized to feed on tui chub, a large minnow. The upper Klamath Lake trout probably also specialized to feed on tui chub and a variety of non-game fishes.

A point to be emphasized is that there can be no "trout for all seasons" or for all waters. But creative and innovative fish culturists working in an experimental hatchery, drawing on the wealth of natural diversity found in redband trout, could produce new races. Viable trout populations might then be established in waters that do not now support trout. Specialized predators might be developed for lakes and reservoirs, trout that could convert a trash fish problem into a forage fish asset.

Pat Coffin, now Chief of Fisheries for the Nevada Department of Wildlife, accompanied me in 1972 when I caught redband trout in 83-degree water. Pat was impressed by this remarkable fish and wrote an article on redband trout in a 1975 issue of *Nevada Outdoors* magazine. He concluded that the redband trout "may have eventual fisheries management implications when fisheries management becomes sophisticated enough to appreciate this unique trout."

I'm afraid that neither Pat nor I will live long enough to see the fisheries management potential of redband trout fulfilled if we must wait for management to become "sophisticated enough." This is a situation where judicious use of common sense, innovation, creativity, and determination to carry out an action-oriented program would be much more important than sophistication. Such a program would be similar to aspects of agricultural plant breeding where wild races of propagated species are constantly sought to establish a base of diversity necessary to incorporate new, desirable traits into specific strains for specific environments.

OUR READERS WRITE

REDBAND REDUX

Dear Editor:

I would like to express my gratitude to Don Roberts and Robert J. Behnke for their fine articles on the redband trout in the autumn 1986 issue of your magazine.

Last summer I spent two delightful days fishing the upper Yuba watershed where I discovered a thriving population of these little gems. They made my stay a delight by their eagerness to take a size 14 dry fly. It was a catch-and-release fantasy that I will long remember. I don't understand why these trout have not mixed with the other rainbows from the lower Yuba River, since there is no barrier to prevent them from doing so. The upper Yuba is such a contrast to Oregon's Great Basin that I must admire the redband's hardiness and adaptability.

When I arrived home from the trip my pleasure was doubled by the delivery of ***Trout*** and the articles on redband trout which I read with eagerness. My thanks again to Mr. Roberts and Dr. Behnke, although, since I am a Californian, I hope I don't follow behind Mr. Roberts after he has stirred up a rattler for us.

Ernest Harrison
San Leandro, California

Dear Editor:

I enjoyed tremendously your article, "Reclusive Redbands," by Don Roberts in the autumn issue of ***Trout.*** Redbands have recently been introduced into Missouri waters in an attempt to enhance our trout fishing experience here. The public relations for the stocking of redbands in Missouri is that they are a hardy and highly adaptable breed; Roberts' article seems to support this. I have encountered this recent Oregon immigrant in two of my favorite haunts: the Meramec River trophy trout area and Blue Spring Creek, a wild trout management area.

Blue Spring redband and rainbow trout are protected from exploitation in two ways. First, the Missouri Department of Conservation places an 18-inch size and three-per-day creel limit on the stream. Second, the fishing is difficult and the trout are spooky. It is an on-your-knees experience that repels most Missouri anglers yet draws me almost every Sunday (notwithstanding the one and one-half hour distance from my home in Saint Louis).

I wonder about your conclusions that Oregon redbands rarely live beyond three to four years or grow beyond 12 inches, and can only hope they will continue to provide fine sport in our Missouri streams.

Ronald A. Caimi
Hillsboro, Missouri

Dear Mr. Caimi:

In a stream environment it is very rare to find redband trout over 12 inches in length. The exception is if there is a lake or reservoir in which they can rear and then enter a stream. In this case redbands may reach six or eight pounds if they have an abundant forage fish food source. This growth pattern occurs in several waters in southeastern Oregon. Redband broodstock maintained at the Klamath Hatchery reached three to five pounds at age three with all the food they could eat.

When fish spawn they absorb a portion of their scales leaving a "check" or rough area on that year's annuli. During the past 10 or 12 years, as we have worked with this special race of trout, we have examined scales from nearly 1000 fish from many different locations. We have not found a single spawning check. All redbands apparently die after spawning. Scale analysis showed most of the fish maturing at age three but some not until four. It is also quite common to find post-spawning mortalities of fish near death in the wild.

At Klamath Hatchery we couldn't keep our brood redbands alive for more than a few months following spawning. At the Ennis National Fish Hatchery in Montana, 50 percent of their brood redbands have been kept alive following spawning. To my knowledge, this is the only place where this has occurred. I would assume that this post-spawning survival must be associated with the diet fed the trout by the U.S. Fish and Wildlife Service. However, the post-spawning mortality characteristic may be an indication of the species' hereditary link to salmon. It would appear to me that the 18-inch regulation that Missouri has placed on redbands will not be too effective if the fish maintain the same life history as they do here in Oregon.

It is difficult for many catch-and-release anglers to understand that some races of trout will never grow large in streams because they will reach a maximum of age four in the wild. The surplus may just as well be harvested as these fish cannot be stockpiled.

Bill Hosford
District Fish Biologist
Oregon Department of Fish and Wildlife
Hines, Oregon

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ROBERT J. BEHNKE

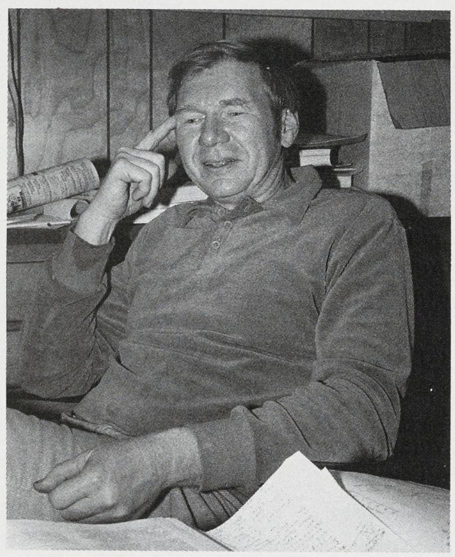
Even the Wilderness Act and the Endangered Species Act are not sufficient to protect this rare native trout subspecies.

Paiute Cutthroat

Last Labor Day weekend I joined about 50 people on a nine-mile hike to the headwaters of Silver King Creek to participate in a Trout Unlimited-sponsored habitat enhancement project to help the threatened Paiute cutthroat trout. Although the scenic setting of Upper Fish Valley on the east slope of the Sierra, Alpine County, California, where the headwaters of Silver King Creek are located, is magnificent, the lure of the rare Paiute trout, *Salmo clarki seleniris,* must have been a factor to attract so many volunteers.

It is doubtful that any Paiute trout would still exist if they had not been officially endowed with their own subspecific name. This demonstrates a practical aspect of subspecies taxonomy—having a unique name can help save a special form of life from extinction. Official taxonomic recognition facilitates listing under the Federal Endangered Species Act. Such recognition promotes active management and protection programs by federal and state agencies, and also can stimulate volunteers to participate in enhancement activities such as the expeditions to Silver King Creek over the Fourth of July and Labor Day holidays in 1986.

The Paiute cutthroat trout was discovered and named in 1933 when J.O. Snyder of Stanford University received some specimens of trout collected in Silver King Creek above Llewellyn Falls (named after Mrs. Lynn Llewellyn, who caught the specimens). Snyder realized that Silver King Creek is a tributary of the East Carson River of the Lahontan Desert Basin. He knew the trout found



above the waterfall represented an isolated population derived from Lahontan cutthroat trout (*Salmo clarki henshawi*), but he was so impressed by their distinctive characteristic—the absence of spots on the body—that he originally described them as a new species, *Salmo seleniris.* The name *seleniris* for the new trout was selected because it suggested a "fanciful resemblance of its evanescent tints to the lunar rainbow." Similar to the Lahontan cutthroat, the Paiute trout lacks brilliant colors. The body is typically a pale silvery color with yellowish and greenish tints. The absence of spots on the body distinguishes the Paiute from the Lahontan and all other subspecies of cutthroat trout.

About 25 years after the 1933 description of *seleniris,* I examined the specimens of the original collection and compared them to Lahontan cutthroat trout. I found the Paiute trout to be identical to Lahontan trout in every character except for the spots on the body.

Obviously, Paiute trout are extremely closely related to Lahontan cutthroat, and their isolation in Silver King Creek from the parent stock in the East Carson River is only a matter of a few thousand years. Subsequent electrophoretic analysis of Paiute trout showed them to be identical in their protein patterns to Lahontan cutthroat. Because of such close relatedness between the Paiute and the Lahontan, some biologists have questioned the validity of the subspecies *seleniris.* I would point out that the subspecific category in taxonomy is a practical device for classifying geographically unique populations or races of a species. There are no rules or standards of quantifiable genetic differentiation to qualify as a subspecies; only that a subspecies should possess one or more unique characters which differentiates it from all other subspecies of a species. Thus, the lack of spots on the body of Paiute trout "validates" the subspecies *seleniris.*

No unique life history or behavioral attributes have been discovered for Paiute trout. They typically spawn when they are two years old. In the small mountain streams where Paiute trout live at elevations of 8000 feet and higher, spawning occurs from May to July at water temperatures of about 42–48 degrees Fahrenheit. An eight-inch female will spawn from 250 to 400 eggs. The eggs will incubate in the redd for about 35 days before hatching. Evi-

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dently mortality is high after spawning and few fish in the population attain an age of four years or older. Feeding is opportunistic, on a variety of aquatic and terrestrial insects.

The major limitation for the continued survival of the Paiute trout concerns their evolutionary heritage (or burden) that makes them imperfectly adapted to survive in small streams in competition with other trout species. Their ancestral origins are with the Lahontan cutthroat trout, which specialized as the top level predator in ancient Lake Lahontan. About 12,000 years ago Lake Lahontan was 8500 square miles in area and had a maximum depth of 880 feet. Except for its remnant, Pyramid Lake, Lake Lohontan dried up about 8000 years ago. At that time, an ancestral population of Lahontan cutthroat trout was established in the East Carson River. Subsequently, a fraction of this population became isolated in Silver King Creek to evolve into the present Paiute trout. This most recent evolution, however, occurred in isolation from all other fish species. This evolutionary history leading to the present Paiute trout, first with selection as a large lake predator and then in isolation in a small stream, makes the Paiute extremely vulnerable to extinction when other species of trout gain access to their habitat.

The real benefit to the Paiute of having its own subspecies name was the listing of *S. c. seleniris* under the Endangered Species Act, stimulating large-scale federal and state restoration efforts to save this fish from extinction.

When I first visited Silver King Creek in 1964, the continued existence of Paiute trout was doubtful. Rainbow trout had been stocked into Silver King Creek above Llewellyn Falls and the population had thoroughly hybridized. The only pure populations at that time existed in two tiny isolated tributaries of Silver King Ceek (Four Mile Canyon and Fly Valley Creeks) and a small introduced population in the North Fork Cottonwood Creek, a minuscule rivulet in Mono County, California.

To understand the precarious situation of the Paiute trout in 1964, it is necessary to review some historical events.

Sometime after the 1933 description of the Paiute trout, testimony obtained by the California Department of Fish and Game revealed that no trout occurred above Llewellyn Falls in Silver King Creek until they were stocked by a sheepherder in 1912, who transplanted fish he caught below the falls. Thus, the original habitat of the Paiute trout was about six miles of Silver King Creek, from Llewellyn Falls downstream to a canyon area near the confluence with the East Carson River. A 1933 collection of specimens taken below Llewellyn Falls is made up of hybrids of rainbow trout and Paiute trout. If it were not for that early transplant the world would never have known that a unique spotless form of cutthroat trout ever existed.

An early transplant from Silver King Creek also established Paiute trout above a falls in Coyote Valley Creek, a tributary of lower Silver King Creek, and in its tributary, Corral Valley Creek. In 1946, Paiute trout were transported to the White Mountains of Mono County and stocked into the North Fork of Cottonwood Creek, a tiny, fishless stream near the Nevada–California border. In 1947, some Paiutes were moved above a falls in Fly Valley Creek, the uppermost tributary of Silver King Creek, to establish a new population in this formerly fishless stream. This proved to be a most significant transplant, because the Fly Valley population became the ultimate source to re-establish Paiute trout in the Silver King drainage after the hybridization tragedy occurred.

During the dark ages of fisheries management, when state fisheries programs consisted almost entirely of setting regulations, stocking lots of hatchery fish, and law enforcement, pack trains of mules and horses carrying eyed eggs and fry became a popular method of stocking mountain streams in the West. This is an example of the "Johnny Appleseed" mentality—to seed all headwater streams with eggs and baby trout in hopes that they would be fruitful and multiply. It seemed like a good idea but, in actual practice, these small headwater streams, with good habitat, were already overseeded from natural reproduction. Besides being a wasteful practice, headwater stocking of non-native trout in the West was responsible for the virtual extinction of the native cutthroat trout throughout vast areas—such as the entire Lahontan Basin.

In 1949, a California Department of Fish and Game pack train, a lingering vestige from the dark ages, headed out with its cargo of baby rainbow trout. In the Carson River drainage the pack train took a wrong trail and Silver King Creek above Llewellyn Falls was mistakenly stocked. Coyote Valley and Corral Valley Creeks were also stocked with rainbow trout, and by 1964 all Paiute trout in the Silver King drainage were thoroughly hybridized with rainbow trout except for the small population isolated in Fly Valley Creek and a small population in Four Mile Canyon Creek, where a beaver dam had blocked access to the hybrids.

In late summer 1964, Silver King Creek, Coyote Valley Creek, and Corral Valley Creek were poisoned with rotenone to remove the hybrids. Pure fish from Fly Valley Creek were used to re-establish pure populations. Unfortunately, the eradication was not complete. After a few years, hybrids again appeared in Silver King Creek and Coyote Valley and Corral Valley Creeks. Intensive electrofishing to remove all hybrid specimens (those with more than five spots on the body) failed to reverse the tide of hybridization. Chemical treatment and restocking was again carried out in 1976 in Silver King Creek and in 1977 in Coyote Valley and Corral Valley Creeks. Again the hybrid eradication efforts failed. In recent years, hybrid specimens have been found in Silver King Creek and Coyote Valley Creek.

During my visit to Silver King Creek last summer, I estimated that 85 percent of the population appeared to be pure Paiute trout (including some of the largest Paiute specimens I had ever seen—11–12 inches) and 15 percent were hybrids. It can safely be predicted that hybridization will continually increase and Silver King Creek will have to be treated again if the goal of re-establishing a pure Paiute population is to be achieved.

Even in small streams, a complete fish kill from chemical treatment is extremely difficult. For the next treatment program, it will be essential to

PAIUTE CUTTHROAT *(Salmo clarki seleniris)*

From an original acrylic painted for Trout Unlimited by Lee Stroncek

have a crew experienced in eradication techniques and the treatment done twice, in successive years, to ensure complete elimination of hybrids.

In the meantime, besides the pure populations in Fly Valley and Four Mile Canyon Creeks and in the North Fork Cottonwood Creek, a few small populations have been established in tiny, isolated streams in California. Paiute cutthroat trout are presently protected by angling closures, but I would suggest that an active propagation program be instituted to stock small lakes with Paiute trout for special regulation or no-kill fisheries. The opportunity for catching and perhaps photographing this rare and beautiful trout should stimulate increased public awareness and support for restoration programs. Paiute trout once stocked in Bircham Lake, Inyo County, attained a size of 18 inches (the world record for Paiute).

Many might wonder why habitat enhancement would be needed in Silver King Creek, so far from civilization. Silver King Creek is in a wilderness area of the Toiyable National Forest, where domestic livestock grazes on Forest Service lands. Cattle destroyed the riparian vegetation, caved in streambanks, and initiated erosion to degrade the habitat of Silver King Creek. Even protection granted by the Wilderness Act or the Endangered Species Act is not sufficient to overcome the forces of the powerful Western livestock lobby when conflicts between livestock and endangered species' habitat arise. Forest Service employees are well aware of political realities and the best they can hope for is a workable compromise.

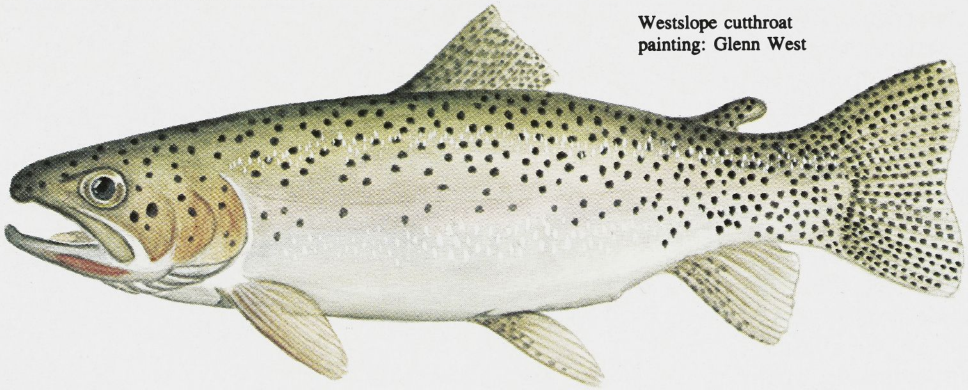
In the case of Silver King Creek, the Forest Service worked out a revised grazing program with the livestock operator which will greatly lessen the cattle's impact on the creek. To more fully restore the habitat to near-pristine conditions and revegetate the streambanks, it was necessary to construct fencing to exclude the cattle from the stream in a critical meadow area of Silver King and to initiate erosion control measures. This is expensive, labor-intensive work. The Forest Service lacked the funds and manpower to get the job done. Thus, the cooperative venture between the Forest Service, California Fish and Game, and Trout Unlimited resulting in the volunteer task force to accomplish what needed to be done.

The diverse group of TU volunteers consisted of men, women, and children from all over the state. They all deserve a round of applause for devoting their holiday time to the Silver King Creek project. I would single out for special commendation a key individual as an example of the type of person necessary to make such projects successful.

Fred Divita was the first one up in the morning, before sunrise, to get the fire blazing and the coffee brewing. He took charge of preparing three hearty, gourmet meals each day for more than 50 people. After mealtime Fred was the most tireless worker, installing logs to protect an eroding streambank. I tried to keep up with him but ended up with a sore back. I couldn't keep up with him on the job or on the trail. I would be embarrassed to reveal Fred's age so I will only provide a clue with the term "three score and ten plus." All habitat enhancement projects should have people like Fred!

I found the Silver King project to be a learning experience regarding habitat enhancement methods. Since my return home, I have devoted some time to thinking and reading on the subject. Habitat improvement of trout streams is still much a trial-and-error, learn-by-doing type of activity—more of an art than a science. Present methods for protection of eroding streambanks, consisting of gabion baskets, large boulder rip-rap, or log revetments, is extremely labor-intensive and expensive. Thus, I have been learning more about the river restoration techniques of George Palmiter and of trout stream enhancement projects conducted by Allen Binns of the Wyoming Game and Fish Department, where the goal is to understand river hydrology and to work with the river to manipulate and dissipate the energy of flowing water with strategically placed brush and trees. I plan to participate in a U.S. Forest Service stream habitat workshop to be held at Colorado State University in 1987.

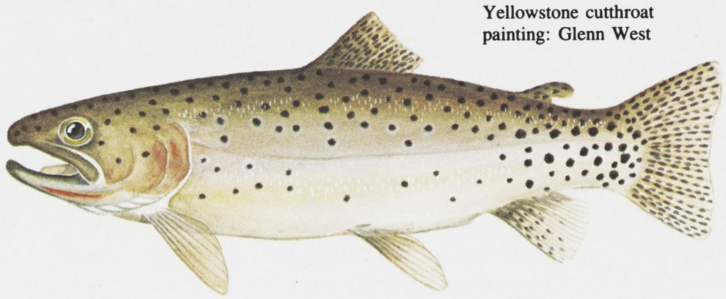
It's stimulating and exciting to learn new things and get involved in new and varied aspects of fisheries work. One can never tell where participation in a TU habitat project might lead.



Westslope cutthroat
painting: Glenn West

How the Cutthroats Reached Montana

by Jim Roscoe



Yellowstone cutthroat
painting: Glenn West

You have a week's summer vacation and are fortunate enough to live in Montana. You want to go fishing. Should you try for rainbow trout in the Madison or Beaverhead rivers, or maybe fish that secret little stream to get some of those pan-sized "natives"?

But what trout are really native to Montana, and how did they get here? After all, Montana hasn't had any ocean beaches for millions of years, and stocking programs have existed only in the last inkling of geologic time.

Your decision about where to fish may be tempered by the knowledge that the rainbow trout largely found its way to Montana only with the help of man during that last geologic inkling. However, the cutthroat trout found its own way here with the help of the ice age, when the woolly mammoth and other long-gone creatures roamed Montana.

The cutthroat trout, the first black spotted, or true trout, to reach the interior of western North America, appeared before the last ice age, perhaps 70,000 years ago. All 14 subspecies of cutthroat trout (*Salmo clarki*) currently recognized can be traced to a single ancestral cutthroat, most closely related to an Asian trout, *Salmo mykiss*. Before the last glaciation, this ancestral cutthroat had invaded the interior of western North America through the Columbia River system from the Pacific Ocean.

It moved up the Columbia into the headwaters of the Clark Fork and Kootenai rivers, as well as occupying the entire Snake River watershed. Those fish occupying the upper Columbia River drainage eventually gave rise to the subspecies of cutthroat known today as the westslope cutthroat (*Salmo clarki lewisi*), while those in the upper Snake River developed into today's Yellowstone cutthroat (*S. c. bouvieri*). These two subspecies represent the first divergence or splitting of the original cutthroat stock. The westslope cutthroat eventually crossed into the headwaters of the Missouri River in Montana and the South Saskatchewan River in Alberta. Likewise, the Yellowstone cutthroat crossed the Continental Divide to populate the Yellowstone River drainage (Fig. 1). However, this movement took place over thousands of years and was influenced by some drastic geologic events.

Continental glaciation probably had the greatest effect on historical fish distribution in the upper Columbia River Basin. During the last glacial period, the main continental ice sheet was thousands of feet thick across Canada and extended southward into northern Washington, Idaho, and Montana. Glaciation also occurred in most high mountain areas, particularly along the spine of the Continental Divide.

Wherever these glaciers blocked major river drainages, huge lakes were formed; particularly along the main ice front, entire drainage patterns were altered (Fig. 2). This kind of lake formation occurred throughout the area where the original cutthroat was found,

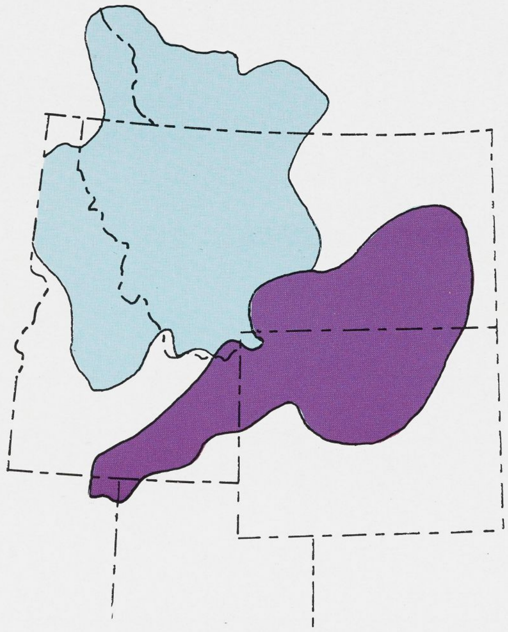


Fig. 1—Probable original distribution of the westslope cutthroat trout, *Salmo clarki lewisi*, and the Yellowstone cutthroat trout, *S.c. bouvieri*.

□ Yellowstone cutthroat trout
□ Westslope cutthroat trout

and provided a crucial refuge for all existing fish species. Where these glacial lakes spanned drainage divides, as they did in north central Montana, cutthroat trout moved easily from one drainage to another. Over several thousand years, these lakes were repeatedly formed and then drained, as ice dams failed and were then re-created with the ebb and flow of the ice sheet.

Glacial Lake Missoula probably had the greatest influence on the present distribution of the cutthroat trout indigenous to western Montana, the westslope cutthroat. This glacial lake occupied the Clark Fork, Flathead, and Bitterroot valleys and was formed by an ice dam on the Clark Fork River at the present location of Lake Pend Orielle in Idaho. The lake had a surface area of approximately 2,900 square miles and was first formed about 70,000 years ago. It withdrew for the last time about 7,000 years ago. The lake was sporadic, flooding at least seven times because of repeated failure of the ice dam.

The scouring action of these floods, which lasted for weeks, gouged over 1,000 feet into bedrock to form the basin holding today's Lake Pend Orielle. Downstream in eastern Washington, stream channels were severely eroded, waterfalls were created, and fish populations were destroyed; this flood-caused erosion created the rugged area called the Scablands. Over time, these events barred fish movement into the upper Columbia River Basin and ensured isolation of the westslope cutthroat above Lake Missoula.

While effects of glaciation lingered, the westslope cutthroat dispersed throughout the upper Columbia River Basin. Where there were glacial lakes, movement was easy. It invaded neighboring systems, often by direct stream connections over drainage divides, situations where a lake or stream in a divide flowed to both sides. One direct connection between the drainages of the Columbia and Missouri rivers was present until fairly recently. Summit Lake, on the Continental Divide on Marias Pass near Glacier National Park, drained into both the Flathead and Marias rivers, until the western outlet was dammed by the Great Northern Railway Company in 1891.

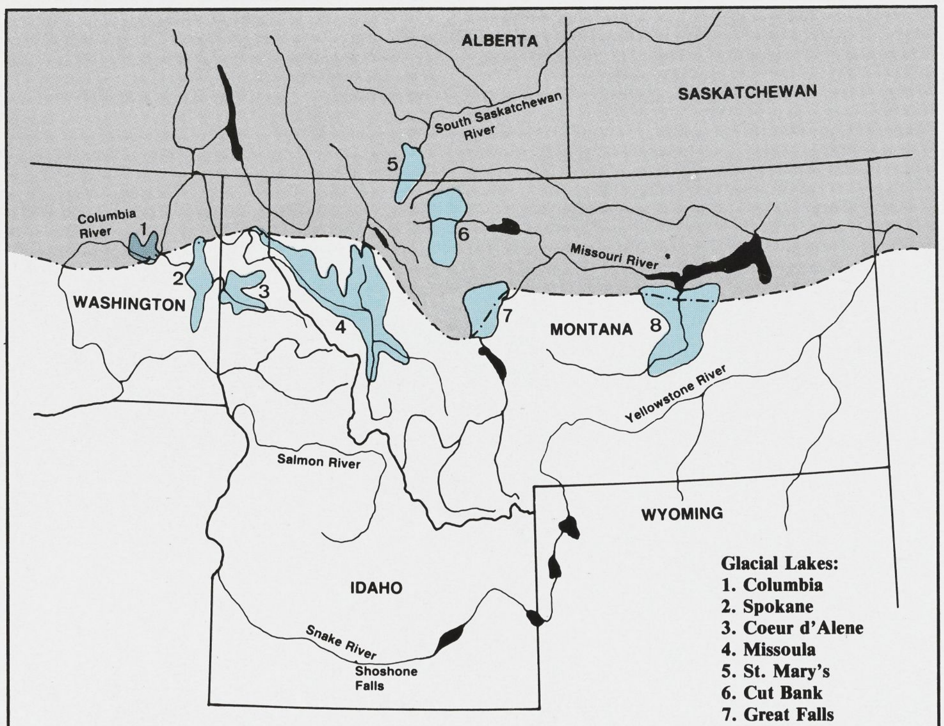
Fish probably also were transferred between streams by a process called "headwater stream capture." Cirques are the semicircular basins found in the peaks of many high mountain headwaters. During the last ice age, these formations were at the heads of alpine glaciers. As these glaciers exerted their tremendous erosive power on the mountains, the cirques slowly migrated uphill into the mountains. Occasionally, where all conditions were right, the head of a cirque collapsed, merging the head of the first drainage with that of its neighbor. Any tilting or uplifting of the earth's surface—which was also occurring at this time—enhanced the process. Later, as the glaciers withdrew and disappeared, these altered drainages provided new avenues of dispersal for the westslope cutthroat. In some cases, these avenues even extended across the Continental Divide.

A likely place for crossovers between drainages is in the vicinity of Glacier National Park. Headwaters of the Columbia, Missouri, and South Saskatchewan River systems all originate within the park, and westslope cutthroat are found in all three systems. As mentioned, one direct connection between systems existed in the area until quite recently. The erosional effects of local glaciation are dramatically obvious in the spectacular sculpturing of the alpine cirques and ridges. With headwaters of streams on both sides of the divide within one mile of each other, the potential for headwater capture and stream transfer is significant.

The historical distribution and physical characteristics of cutthroat trout in Alberta and Montana east of the Continental Divide (excluding the Yellowstone River drainage) indicate that westslope cutthroat from the upper Columbia River Basin entered the upper Missouri and South Saskatchewan River drainages after the end of the last glacial period, from 7,000 to 10,000 years ago. Historically, cutthroat trout were not found in tributaries to Hudson Bay in Canada, other than the South Saskatchewan River, or farther east in this drainage than central Alberta. Likewise, in the Missouri River Basin, cutthroat trout were not found downstream from the Musselshell River.

When the westslope cutthroat reached the east slope of the Continental Divide, its dispersal throughout the upper Missouri system was aided by extensive ice-front lakes similar to Lake Missoula. Early retreat of the main ice sheet formed small glacial lakes in valleys close to the Continental Divide. As the ice retreated farther and meltwater flowed out, these lakes eventually spread out of a single valley or drainage basin and covered fairly large areas. Glacial lakes Cut Bank, St. Mary's, and Cardston are examples. At one time, they spanned the lowland divides now separating the Missouri and South Saskatchewan River basins. Wherever these lakes spread, new habitat for the westslope cutthroat was available and new populations flourished.

The environmental conditions under which the westslope cutthroat survived in western Montana had a direct effect on its survival until the present. As



Glacial Lakes:
1. Columbia
2. Spokane
3. Coeur d'Alene
4. Missoula
5. St. Mary's
6. Cut Bank
7. Great Falls
8. Musselshell

Fig. 2—Maximum southward extent of the continental ice sheet and glacial lakes present along the ice front.

glacial lakes repeatedly flooded and drained, the westslope cutthroat adapted to live in large lakes and large rivers, as well as small headwater streams. This ability to live in a variety of habitats allowed its original widespread distribution into the headwaters of three major river systems.

At the same time the westslope cutthroat was establishing itself in the upper Columbia River Basin, the ancestral cutthroat spread into most tributaries of the Snake River, and eventually crossed the Continental Divide into the headwaters of the Yellowstone River. This fish ultimately became known as the "Yellowstone cutthroat trout." Just how it was distributed in the lower Snake River Basin is unclear today, since many populations have been destroyed naturally, most due to volcanic activity, or have been replaced by the redband trout. The redband is a late comer, not yet taxonomically described, with characteristics in between those of rainbow and cutthroat trouts. Small, relict populations of ancestral cutthroat stock have survived in isolated streams in the lower watershed until recent times.

In contrast to the northern Rocky Mountains where continental glaciation was the primary factor influencing fish distribution, extensive volcanic activity occurred in southern Idaho and northwestern Wyoming. This activity, in conjunction with more localized alpine glaciation, had a profound effect on fish distribution and habitat throughout the Pleistocene Era.

Development of the Snake River Plain over the last several thousand years removed much of the area north of the Snake River as suitable fish habitat. The plain is comprised of overlapping lava flows, some only 2,000 years old, extending from the foot of the mountains on the north to the Snake River on the south. Because lava is porous, any water flowing out of the adjoining mountains is "absorbed," completely eliminating downstream water courses. As a result, streams originally tributary to the Snake River, such as Big Lost River, Little Lost River, and Birch Creek, and the cutthroat populations inhabiting them, are now completely isolated.

During this same time, a huge inland lake called Lake Bonneville was forming in the Great Basin of Utah as a result of melting alpine glaciers. This lake continued to grow until approximately 30,000 years ago when it finally overflowed through Red Rock Pass south of Pocatello, Idaho, and into the Snake River. As flows increased through the narrow pass, an overwhelming flood rushed into the Snake River. The flood continued for weeks and carried house-sized boulders as far as 100 miles downstream. The erosive force of such a flood was tremendous and resulted in significant channel damage all the way to the Columbia River. Most important, this flood created the 212-foot Shoshone Falls near Twin Falls, Idaho, blocking fish movement into the upper watershed and isolating the cutthroat trout already there.

Farther up the Snake River, much more violent volcanic activity was shaping the Yellowstone Plateau. Whatever fish managed to move upstream into the headwaters were periodically destroyed by repeated volcanic eruptions and lava flows. In addition, the ebb and flow of alpine glaciers continued to sculpt the landscape, at times even overlying active lava flows.

Life for the ancestral cutthroat trout has been tenuous in the Snake River. But during the thousands of years this geologic activity has been going on, suitable habitat was always available and the fish survived, sometimes by inhabiting small headwater streams spared from volcanic destruction or glaciation, or by retreating to the refuge of the mainstem Snake River.

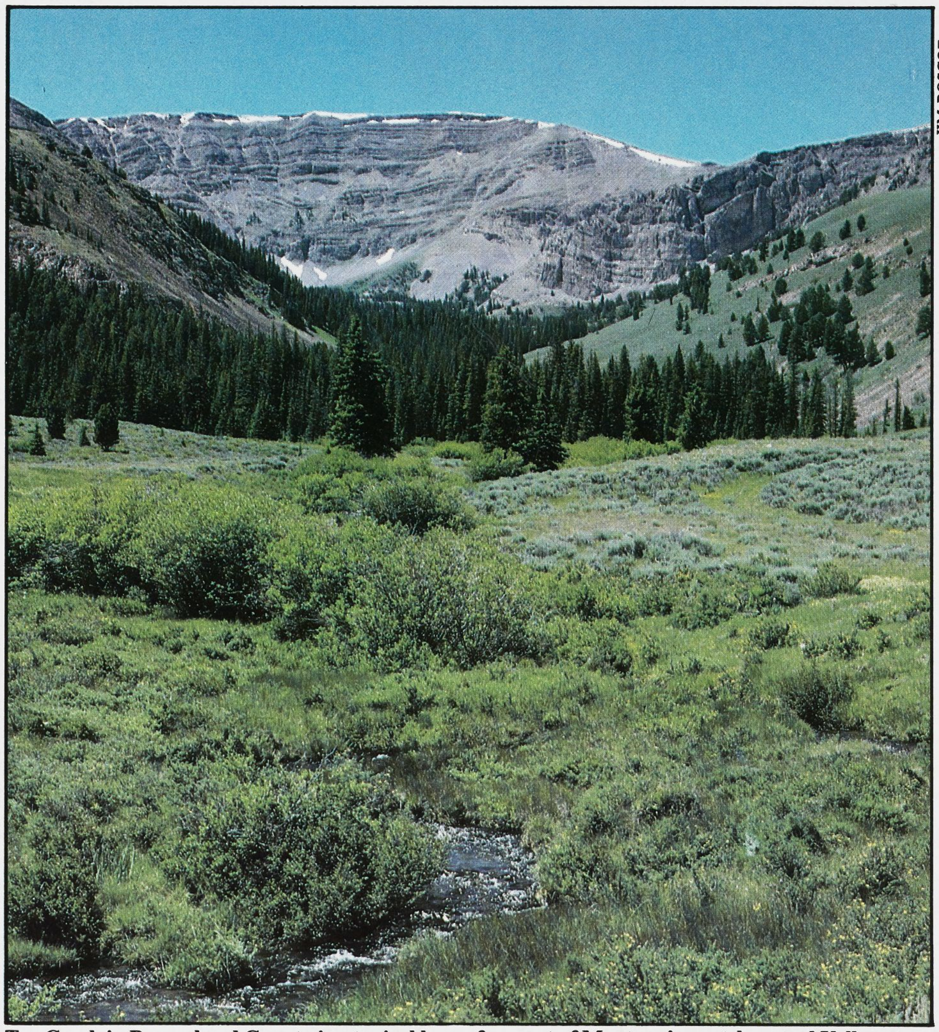
The last major geologic event in the upper Snake River-Yellowstone area was the Pinedale Glaciation which coincided with the last major advance of the continental ice sheets approximately 75,000 years ago. Alpine glaciers, often up to 3,000 feet thick, covered the entire Yellowstone Plateau periodically during this time. With the final melting of these glaciers about 8,000 years ago, the area was once again open to occupation, and development of present-day plant and animal communities began.

Cutthroat trout which had survived in the Snake River Basin and were now isolated above Shoshone Falls gradually spread once again into the headwaters. The headwaters of the Yellowstone River across the Continental Divide were devoid of all fish life, and recolonization had to occur from across the divide. In the absence of large glacial lakes such as those which aided westslope cutthroat movement in northern Montana, fish could move across drainage divides only through direct connections or headwater capture. Stream transfers between headwaters probably occurred between adjacent tributary drainages in this area, but there is little evidence that a major headwater capture and transfer occurred across the Continental Divide. However, early explorers of the area around Yellowstone National Park found a *continuous* water route that straddles the divide in Two Ocean Pass, in the southeastern corner of the park. This probably served as a route by which cutthroat trout occupied the Yellowstone River system.

Two Ocean Pass is a broad saddle which holds the headwaters of Pacific Creek (Two Ocean Creek), tributary to the Snake River, and Atlantic Creek, flowing into Yellowstone Lake and the Missouri River. Because of the unique topography of the pass, water flowing into the saddle from the north in North Two Ocean Creek actually divides into two channels and flows both ways off the Continental Divide. This area was first recognized in 1893 by Barton Everman and David Starr Jordan as the most likely route for fish to move across the divide. Unfortunately, they thought that cutthroat trout in the Yellowstone drainage had progressed upstream from the Missouri River and then crossed into the headwaters of the Snake River—exactly the reverse of what actually had happened.

At this point, the westslope cutthroat and the Yellowstone cutthroat, which had been physically separated for thousands of years and had become genetically different subspecies, were about to be reunited through man's oversight. During their expeditions in the early 1890s, Everman and Jordan also found the westslope cutthroat in the upper Missouri drainage. By failing to recognize the physical differences between the two subspecies, Everman and Jordan assumed they were the same fish. They logically surmised then that the fish in the Yellowstone system and the upper Missouri must have had a common origin in the Missouri River.

This idea has caused confusion for both taxonomists and biologists for over 80 years, since no one acknowledged that the westslope and Yellowstone cutthroat were genetically different fish and that their original ranges did not overlap. By the early 1900s, the Yellowstone cutthroat was found to be a quality sport fish suitable for stocking programs, with a relatively accessible brood stock available in Yellowstone Lake. Consequently, during intensive and indiscriminate stocking by state and federal agencies, the Yellowstone cutthroat was introduced into waters far outside its native range, often displacing or replacing whatever native fish were present. Hybridization readily occurred where Yellowstone cutthroat were introduced into westslope cutthroat streams, and often the westslope was simply overwhelmed by the sheer numbers of Yellowstone cutthroat released. Since, habitat losses and population declines in many areas have further obscured the original distribution of both Yellowstone and westslope cutthroats.



JIM ROSCOE

Tex Creek in Beaverhead County is a typical home for most of Montana's westslope and Yellowstone cutthroat trout. When left undisturbed, such streams have been vital refuges for cutthroat survival.

Fortunately, within the past 15 years, researchers, such as Dr. Robert Behnke at Colorado State University and Dr. Fred Allendorf at the University of Montana, have traced the geographic and genetic backgrounds of both the westslope and Yellowstone cutthroat trout, and have provided much-needed physical descriptions of both subspecies. This has allowed biologists to determine existing distributions of both fish and to identify relatively pure populations.

Both cutthroat subspecies are now integral parts of fishery management programs in western Montana. Because of the scarcity of pure populations, both cutthroats are designated a priority species of special concern by the Montana Department of Fish, Wildlife and Parks and are the focus of population and habitat rehabilitation projects in several areas. In addition, the Yellowstone cutthroat supports a nationally known fishery in the Yellowstone River and is the mainstay of the alpine lake stocking program in southwestern Montana.

Together, the westslope and Yellowstone cutthroat trout are Montana's state fish and are a treasured part of Montana's natural heritage. With continued management emphasis and public recognition, these prized "natives" can assuredly be maintained as a valuable fishery resource, and serve as a reminder of the days when the forces of nature were busily sculpting the face of Montana. ■

ABOUT TROUT

ROBERT J. BEHNKE

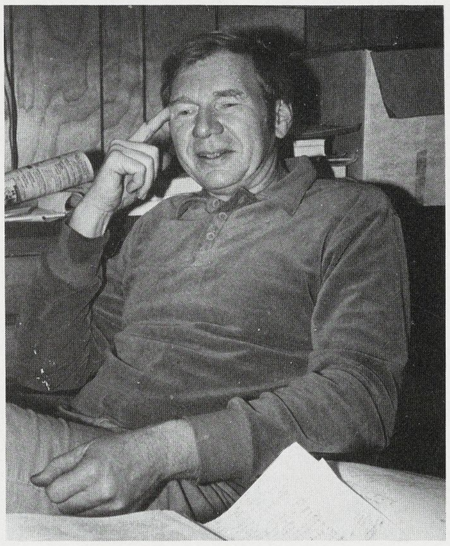
In the Rangeley Lakes of Maine, 12-pound brook trout once preyed on relict char called bluebacks.

Brook Trout

A boyhood impression indelibly fixed in my mind is the first trout of my life—a brook trout caught in the Rippowam River in Stamford, Connecticut. The elegant form and total beauty of the seven-inch fish in my hand induced such awe, wonder, and complete fascination that I ran home as fast as I could and placed the little fellow in a basin of water so I could observe the living fish and prolong my ecstasy. Undoubtedly, this imprint learning experience was a strong influence in determining direction in my life.

The brook trout, *Salvelinus fontinalis,* is a char, the common English name given to all members of the genus *Salvelinus.* Char can be spelled with one "r" or two (originally "charre") and the word is derived from the Gaelic *"ceara"*—red, blood-colored. The first English and European immigrants to America were probably only vaguely familiar with the Arctic char, *S. alpinus,* in their homelands because it is restricted to deep lakes. The brook char they encountered in North America was ecologically and morphologically more similar to the European brown trout, *Salmo trutta,* than to other species of char; thus, it would logically be called "trout" by the first European settlers. No inviolate rules or protocol can be invoked to determine the most correct common name of *Salvelinus fontinalis;* "brook trout" or "brook char" is equally correct so long as the scientific "Latinized" name leaves no doubt what species is being referred to.

Species in the genus *Salvelinus* are distinguished from species of the other



genera of the family *Salmonidae* by the absence of black spots on the body. *Salvelinus* species also lack teeth on the shaft of the vomer bone in the roof of the mouth and have tube-like lateral line scales. These two traits are shared with the genera *Hucho* and *Brachymystax,* with which *Salvelinus* evidently shares common ancestry. *S. fontinalis* differs from other species of *Salvelinus* by the mottled, worm-like markings (vermiculations) on their back and on the dorsal fin and tail.

The brook trout has been one of the most intensively studied fish species in the world in regard to its life history, ecology, behavior, and physiology. Yet its intraspecific taxonomic structure is not well defined. For example, should subspecies of brook trout be recognized for northern and southern races? What are the aurora trout of Ontario and the silver trout of Monadnock Lake, New Hampshire? Are they only "color varieties" of *S. fontinalis,* subspecies of *fontinalis,* or distinct species?

The native distribution of brook trout in northeastern North America covers a vast area from tributaries of Hudson Bay (to northeast Manitoba) and James Bay in the north, continuously southward throughout Ontario, Quebec, Labrador, the Island of Newfoundland, New England, the Great Lakes and upper Mississippi drainage of Minnesota and Wisconsin (and the Iowa River of Iowa), and on both sides of the Appalachian Mountains to northeast Georgia and northwest South Carolina.

There are some unusual and unexplainable aspects of the original distribution of brook trout, such as its native range in Michigan.

Brook trout occurred naturally only in rivers of the northern tip of the Lower Peninsula, north of a line drawn from Traverse Bay (Lake Michigan) to Thunder Bay (Lake Huron). South of this area, the Michigan grayling was native. Many of Michigan's most famous trout streams—the Pere Marquette, Manistee, Muskegon (Lake Michigan tributaries), and the Au Sable River (Lake Huron tributary)—lacked brook trout before they were stocked. These rivers had native grayling, which soon became extinct after brook, brown, and rainbow trout were introduced. Why didn't brook trout establish natural populations in the rivers of lower Michigan by movement along the coasts of Lake Michigan and Lake Huron? Superficially, it would appear that brook trout and grayling are incom-

patible (competitive exclusion), but both species naturally occurred together in the Jordan River (Traverse Bay area) and in Otter Creek of the Upper Peninsula (tributary to Lake Superior). Brook trout became readily established in Lower Peninsula drainages after they were introduced by man.

In Ohio, brook trout were native to only two streams (Lake Erie Basin), but were absent from Cold Creek, Ohio's best trout stream (Castalia Trout Club waters). The first artificial propagation of fish in the United States was with brook trout near Cleveland, Ohio, by Theodatus Garlick and H.A. Ackley in 1853. Garlick traveled almost 600 miles to Sault Ste. Marie to obtain large specimens in the outlet of Lake Superior, for their broodstock.

With such a vast range, exposure to evolution in diverse environments, and the rearrangements of the landscape during the last glacial period, it would be expected that a great amount of intraspecific diversity is contained in *S. fontinalis* which can be applied in modern fisheries management. A simple example concerns the proclivity for benthic feeding in brook trout and pelagic feeding in rainbow trout, which suggests that if both species are stocked in a lake, the total food supply (benthic invertebrates and pelagic zooplankton) will be more fully utilized and total trout production will increase. Ecologically, brook trout can be divided into three major groups: those evolving in large lakes with specialization as lacustrine predators; sea-run populations that use the marine environment for feeding and rapid growth for a few months of the year; and the "generalist" type of brook trout whose evolution since the last glacial period has been associated with small streams and ponds.

The most common and widely distributed type of brook trout is of the generalist ancestry. They rarely live much more than three years or attain a size much larger than 12 inches. Recognizing the genetic basis for different types of life histories and the limitations of hatchery stocks of brook trout imposed by their evolutionary history and domestication, many years ago the late Dwight Webster of Cornell University imported the Temiscamie and Assinica strains of brook trout from Canada as representatives of the large predatory form. Webster and Bill Flick studied the performance of the Canadian strains in Adirondack lakes for years. They conclusively demonstrated a great advantage in survival, longevity, maximum size, and total return to the fishery of the wild Canadian strains over hatchery strains. In recent years, the Assinica and Temiscamie brook trout have been raised and stocked in several states, but we have barely scratched the surface in regard to innovative uses of the genetic diversity of *S. fontinalis* in fisheries management.

It should be understood that Flick found the Temiscamie and Assinica brook trout to be extremely susceptible to angling. Even with light angling pressure, it is necessary to impose restrictive regulations if the inherent longevity and growth potential of these strains are to be realized in a fishery. There are numerous races of brook trout with the genetic potential to produce a new world record if introduced into a new lake with optimum environmental conditions and abundant forage.

The 14½-pound brook trout caught by Dr. J.W. Cook in the Nipigon River has been the world record for the species since 1916. The Nipigon River was famous for large brook trout. Nineteenth-century reports include fish up to 17 and 19 pounds. I suspect that the Nipigon no longer produces record brook trout because the original race that produced these giant fish was lost. A dam was constructed on the Nipigon River which blocked fish movement between Lake Superior and Lake Nipigon. It is likely that the great size of the Nipigon brook trout was related to feeding and spawning migrations between the two lakes. When the migration route was blocked, this particular race was lost.

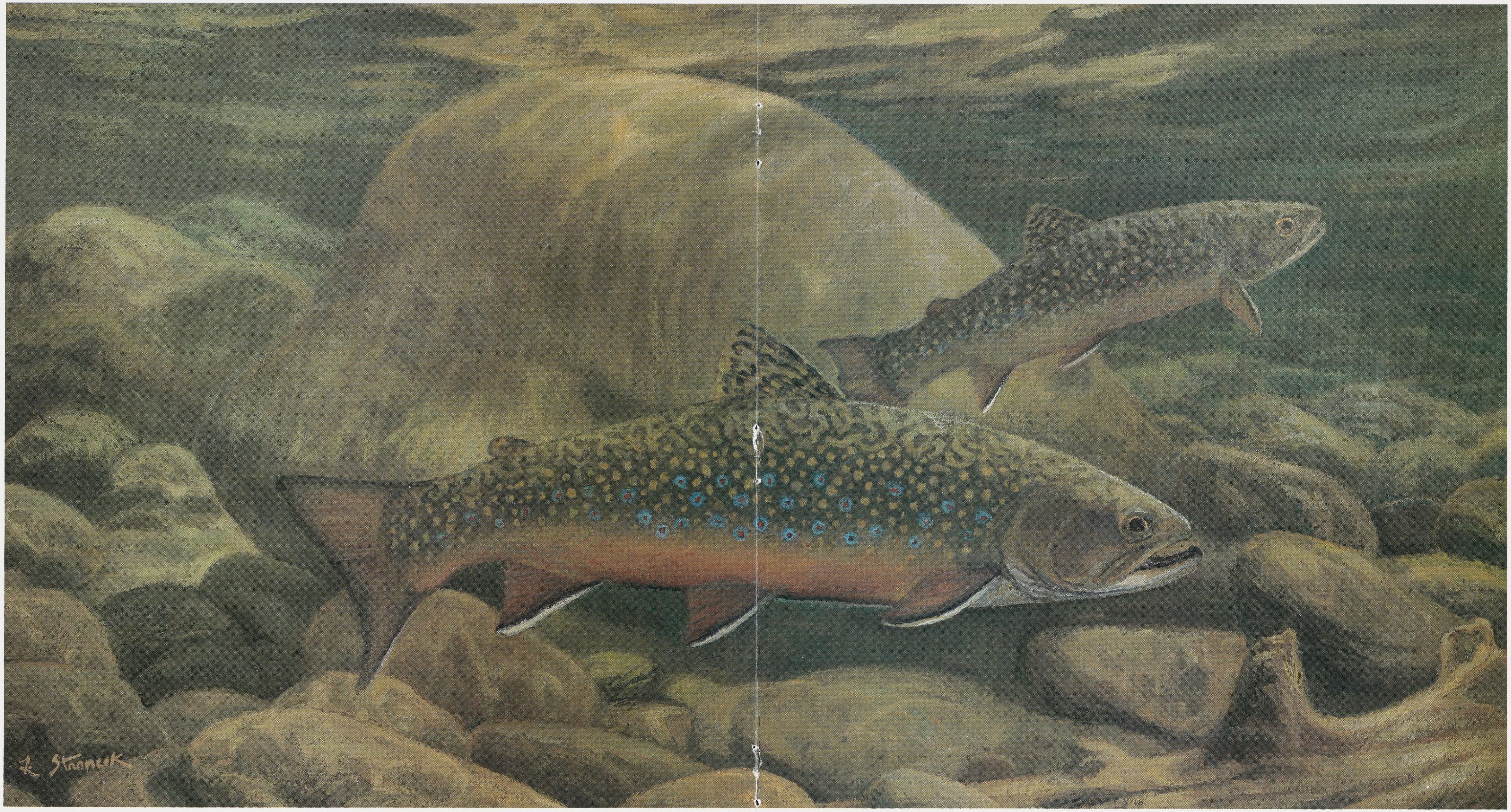
The Rangeley Lakes of Maine, a most significant area in the lore and history of brook trout, was noted for large brook trout in the nineteenth century. Specimens of 12 and 12½ pounds were recorded. In the Rangeley Lakes, brook trout originally coexisted and preyed on relict populations of Arctic char, locally known as blueback trout. About 1890, Atlantic salmon and smelt were stocked and became established, which led to the extinction of the blueback trout and a change in the feeding relationships of brook trout. Since then, brook trout in the Rangeley Lakes have never attained their former maximum size.

Brook trout of world record size on Long Island, implied in the legend of the brook trout and Daniel Webster, is a myth similar to the story of the devil and Daniel Webster. When Samuel Mitchill described the species *fontinalis* in 1815, based on the fish known to him in the vicinity of New York City, he discussed the excellent trout fisheries known on Long Island at that time. Long Island trout averaged less than one pound and the largest specimen Mitchell had heard of weighed 4½ pounds.

Brook trout have been introduced all over the world, although not with the success of brown and rainbow trout introductions. Some exceptionally large brook trout are known in some South American lakes. I can recall a photograph in an Ashaway Line catalog of many years ago of a brook trout from Argentina reputed to be 15 pounds.

Concerning geographic variation in brook trout, populations native to the southern Appalachian Mountains differ from typical northern brook trout by their more profuse, smaller spots. Biologists at Pennsylvania State University published a paper in 1981 on an electrophoretic analysis of enzymes of brook trout from three populations from Pennsylvania, two from New York, two from Tennessee, and one from Great Smoky Mountains National Park in North Carolina. The three southern samples clearly differed from the five northern samples at a level typical of subspecies differentiation. A problem is that there are no comparisons of brook trout in the intervening area of Virginia and West Virginia. If a complete transition occurs between northern and southern brook trout, then the case for separate subspecies recognition is weakened.

During the past 100 years, the distribution of the southern Appalachian brook has been drastically reduced by environmental changes and the introduction of rainbow and brown trout which have pushed the remaining



BROOK TROUT *(Salvelinus fontinalis)*

From an original acrylic painted for Trout Unlimited by Lee Stroncek

brook trout populations back to the uppermost headwaters. Several protection and restoration programs are attempting to halt and reverse this decline. In Great Smoky Mountains National Park, certain streams, in which rainbow trout distribution overlaps with brook trout, are systematically electrofished to remove the rainbow trout (which are transplanted downstream in public angling waters).

It is ironic that the most massive abundance of brook trout now occurs in the West, where they are a non-native species. Brook trout dominate most headwater streams of the Rockies, Sierras, and Cascade Mountains, where they have replaced native subspecies of cutthroat trout. A common practice for cutthroat restoration concerns poisoning brook trout and restocking with the native cutthroat.

The "aurora trout," known from three lakes in the headwaters of the Montreal River (Saint Lawrence River Basin), Ontario, was described as a new species, *Salvelinus timagamiensis,* in 1925. At first it was believed to be related to Arctic char rather than brook trout, but subsequent studies have clearly demonstrated that the aurora trout was derived from a brook trout ancestor. The aurora trout differs from brook trout by the absence of vermiculated markings. Currently, the aurora trout is recognized as a subspecies of brook trout, although it did occur together with brook trout without hybridizing in one of its native lakes.

The most interesting and mysterious variety of char related to the brook trout is the silver trout of Monadnock Lake, Dublin, New Hampshire. The local people of the area had long known that large numbers of "silver trout" would suddenly appear in shallow water for spawning each October, and they would be snagged and snared for human and hog food. The first written account of the Monadnock silver trout appeared in 1850 when it was already mentioned that their abundance had declined from former times. In the 1870s and '80s, fishermen claimed that because the silver trout was not a brook trout ("normal" brook trout also occurred in Monadnock Lake and spawned about two weeks later than the silver trout), they were not protected under brook trout regulations in regard to season and bag limits. This caused the New Hampshire Fish Commission to send specimens of silver trout to Harvard and to the U.S. National Museum for identification. It was first identified as a form of lake trout and then as a variety of brook trout. In 1885 the silver trout was described as a a new species, *Salvelinus agassizi.* W.C. Kendall studied the silver trout, and the results of his study, including a color painting, are included in his monograph of New England chars published in 1914. Kendall concluded that the silver trout was related to the Arctic char rather than the brook trout because their body shape and tail are more similar to Arctic char and they lacked vermiculated markings on the body.

Not much more has been said about the silver trout of Monadnock Lake since Kendall's 1914 monograph.

About 20 years ago I was studying trout specimens in the National Museum's fish collections and I came across 13 specimens of silver trout collected from Monadnock Lake in the 1870s and '80s. When I examined them I realized that the silver trout was derived from a brook trout ancestor—markings on dorsal fin and tail and numbers of vertebrae, gillrakers, and pelvic fin rays are characteristic of brook trout and of no other species of char. But they were quite distinct from brook trout. I found eight of the 13 specimens to have basibranchial teeth (tiny teeth in throat between gill arches) and the structure of the gillrakers was highly distinctive. Most of the protuberances on the gill arches were rudimentary knobs bearing tiny teeth, similar to gillrakers of highly predacious fish such as northern pike.

The differentiation of characters in the silver trout specimens I examined are outside the range of variation of *S. fontinalis.* Undoubtedly, the silver trout of Monadnock Lake represented a significant divergence from a brook trout ancestor—perhaps evolving to fill the "lake trout niche" outside the range of lake trout. It is improbable that this significant evolutionary divergence could have occurred in Monadnock Lake during the past few thousand years. More likely, the silver trout of Monadnock Lake is a relict of an ancient lake system. As the last glaciers retreated from the Connecticut River Valley, a series of large glacial lakes formed. One of these, Lake Hitchcock, was more than 150 miles long, extending from Connecticut into New Hampshire and Vermont, and persisted for 4000 years. Kendall also found a form of silver trout in Christine Lake, Stark, New Hampshire. Both Monadnock and Christine Lakes are in the Connecticut River Basin; both have similar characteristics—deep, clear, cold, well oxygenated. The evidence suggests that the silver trout diverged from a brook trout ancestor, its evolution directed toward specialization for pelagic life in large glacial lakes. When the large glacial lakes disappeared the silver trout persisted in the most suitable environments to which they had access—Monadnock and Christine Lakes.

The silver trout is presumed extinct. In 1939, the New Hampshire Fish and Game Department published the *Biological Survey of the Connecticut Watershed.* The results of sampling Monadnock and Christine Lakes were given in this report. No silver trout were found and they were believed to be extinct due to stocking of non-native fishes such as rainbow, brown, and lake trout, salmon, and smelt.

I would prefer not to finish a story on the dismal theme of extinction, so I will mention that the January 1939 issue of *Outdoor Life* contained a story entitled "Warriors in Silver," with the intriguing heading, "As mysteriously as it had disappeared, a scrappy species of trout returns to a mountain lake." The story concerns catching silver trout in Monadnock Lake and has a photo of an angler holding four silver trout of about two to three pounds. Are they indeed *S. agassizi?* I cannot tell from the photo; I would have to examine their gillrakers for positive identification.

If anyone believes he has caught a true silver trout, I request that the specimen be preserved and I be notified. Until then, I will consider that *S. agassizi,* the most interesting divergence in brook trout evolution, is most probably extinct. But, based on the lessons of the return from "extinction" of the original Pyramid Lake and Alvord Basin cutthroat trout, there is always hope.

ROBERT J. BEHNKE

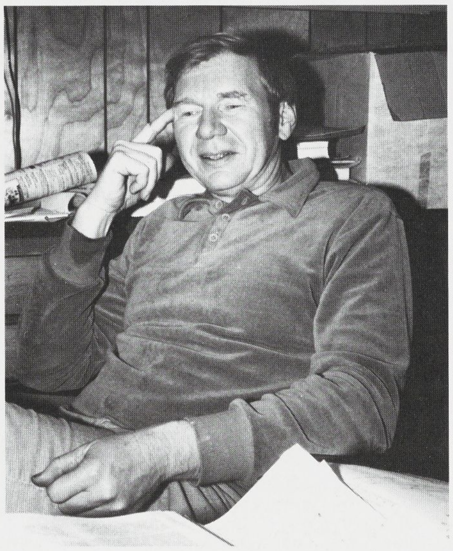
Native trout are found in high elevation tributaries leading to the Sea of Cortez.

Mexican Golden Trout

Trout have been long known to occur in Mexico, but the diversity and complexity of Mexican native trout have become apparent only in recent times. Several distinct forms of native trout are known from the Sierra Madre Occidental of the mainland, in high elevation tributaries to the Gulf of California (also known as the Sea of Cortez), and in one stream of the San Pedro Matir Mountains of northern Baja California. The most distinctive of these forms was in 1964 described as a new species: the Mexican golden trout, *Salmo chrysogaster.*

The Mexican golden trout and all Mexican trout, along with the Gila and Apache trout, have their closest relationships to the rainbow trout line of evolution rather than to the cutthroat trout line. They represent varying degrees of evolutionary divergences from a primitive ancestor of the rainbow. The Baja Peninsula and warm southern ocean temperatures have protected the Gulf of California from large-scale invasions of "modern" forms of rainbow trout, creating a refuge area for the persistence of ancient forms.

The first record of Mexican trout published in a scientific journal was by the famous paleontologist E.D. Cope in 1886. Cope's short note, entitled "The Most Southern Salmon," concerned two specimens of trout sent to him by Professor Lupton from "the southern part of the State of Chihuahua near the boundaries of Durango and Sinaloa." Cope believed the specimens to be cutthroat trout. He wrote,



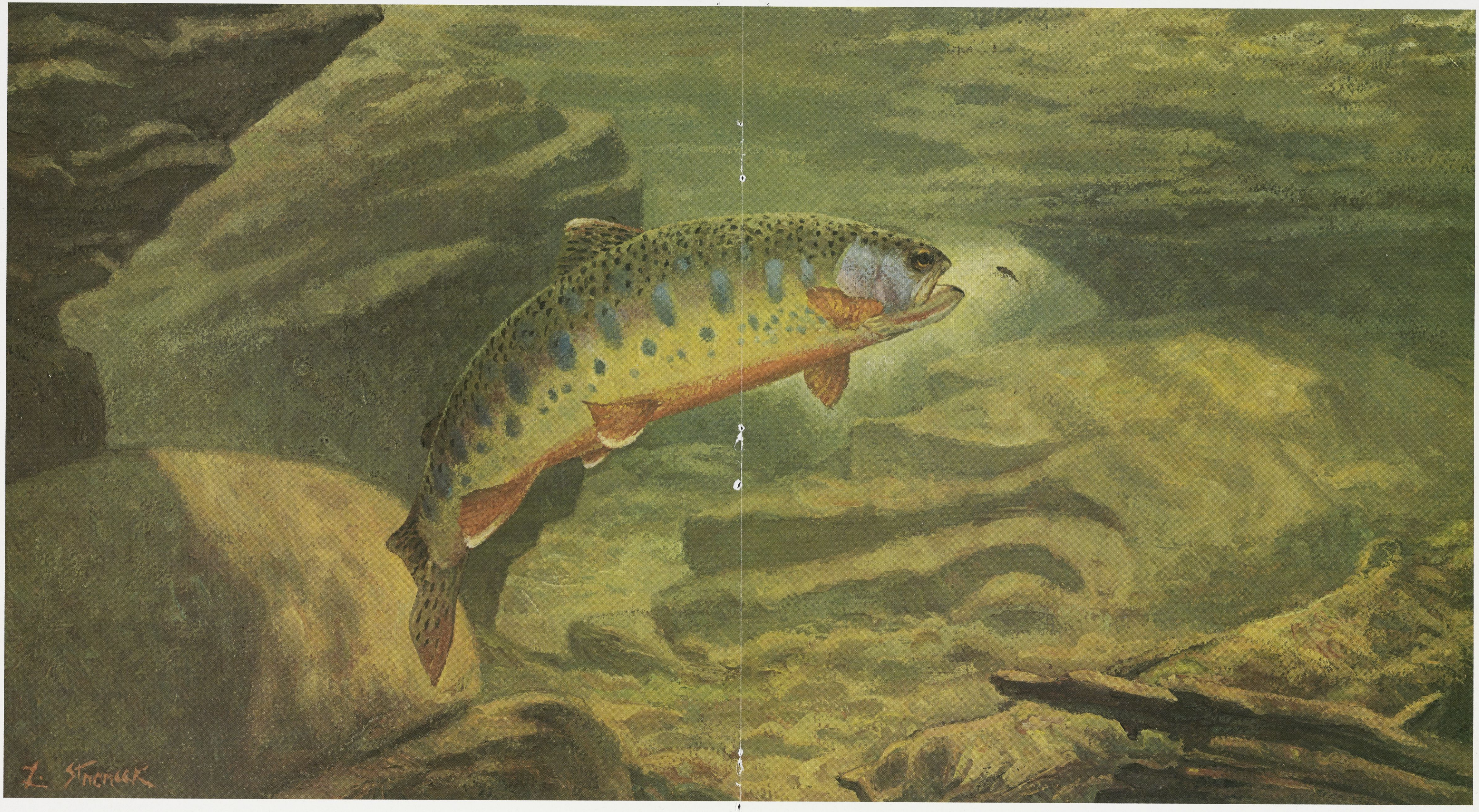
"The specimens are young and have teeth on the basihyal bones, as in *Salmo purpuratus*, which they otherwise resemble." *(S. purpuratus* is a name that was incorrectly used for cutthroat trout, *S. clark.*)

This first record of trout in Mexico also introduces the first mystery and confusion concerning Mexican trout. The precise collection locality with identification of the river basin was not included with the specimens sent by Professor Lupton to Cope. The correct identity of these first specimens probably will never be known, because they were never seen again and have never been found in any museum collection. Cope's mention of "basihyal" teeth can be assumed to mean basibranchial teeth, the tiny teeth that occur between the gill arches in cutthroat trout (absent in rainbow trout). Examination of hundreds of Mexican trout specimens collected from numerous localities since 1886 has failed to find a single specimen with basibranchial teeth. If Cope was correct, and his specimens were a form of cutthroat trout, then this first record of Mexican trout represents a form of trout that has not been found since 1886.

This dubious record of cutthroat trout in Mexico has long persisted in the literature. The 1984 edition of Ernest Schwiebert's *Trout*, for example, gives the distribution of cutthroat trout "...from the mountains of northern Mexico to the Alpine tributaries of Alaskan rivers."

Most of the early records of the occurrence of trout after 1886 were made by E. W. Nelson, a naturalist with the U. S. Biological Survey who served as chief of this bureau from 1916 to 1927. (In 1940 the Biological Survey of the Department of Agriculture and the Bureau of Fisheries of the Department of Commerce were combined into a new agency, the Fish and Wildlife Service in the Department of Interior.) Nelson made natural history observations and collections on the Mexican mainland in 1898 and in Baja in 1905, traveling on horseback.

In 1898 Nelson attempted to find the trout described by Cope in 1886. He found trout in streams draining the slopes of Mount Mohinora, a few miles south of Guadalupe y Calvo in southern Chihuahua. There are three rivers tributary to the Gulf of California whose headwaters drain the slopes of Mount Mohinora; all are presently known to contain only the Mexican golden trout. The headwaters of the



MEXICAN GOLDEN TROUT *(Salmo chrysogaster)*

From an original acrylic painted for Trout Unlimited by Lee Stroncek

Rio Fuerte drain the northern and northeastern slopes of Mount Mohinora. The Rio Culiacan drains the southeastern slope, and the Rio Sinaloa drains the southern and western slopes. It can be assumed that Nelson collected Mexican golden trout in 1898, probably from the headwaters of the Rio Sinaloa. Unfortunately, the specimens were not described, and evidently they were not preserved in any museum collection.

Also in 1898, Nelson reported trout in a stream tributary to the Rio del Presidio near El Salto, Durango, about 70 miles west of Durango City. There has been debate concerning the origin of the Rio del Presidio trout – native or introduced. I belive the Rio del Presidio trout are native, because of their distinctive characteristics cannot be explained by any known form of rainbow trout propagated in hatcheries. If they are native, the headwaters of the Rio del Presidio, just north and just south of 24° N latitude (virtually on the Tropic of Cancer and south of the southernmost tip of Florida) represents the most southern natural distribution of any species of the family Salmonidae. A subspecies of the far eastern masu salmon (*Oncorhynchus masou*) is native to the headwaters of a mountain stream on the island of Taiwan just north of 24° N latitude. The southernmost natural distribution of brown trout, *Salmo trutta*, occurs in the Atlas Mountains of North Africa at about 34-36°N latitude and in the Orontes River of Lebanon at about 34°.

All of these distributions reflect a colder climate and colder ocean temperatures during glacial periods, which allowed salmonid fishes to extend their ranges much farther southward than has been naturally possible during the past several thousand years. These salmonid relics have persisted to the present in the most southern areas only where mountain rivers maintain cool temperatures.

Fossils of trout and salmon have been found in the Lake Chapala basin about 250 miles south of the headwaters of the Rio del Presidio. One of the fossils has been described as a new (but extinct) species, *Salmo australis*, by Ted Cavender (Ohio State University) and Robert Miller (University of Michigan), who have described many salmonid fish fossils.

The skull of *S. australis* indicates a trout of about three feet in length. Lake Chapala once connected to the Rio Lerma, which flows into the Pacific Ocean as the Rio Grand de Santiago about 100 miles south of the mouth of the Rio del Presidio (which enters the ocean about 10 miles south of Mazatlan).

Thus, it is likely that during the four major glacial epochs of the Pleistocene – beginning almost two million years ago with the onset of the first epoch and terminating only about 10,000 years ago – there were periods when trout and salmon occurred in Mexican rivers at least as far south as the Rio Grande de Santiago.

The effects of introduction of hatchery trout on the distribution and purity of the native trout of Mexico cannot be ignored.

In 1888, 33,000 McCloud River rainbow trout were sent by the U.S. Fish Commission to Señor Chazari of the Mexican Fish Commission. At that time, a hatchery was constructed on the upper Rio Lerma. None of the Mexican trout I have examined, however, are identical to the McCloud rainbow.

During Nelson's Baja expedition of 1905, he preserved specimens of the Rio Santo Domingo trout. In 1908, B. W. Evermann described the Santo Domingo trout as a new species, *Salmo nelsoni*. The Baja rainbow has the most recent origin and the least differentiation from the modern coastal rainbow trout of all the Mexican trout. There is no valid basis to recognize the Baja trout as a distinct species. The ocean temperatures off northern Baja are still sufficiently cold to maintain Pacific salmon and steelhead trout. With a trend for a cooler and wetter climate allowing perennial flow in the Rio Santo Domingo to reach the Pacific Ocean, a steelhead run would likely become established. The present isolation of the Rio Santo Domingo trout has been a matter of only a few thousand years, not sufficient time for significant differentation to take place. Taxonomically, there is little justification to recognize *nelsoni* as a subspecies of *S. gairdneri*. But the name has been officially endowed upon the Santo Domingo trout, and has well served to emphasize the fact that the Santo Domingo rainbow is the only trout native to Baja California. As such, Mexican fisheries biologists have undertaken studies and transplant operations to ensure the perpetuation of their native "*nelsoni*," a small segment of the biodiversity of the rainbow trout species and of the biological heritage of Mexico.

After Evermann's 1908 paper on Baja trout, little more was learned of Mexican trout until Paul Needham, then employed by the U. S. Bureau of Fisheries, led expeditions to the Rio Santo Domingo in 1936, 1937, and 1938. Needham visited Mexico with the objective of bringing live fish back to start a hatchery brood stock. The idea in back of th expedition was that the Rio Santo Domingo rainbow might offer advantages over available hatchery rainbow trout by a tolerance of higher temperatures and a lesser migratory propensity after stocking. Needham was successful in bringing the Santo Domingo trout back alive, but all perished in fish hatcheries before they were spawned.

In 1952, Needham led an expedition to the Rio Truchas (tributary to the Rio San Lorenzo) on the Mexican mainland, also to bring back live fish for a hatchery brood stock – again, all fish died before spawning. This was followed by trips by Needham and University of California students in 1955 and 1956, during which trout were collected and preserved from numerous localities from several different river basins tributary to the Gulf of California. The collections and examination of the specimens culminated in a 1959 University of California Publications in Zoology (Volume 67, Number 1), titled *Rainbow Trout in Mexico and California*, authored by Needham and Richard Gard. This publication might be considered as somewhat of a collectors' item by collectors of angling literature, because it contains a color plate of the Mexican golden trout painted by Tommy Brayshaw, whose artwork graced some of Haig-Brown's books.

The basic distinctions of the Mexican golden trout are well depicted in

Brayshaw's painting – the sparse spotting pattern along the dorsal surface, the light golden body color intensifying to orange on the ventral region, the coloration and markings on fins.

In Needham and Gard's 1959 publication, none of the Mexican trout populations they compared was described as new species or subspecies; all were considered as "forms" of rainbow trout, *Salmo gairdneri.* Comparable data on characters such as the number of scales, vertebrae, fin rays, pyloric caeca (appendages on intestine) were not available on rainbow trout from throughout their range.

In 1957, I began my studies on Western trout with Needham, and we collected rainbow and cutthroat trout from California to Alaska. When the examination of these specimens was completed and their characters compared with characters of Mexican trout, distinctions were apparent;the Mexican golden trout was formally described as a new species.

Besides the distinctive appearance of the Mexican golden trout, they were found to have the lowest number of vertebrae and pyloric caeca of any form of rainbow or cutthroat trout. The typical number of vertebrae in Mexican golden trout is 57 and 58, whereas most rainbow trout have 62-64 (cutthroat typically have 60-63). The other Western trout with the lowest vertebrae numbers of 58-60 include the California golden trout and the Gila and Apache trout, which also exhibit yellow-golden colors, similar fin markings, and a yellow or orange "cutthroat" mark. Most likely, these are shared primitive characters reflecting traits of an ancient ancestral transition toward the evolution of rainbow trout after the rainbow and cutthroat trout lines of evolution split from a common ancestor.

Most surprising was the number of vertebrae found in the trout in the headwaters of the Rio del Presidio, typically 64 and 65 – counts otherwise found only in the redband rainbow trout of the middle Columbia River Basin. The number of pyloric caeca, scale counts, and spotting pattern of the Presidio trout also indicate relationships to Columbia Basin redband trout and emphasize the diversity of ancestral origins and long isolation of the trout associated with the Gulf of California.

To summarize what is presently known of this diversity, the trout native to individual river basins can be considered, from south to north.

As mentioned, the trout of the Rio del Presidio, the southernmost natural distribution of Salmonidae, are characterized by a high vertebral number suggesting relationships to a northern form of redband rainbow trout. Of all native trout populations of mainland Mexico, the Rio del Presidio was likely the one most recently established in geological time – perhaps during the last glacial period.

The trout native to the next drainage north of the Rio del Presidio, the Rio San Lorenzo, is known only from one tributary, the Rio Truchas (or Trout River). The Rio Truchas trout are peculiar; they appear almost intermediate between the Mexican golden trout in the drainages to the north and the del Presidio trout to the south. (For example, they typically have 60-62 vertebrae.) Perhaps the golden trout was the original trout of the San Lorenzo drainage and a later invasion of the same ancestor which invaded the Rio del Presidio resulted in hybridization, but this is pure speculation. The next three rivers to the north of the Rio San Lorenzo, the Rio Culiacan, the Rio Sinaloa, and the Rio Fuerte all contain the Mexican golden trout in their high elevation headwater areas.

The two remaining rivers north of the Rio Fuerte which contain native trout are the Rio Mayo and Rio Yaqui. The Yaqui and Mayo trout are similar to each other, indicating a recent common ancestor. This trout shows some external similarities to the Mexican golden trout with its light golden color and tints of orange or red, but of lesser intensity. The Yaqui and Mayo trout have smaller and more profuse spots than does the Mexican golden trout. They have a general resemblance to the Gila trout of New Mexico. Observation on chromosome numbers, however, are puzzling. Gila and Apache trout have 56 chromosomes. (Most redband and rainbow trout have 58, but some California and Oregon coastal rainbow trout have 60 or 64 chromosomes.) The Rio Mayo trout has 64 chromosomes, the Mexican golden trout has 60. Based on the sum of the other divergent characters, it appears that the 64 chromosomes of the Mayo – and probably Yaqui – trout and the 60 chromosomes of the Mexican golden trout were evolved independently of the 60 and 64 chromosome population of some coastal rainbow trout. That is, the chromosome numbers do not reflect recency of common ancestry of all Western North American trout with 60 and 64 chromosomes.

On geographical grounds, it could be assumed that cutthroat trout were once native to Mexico. Immediately east of the Continental Divide, the drainages east of the headwaters of the Rio Yaqui, Rio Feurte, Rio Sinaloa, and Rio Culiacan were once part of the Rio Grande Basin. During glacial times when cutthroat trout occurred much further south in the Rio Grande and the Rio Casas Grandes and Rio Conchos had large volumes of colder waters connecting to the Rio Grande, cutthroat would be expected to inhabit these Mexican drainages. No trout has been documented in the Rio Conchos drainage, and a trout found in a small section of the Rio Casas Grandes drainage appears identical to the Yaqui trout – which occurs only a few miles to the west in the headwaters of the Yaqui – and was not possibly transported from the Yaqui drainage by man.

For adventurous anglers contemplating a trip to catch any of the native Mexican trout, I would suggest reading Robert H. Smith's book, *Native Trout of North American* (1984). Smith made expeditions to Baja and the mainland in search of Mexican trout. He describes the difficulties of travel and of finding and catching these rare trout. His book includes color photographs of the Mexican golden, the Rio Yaqui, the Rio San Lorenzo, and the Rio del Presidio trout. To reach the more remote and roadless areas of the Sierra Madre Occidental and to fish waters not yet surveyed for trout, one would have to emulate E. W. Nelson and go by pack trip with a knowledgeable guide.

Let me know what you find.